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Purification of Pharmaceutical Grade Salmon-Derived Thrombin and Fibrinogen for Hemostatic Bandages

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Abstract
Hemorrhage due to trauma is the leading cause of preventable death among American soldiers, according the National Institute of Trauma. Uncontrollable bleeding is also seen regularly in civilian incidences of trauma and is a common major surgical complication. The human blood clotting process involves a complex cascade of tightly regulated enzymatic reactions. Two of the most important proteins in this cascade are fibrinogen and thrombin. Thrombin is an enzyme that activates fibrinogen monomers to form a polymeric fibrin network, forming the basis of a blood clot. During trauma, a state of consumptive coagulopathy, the body depletes these two proteins causing severe bleeding. A novel way to counteract hemorrhage is to supply additional thrombin and fibrinogen to the focal injury site. However, as of yet fibrinogen has proved technically challenging to produce recombinantly, and mammalian-based proteins carry the risk of pathogen transmission and immune response. Salmon-derived proteins, on the other hand, overcome both of these obstacles. DiamondStat is a novel hemostatic bandage that delivers fibrinogen and thrombin purified from salmon blood. It is a 4 x 4 inch adhesive bandage that delivers 10 mg/cm2 of fibrinogen and 90 units/cm2 of thrombin to effectively stop hemorrhage. The production of DiamondStat bandages begins with harvesting blood from salmon. Through a series of centrifugations and precipitations, prothrombin (a zymogen precursor to thrombin) and fibrinogen are extracted from the blood. Additional precipitations and filtrations further purify the fibrinogen solution to pharmaceutical-grade. The prothrombin is converted to thrombin in an immobilized snake venom catalyst column. Thrombin is then purified through an affinity column and ultrafiltration. Both thrombin and fibrinogen solutions are run through endotoxin removal columns and then sprayed onto pieces of gauze. The proteins are lyophilized onto the gauze and 2 the final bandage, which consists of fibrinogen and thrombin gauze pieces and an adhesive backing, is assembled. Bandages are sterilized via gamma irradiation and ready for use. At a capacity of 300,000 bandages per year and $800 per bandage, DiamondStat production is very profitable. It will yield an internal rate of return of 289.76% and a net present value of over $489 million. Extensive sensitivity analysis indicates that the project will be profitable in all likely scenarios. Investment in the DiamondStat processing plant is highly recommended. It is an economically viable project with the potential to save the lives of hundreds of thousands of American servicemen and women.

Disciplines
Biochemical and Biomolecular Engineering | Chemical Engineering | Engineering

Purification of Pharmaceutical Grade Salmon-Derived Thrombin and Fibrinogen for Hemostatic Bandages

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April 14, 2015

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Professor Leonard Fabiano
University of Pennsylvania
School of Engineering and Applied Sciences
Department of Chemical and Biomolecular Engineering
220 S. 33rd Street
Philadelphia, PA 19104

Dear Professor Fabiano and Dr. Diamond,

Enclosed is a detailed process design and economic analysis of a method to extract and purify fibrinogen and prothrombin from the blood of Atlantic salmon. The prothrombin is then converted to thrombin using an immobilized snake venom column, which is extensively designed in the report. Fibrinogen and thrombin are freeze-dried onto separate pieces of gauze that are combined on an adhesive backing to form our medical device, the DiamondStat bandage, which will be used to treat hemorrhage due to trauma in hundreds of thousands of patients.

The process presented can be broken down into five stages: whole blood processing, fibrinogen purification, prothrombin purification and conversion, thrombin purification, and bandage creation. Over the course of 330 operating days in a year, the blood of 3.3 million Atlantic salmon is converted into 300,000 DiamondStat Bandages. Our strategic bandage manufacturing partner provides the gauze and adhesive bandage layers and also manufactures the bandages. Packaging and sterilization were also outsourced to maintain the scope of the project.

The economic analysis showed the process to be profitable at this scale. With bandages priced at $800 per bandage, the DiamondStat production plant has a net present value (NPV) of over $489 million and an internal rate of return (IRR) of 289.76%.

Best,

Jesse Debes Hanna Elmongy Shannon Keenan Kristin Kirby

Table of Contents

1. Abstract

Hemorrhage due to trauma is the leading cause of preventable death among American soldiers, according the National Institute of Trauma. Uncontrollable bleeding is also seen regularly in civilian incidences of trauma and is a common major surgical complication.

The human blood clotting process involves a complex cascade of tightly regulated enzymatic reactions. Two of the most important proteins in this cascade are fibrinogen and thrombin. Thrombin is an enzyme that activates fibrinogen monomers to form a polymeric fibrin network, forming the basis of a blood clot. During trauma, a state of consumptive coagulopathy, the body depletes these two proteins causing severe bleeding. A novel way to counteract hemorrhage is to supply additional thrombin and fibrinogen to the focal injury site. However, as of yet fibrinogen has proved technically challenging to produce recombinantly, and mammalian-based proteins carry the risk of pathogen transmission and immune response. Salmon-derived proteins, on the other hand, overcome both of these obstacles.

DiamondStat is a novel hemostatic bandage that delivers fibrinogen and thrombin purified from salmon blood. It is a 4 x 4 inch adhesive bandage that delivers 10 mg/cm^2 of fibrinogen and 90 units/cm^2 of thrombin to effectively stop hemorrhage. The production of DiamondStat bandages begins with harvesting blood from salmon. Through a series of centrifugations and precipitations, prothrombin (a zymogen precursor to thrombin) and fibrinogen are extracted from the blood. Additional precipitations and filtrations further purify the fibrinogen solution to pharmaceutical-grade. The prothrombin is converted to thrombin in an immobilized snake venom catalyst column. Thrombin is then purified through an affinity column and ultrafiltration. Both thrombin and fibrinogen solutions are run through endotoxin removal columns and then sprayed onto pieces of gauze. The proteins are lyophilized onto the gauze and

the final bandage, which consists of fibrinogen and thrombin gauze pieces and an adhesive backing, is assembled. Bandages are sterilized via gamma irradiation and ready for use.

At a capacity of 300,000 bandages per year and $800 per bandage, DiamondStat production is very profitable. It will yield an internal rate of return of 289.76% and a net present value of over $489 million. Extensive sensitivity analysis indicates that the project will be profitable in all likely scenarios. Investment in the DiamondStat processing plant is highly recommended. It is an economically viable project with the potential to save the lives of hundreds of thousands of American servicemen and women.

2. Introduction

2.1. Background Information

Hemostasis, defined as the cessation of blood loss at a damaged blood vessel, is achieved in two stages. Primary hemostasis begins with the activation of platelets, the blood cells involved in sealing the vessel injury and coagulation. Injury in a blood vessel exposes the platelets to sub-endothelial proteins such as collagen which activates the platelets inducing platelet aggregation. The aggregated platelets form a platelet plug which begins to seal the damaged blood vessel. Secondary hemostasis involves the formation of a fibrin mesh composed of polymerized fibrin to strengthen the platelet plug. Fibrinogen, the circulating zymogen, or inactive form, is converted to fibrin by the serine protease thrombin. Thrombin is also activated from its circulating zymogen form, prothrombin. Injury at the blood vessel initiates a coagulation cascade that leads to the activation of prothrombin to thrombin.

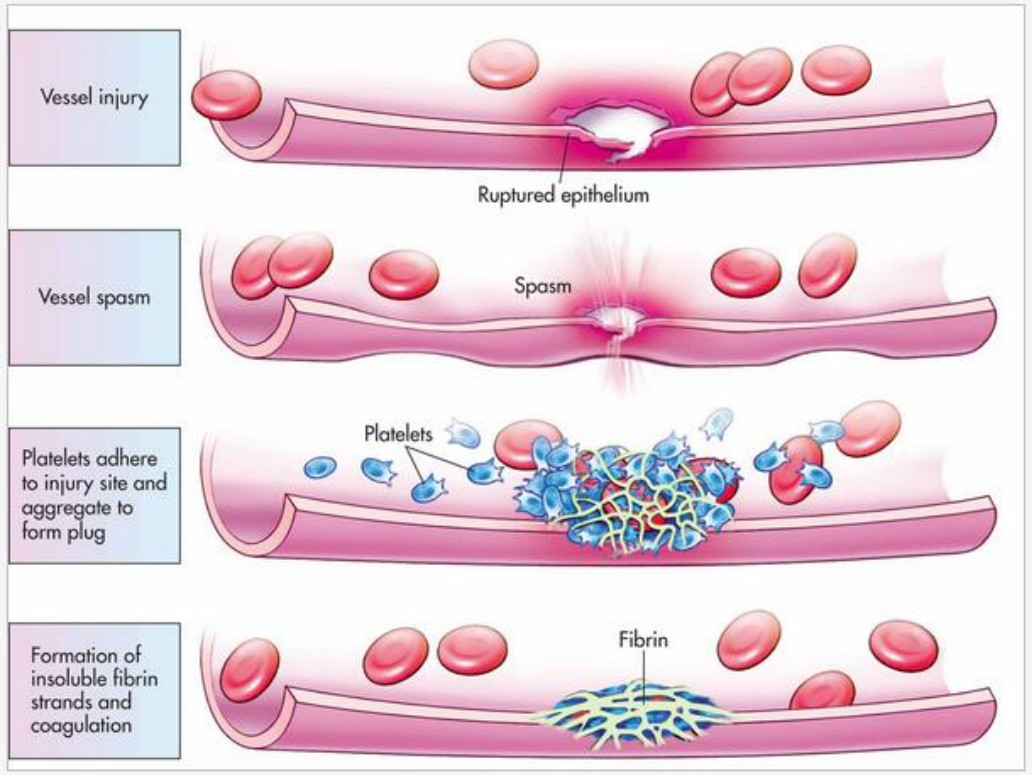


Figure 2.1.1: Primary and Secondary Hemostasis (Porth)

Existing hemostatic agents, such as microfibrillar collagen or kaolin, can initiate these pathways that activate thrombin and fibrin. However, using collagen to activate coagulation at the platelet level can prove to be problematic due to platelet dysfunction in trauma-induced coagulopathy, which is a likely possibility for our target demographic. Also, kaolin activates the intrinsic pathway, the physiologic relevance of which is still under investigation. Moreover, in acute trauma the human body consumes its supply of thrombin and fibrinogen, making hemostasis difficult to achieve. A hemostatic agent that replenishes both these final protein products is a novel way to aid in hemostasis in the case of traumatic injury.

The fibrinogen monomer is too large (340 kDa) and complex (two copies of three subunits coded by three different genes) to be produced by recombinant methods. Isolating these proteins from human or bovine sources introduces health risks and complicates FDA approval because of the risk of blood borne diseases such as hepatitis C or bovine spongiform encephalopathy (Mad Cow disease). However, fibrinogen and thrombin protein tertiary structures are conserved in the Salmonidae family of the bony fish, which includes salmon and trout ("Prothrombin-Human," "Prothrombin-Rainbow Trout"). Proteins from these cold water fish have reduced the pathogenic risks when compared to their mammalian counterparts. In preliminary animal trials some immune response is observed in the tissue near the bandage, but this may be due either to exposure to foreign proteins or to increased coagulation in the healing tissue. While the animals do produce low levels of antibodies against the salmon proteins, there is no adverse immunological reaction and healing occurs normally. (Rothwell SW, et al.)

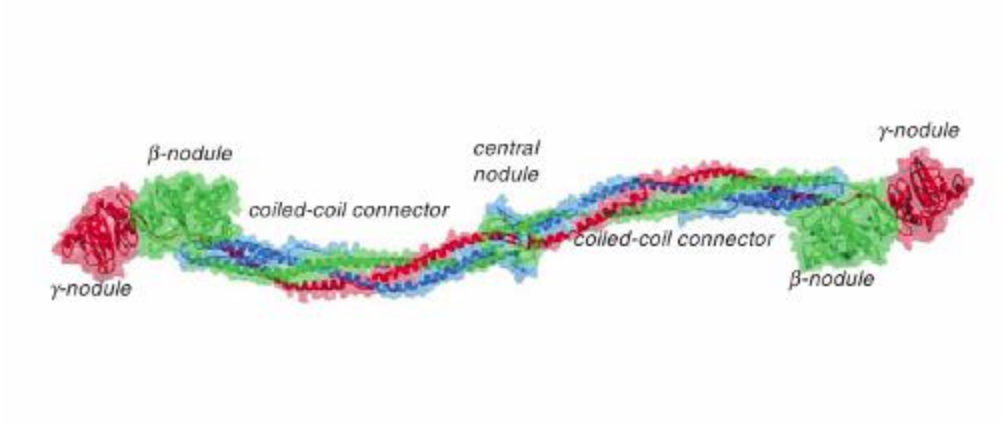


Figure 2.1.2: Crystal structure of fibrinogen showing complex tertiary structure consisting of six subunits (Medved and Weisel)

Salmon blood is a convenient starting material as a byproduct of the food industry. Salmon are currently bled prior to human consumption in order to maintain the iconic pink color of the meat. However, this natural resource is discarded and its potential wasted. Therefore, a partnership with salmon fisheries will prove mutually beneficial. Additionally, due to homology between salmon and trout, the process can utilize trout blood if there is a salmon shortage.

The dosages of thrombin and fibrinogen were determined by consulting the literature and balancing with realistic production goals. In animal trials fibrinogen doses ranging from 0-15 mg/cm^2 were tested, and 15 mg/cm^2 achieved significant decrease in blood volume loss compared to the control (Pusateri, et al). However, this dosage would require harvesting an unrealistic amount of salmon. A dosage of 10 mg/cm^2 still showed improved coagulation and is a more realistic target for this process. Thrombin is typically applied at 50 NIH units/cm^2 (Rothwell, et al). However, a large excess of prothrombin is available at the production level required for the fibrinogen goals. As a result utilizing 20% of the prothrombin available gives a dosage of 90 U/cm^2. As fibrin polymerization is the ultimate goal of the bandage, the dosage of fibrinogen is more important, and an excess of thrombin may speed up the coagulation process. Fine tuning of dosage will be completed during preclinical and Phase I clinical trials.

2.2. Objective-Time Chart

Project Name: Purification of Pharmaceutical Grade Salmon-Derived Thrombin and Fibrinogen for Hemostatic Bandages

Project Team: Jesse Debes, Hanna Elmongy, Shannon Keenan, and Kristin Kirby

Project Goal: To design a pharmaceutical plant that will produce 300,000 bandages per year containing fibrinogen and thrombin purified from salmon blood for use in acute traumatic injuries

Project Scope:
In-Scope

- Blood collection from salmon through fisheries
- Anticoagulation and centrifugation of raw salmon blood
- Separations to produce highly purified fibrinogen and prothrombin
- Design of solid-phase immobilized enzyme column for activation of prothrombin to thrombin using snake venom
- Endotoxin removal of purified proteins
- Freeze-drying of proteins onto bandages
- Packaging and sterilization of bandages with radiation

Out-of-Scope

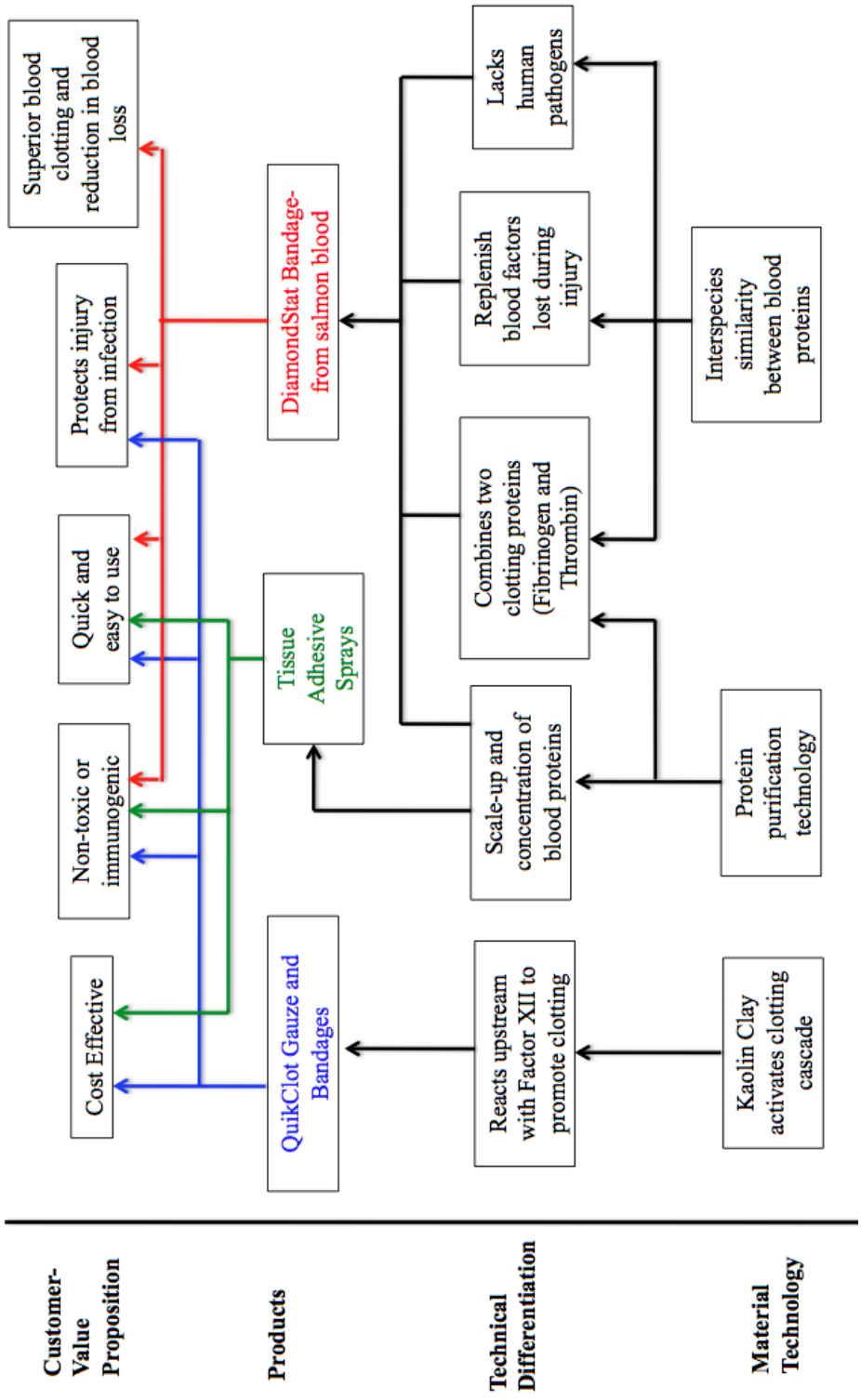
- Fish harvesting
- Fish processing post blood collection
- Production of bandages before addition of proteins
- Distribution of bandages
- Seeking FDA approval of bandages and clinical trials

Deliverables

- Business Opportunity Assessment
  - What are similar bandages that promote clotting currently on the market, and who are the target customers?
  - How does the DiamondStat Bandage compare to those currently on the market?
- Technical Feasibility Assessment
  - Is it technically feasible to produce fibrinogen and thrombin on a large scale from salmon blood?
  - Is the number of fish needed per week a feasible number to produce a profit?
- Manufacturing Capability Assessment
  - How many bandages be produced per year? Can this process later produce more bandages to increase profitability?

Time Line: Complete facility and process design with economic analysis between January 20, 2015 and April 14, 2015.

3. Innovation Map



4. Market and Competitive Analyses

4.1. The Medical Sealant and Adhesive Industry

The American medical adhesives and sealants industry serves a wide market. U.S. medical professionals are key buyers in this industry, with many healthcare providers in other countries choosing to import American medical sealants, as well. The military is an additional customer base that has been showing increased interest in medical adhesives for soldiers in combat.

As of 2014, the medical adhesives and sealants industry was a $1.7 billion dollar industry, with projected annual growth of 10.8%. Four large conglomerates dominate the industry, as shown in Figure 4.1.1. They benefit from their reputation and contacts within the industry, as well as the economies of scale and ability to invest in R&D that they achieve from their large size. As technological changes continue to accelerate innovation in this market, development in novel and unique methods is critical.

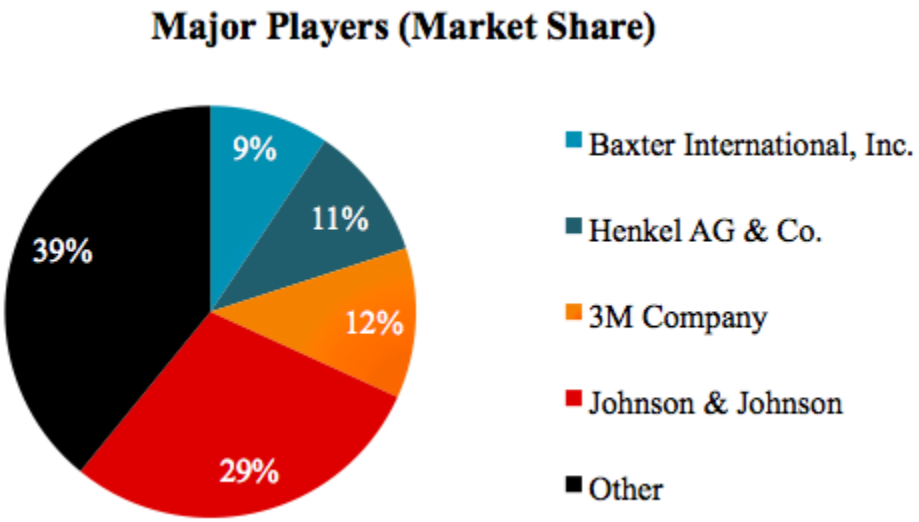


Figure 4.1.1 Major market players in the U.S. Medical Adhesive & Sealants Industry, as reported by Goddard, 2014.

The three major product segments in the industry are: internal adhesives, dental adhesives, and external adhesives, representing 49.4%, 38.0% and 12.6% of 2014 industry revenue, respectively. DiamondStat falls into the external adhesives category, which is a positive indicator for product success. As technology has only recently allowed for the development of effective sealants in this category, the external medical adhesive and sealant industry has the highest potential for growth.

4.2. Competition in the Hemostatic Agent Market

Currently there are several hemostatic agents on the market. DiamondStat differentiates itself from existing products with two key features: its clotting efficiency and its ease of use.

Kaolin gauzes represent one category of competition, led by QuikClot® products from the Z-Medica Corporation. These products contain kaolin clay, a natural silicate mineral that has been found to active the blood clotting factor, Factor XII, which promotes the coagulation cascade upstream of prothrombin and fibrinogen activation. Because kaolin is relatively easy to acquire, these bandages are very cost-effective. Four yards of QuikClot® Combat Gauze costs about $50. In 2002, when Z-Medica was first established, the company only targeted the military. In 2007, reports showed that this very small company had a net sales of $5 million (Bocair Partners, LLC, 2008). By 2014, annual sales had grown to approximately $6.5 million ("Z-Medica, LLC Company Overview," 2015). Z-Medica has increased their revenue by expanding their customer base to hospitals and ERs for trauma cases, producing a QuikClot® Sports brand for consumers, and selling QuikClot® First-Aid Kits (priced at $90 per kit). DiamondStat has two major advantages over the QuikClot® family of products. First, kaolin gauzes have been shown to be less effective than fibrin sealants in the time required to achieve hemostasis as well as survival rate (Floyd CT, et al). Second, QuikClot® products can only be

used for compressible wounds. According to the National Trauma Institute, over 15% of U.S. military battle injuries are to the torso, where compression cannot be applied, and non-compressible hemorrhage is the leading cause of potentially survivable deaths in American troops ("Hemorrhage").

Surgical sealants that can be used at non-compressible sites of injury sites represent another category of DiamondStat competitors. These products come packaged as a protein serum and compatible gauze that need to be applied separately by a medical professional. Additionally, there is not currently a product in the surgical sealant category that delivers both fibrinogen and thrombin in one application. Because of the time and difficulty of application, these products are more commonly seen in hospital settings rather than combat ones. DiamondStat, on the other hand, contains both freeze-dried fibrinogen and thrombin on a bandage that can be applied in a matter of seconds, making it both easier to apply and a more effective hemostatic agent.

DiamondStat's biggest competitor in this category is a Johnson & Johnson subsidiary, Ethicon Inc. Its products are Evical and Evithrom, a non-bovine fibrin sealant and a thrombin sealant, respectively. They are primarily used to limit and control bleeding during surgical procedures. Several smaller manufacturers, such as Cryolife, Omrix, Vascular, and Zymogenetics, also produce surgical sealants.

The most technologically and functionally similar product on the market is produced by St. Theresa's Medical, using their FASTCLOT® technology. Their technology also delivers salmon fibrinogen and thrombin to wound sites. Proteins are linked to a nano-fiber dextran matrix carrier that immediately dissolves after coming in contact blood. DiamondStat may be more effective for military use because the bandage portion does not dissolve in blood, providing a physical barrier to blood loss during the time it takes the clot to form. Moreover, while

FASTCLOT® technology has been approved for use in animal surgery, it has still not gained FDA approval for human use (“Technology”).

5. Customer Requirements

There is a wide customer base for the DiamondStat. Its ability to quickly clot blood in traumatic wounds makes it appealing to several target markets. Our primary target market is the U.S. military. We will later expand to also serve emergency rooms and ambulances. To be attractive to its customers, DiamondStat will need to be quick to apply, effective at clotting blood quickly, and large enough to cover the size of wounds that typically result in severe blood loss. The product will also need to meet all of these requirements more efficiently than existing alternatives (i.e., stitches, non-sealing gauze, other coagulation sealants). The bandage could be used in any surgical setting, but because of its unique set of features, it offers the highest value in emergency settings for patients with uncontrollable bleeding.

The DiamondStat Bandage is primarily designed to deal with larger injuries that could cause severe blood loss. The fibrinogen and thrombin proteins on the bandage have shown to cause rapid clotting and are meant to replenish the same blood proteins that are lost during hemorrhage. This is not a consumer product, but rather a medical device. Customer requirements encompass the needs of the military and hospitals, which deal with trauma cases daily. The customer requirements will be qualified as Fitness-to-Standard (FTS). Fibrinogen bandages are not necessarily a new product idea. However, the DiamondStat Bandage utilizes fibrinogen and thrombin to act more quickly than other bandages on the market. The proteins are also not purified from human blood, which eliminates the risk of human specific pathogens.

The primary customer requirement for this product to satisfy customer needs is that it is FDA approved and can be shown to be effective in clinical trials. Medical sealants, such as our product, classify as a Class III medical device. As such, our bandage will need to pass a rigorous Food & Drug Administration approval process. There are two pathways through which to bring a

medical device to market: 510(k) premarket notification or the FDA's Premarket Approval Pathway (PMA). To achieve clearance through the 510(k) process, a device must prove that it is substantially equivalent to a product on the market that has already gained 510(k) clearance.

Because there is no approved medical device that currently delivers salmon-derived fibrinogen and thrombin, our bandage will likely need to go through the much more demanding PMA process. A PMA application must demonstrate the safety and efficacy of the product through data from technical, preclinical and clinical trials, manufacturing data and approved labeling.

5.1. Military Use

The first customer segment that the bandage will target is the military. High demand for a more effective hemostatic bandage and a significant degree of price insensitivity make the U.S. military an excellent target market. Studies have found that 25% of all military deaths result from soldiers not being able to make it to a medical facility in time before hemorrhaging. As a result, the military is willing to spend money on innovative products that could aid in blood clotting (Bowen, TE, et al).

Due to its ability to clot blood quickly, the DiamondStat will be invaluable to our soldiers in situations of uncontrollable bleeding, such as a gunshot wounds or explosions, where other methods to stop bleeding (i.e. stitches, traditional sprays) would be ineffective due to their lack of portability and their slow application speed. With our bandage, a military medic will be able to treat a soldier in a matter of seconds and then be free to move on to the next patient. Becoming an approved vendor to the U.S. government is a lengthy and rigorous process, which involves gaining approval by the U.S. General Services Administration (GSA). Our partnership with a larger bandage producer, such as Johnson & Johnson, will allow us to expedite this process.

In order for the bandages to be effective, the two proteins must remain completely dry before being applied to a wound. This means that the packaging must be robust enough to keep out all moisture, even in harsh conditions in which soldiers operate. At the same time, the packaging should be easily opened and accessible for quick application of the bandage.

5.2. Emergency Rooms & Ambulances

Similar to military use, emergency rooms and ambulances will demand our bandage because of its portability and ease of application. Victims of any sort of trauma, from assault to motor vehicle crashes, will benefit from its quick application, portability and clotting ability. Oftentimes in emergency rooms and ambulances, patients are forced to wait for critical treatments, be it in line to be treated by an ER physician or during the ambulance ride to the hospital. Our bandage is easy to apply, and thus can be applied immediately by an ER nurse, rather than having to wait for the doctor to be ready to see the patient. Hospitals will have the same technical and product quality standard requirements as military customers.

The end-users of DiamondStat are the ones who will eventually be paying for it when administered in a hospital setting (in contrast to the US government in the case of the soldiers) and thus are much more price sensitive. As a result, reimbursement approval by insurance companies will be vital for application of the bandage in hospitals and ambulances for civilians.

6. Product Concepts

6.1. Superior Product Concept

Our product will consist of two pieces of thin gauze (similar to a mesh). Solutions of fibrinogen and thrombin will be sprayed on to their respective piece of gauze and freeze-dried. Fibrinogen and thrombin cannot come into contact in the presence of water. If so, thrombin will quickly activate fibrinogen to fibrin, which will polymerize and become ineffective. Once the bandages are fully dry, they will be placed one on top of the other. Then the thrombin side is affixed to the outer adhesive layer of the bandage, so the fibrinogen first contacts the injury. It will be 4 inches by 4 inches, resembling a typical bandage. When the gauze side of the bandage comes into contact with blood, the blood will dissolve the proteins and start the clotting process.

6.2. Alternative Product Concepts

Other product formulations were considered. Creating rolls of gauze, which could later be custom cut and applied, was examined. However, because of relatively low production volumes and the logistics of application in combat setting, rolls of protein-coated gauze were rejected in favor of creating individual bandages.

It was thought that fibrinogen could be sprayed onto gauze and freeze-dried. Thrombin would be freeze-dried from solution into a powder and applied to the bandage in a loose powder form. However, this idea would be more difficult to implement and product quality would likely be lower.

Another option was to create some sort of polymer film that could be placed between the two pieces of gauze to keep the fibrinogen and thrombin sides of the bandage separate, even when wet. This would reduce packaging requirements, because very dry packaging would not be

needed. However, creating a custom polymer that was not water soluble and could be easily removed when the bandage was applied to a wound would have been too costly of a project for the value it added.

Lastly, it was thought that both fibrinogen and thrombin could be freeze-dried from solution into powders, mixed and applied to bandages. Although this idea seemed easier, the final selected method of spraying the protein solutions directly onto the bandages before freeze-drying provides a more homogenous and controlled distribution of the proteins throughout the bandage.

7. Patent and Intellectual Property Analysis

7.1. Analysis of Existing Patents

Many patents exist in the United States for medicinal products that promote wound healing. Amongst these patents, multiple patents exist for bandages that specifically use fibrinogen, thrombin, or different clotting factors. This includes the following patent numbers:

1. WO 2004010913 A1
2. US 4453939 A
3. US 20030040692 A1
4. US 6891077 B2

The earliest patent was filed in 1982, for a sealant (not a bandage) that was composed of fibrinogen, thrombin, and a collagen carrier to promote wound healing. Collagen is the main component of this product. The fibrinogen and thrombin were purified from human or bovine blood. In 1983, a "resorptive sheet material" was patented for the purpose of wound healing. It contains two layers of bandage containing thrombin and fibrinogen (US 4453939 A). This bandage is very similar to the DiamondStat Bandage; however, the thrombin and fibrinogen are formulated in a glycoprotein matrix, consisting of fibrin, fibrin fission products, collagen, albumin, globulins, and even an outer layer of fibroblast cells. This bandage was actually created by a member of the U.S. military for the same purpose as the DiamondStat. All components applied to this bandage were purified from human blood. In 2002, a more recent fibrinogen bandage patent was filed (US 20030040692 A1). The bandage is made of fibrinogen and one other pro-coagulate (they specify propyl gallate as opposed to thrombin). The main drawback to most of these bandages was that proteins purified from human blood could spread diseases such as HIV or hepatitis. Nonetheless, the patent from 2002 claims that human blood will probably be okay to use because at that point in time blood purification techniques had

become much better and eliminated many of the serum borne pathogens. The patent also claims that recombinant fibrinogen is a likely future possibility; recombinant fibrinogen has yet to be made.

In summary, there have been many failed attempts in the past to create an effective fibrinogen bandage for military use. The DiamondStat Bandage is novel because of its use of purified salmon proteins. This has never been done, but studies have shown it to be just as effective as human proteins with less immunogenicity and danger of spreading disease.

7.2. Strength of DiamondStat IP Claims

The DiamondStat will be able to file intellectual property claims in two regards. The product itself, a bandage that contains salmon-derived salmon and fibrinogen, is a novel, patentable product concept. As discussed in Section 7.1, while there are many existing patents for protein-containing hemostatic bandages, none of these patents combine salmon-purified proteins using our method of application.

The DiamondStat also has a patentable process. There are patents that exist for lab-scale purifications of salmon clotting proteins, such as US6007811 A, but there are none that exist on the larger industrial scale that the DiamondStat is being produced on. Furthermore, the DiamondStat process uses a unique series of separation steps, including a novel immobilized enzyme column reactor, that have not been patented.

The combination of a unique product with a novel production process provides DiamondStat with very strong intellectual property claims.

8. Preliminary Process Synthesis

The original process design was based off of a paper by *Michaud et al*, which described a lab-scale process for purifying thrombin and fibrinogen. Some details of the process were also obtained from the article by *Ngai and Chang*. As seen in Figure 8.1, this process had an extensive sequence of precipitations, centrifugations, and ultrafiltrations, particularly when purifying the prothrombin. On a lab-scale, this sequence of precipitations and centrifugations is simple. However, this proved more tedious and expensive on an industrial scale. To simplify the process and reduce the number of unit operations, an immunoaffinity column was added in the second process flow diagram to purify the prothrombin in one step as shown in Figure 8.2. Although uncertain, it was assumed that an antibody specific for salmon prothrombin was available or could be custom synthesized. The initial process in Figure 8.1 also had a heparin affinity column for the purification of thrombin. This unit operation was eliminated in Figure 8.2 because prothrombin was isolated from other coagulation proteins in the immunoaffinity column before being converted to thrombin. Lastly, a gel permeation column was used in place of diafiltration to purify the fibrinogen in Figure 8.2 to eliminate proteins both larger and smaller than fibrinogen.

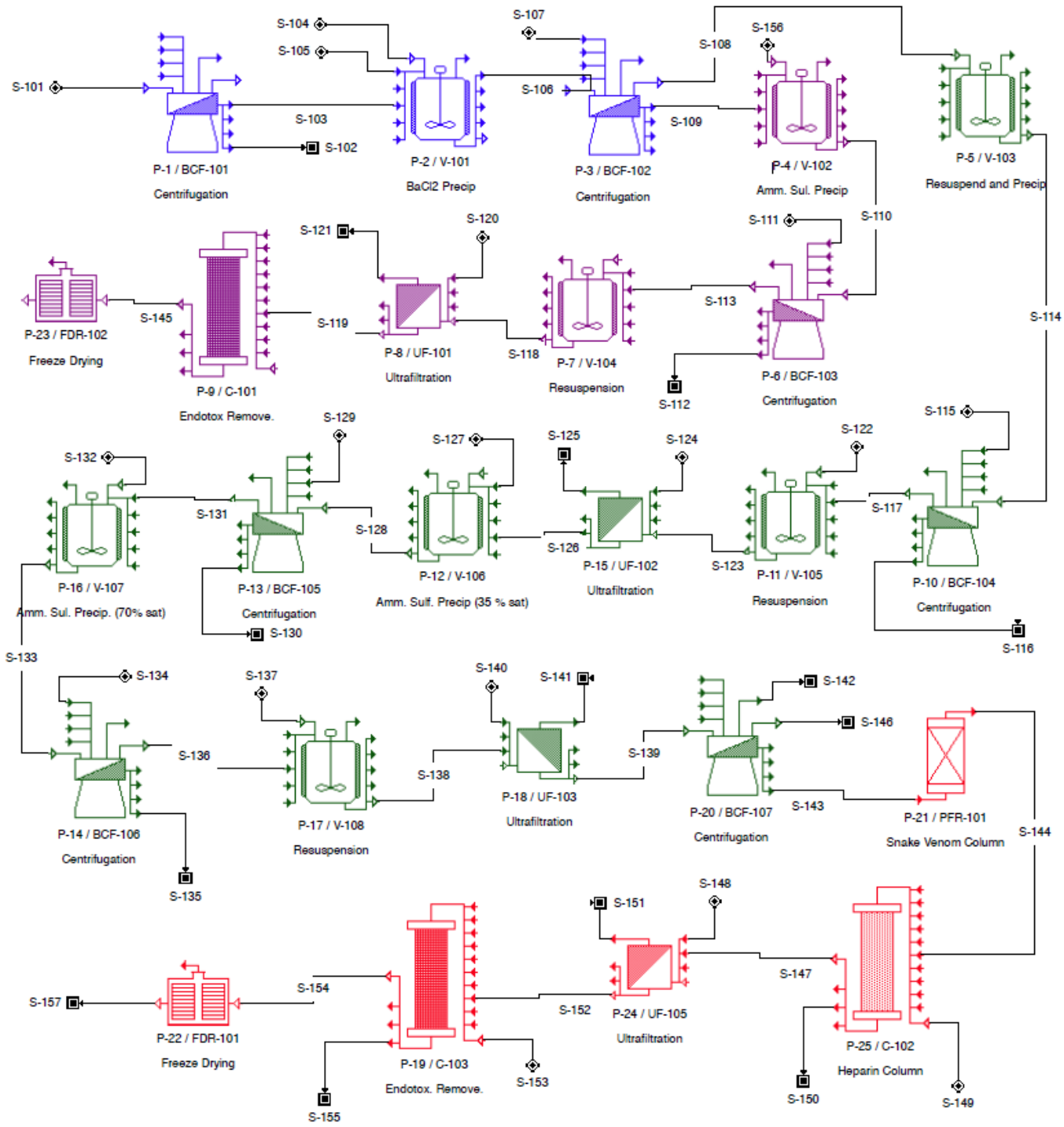


Figure 8.1 Original Process Flow Diagram

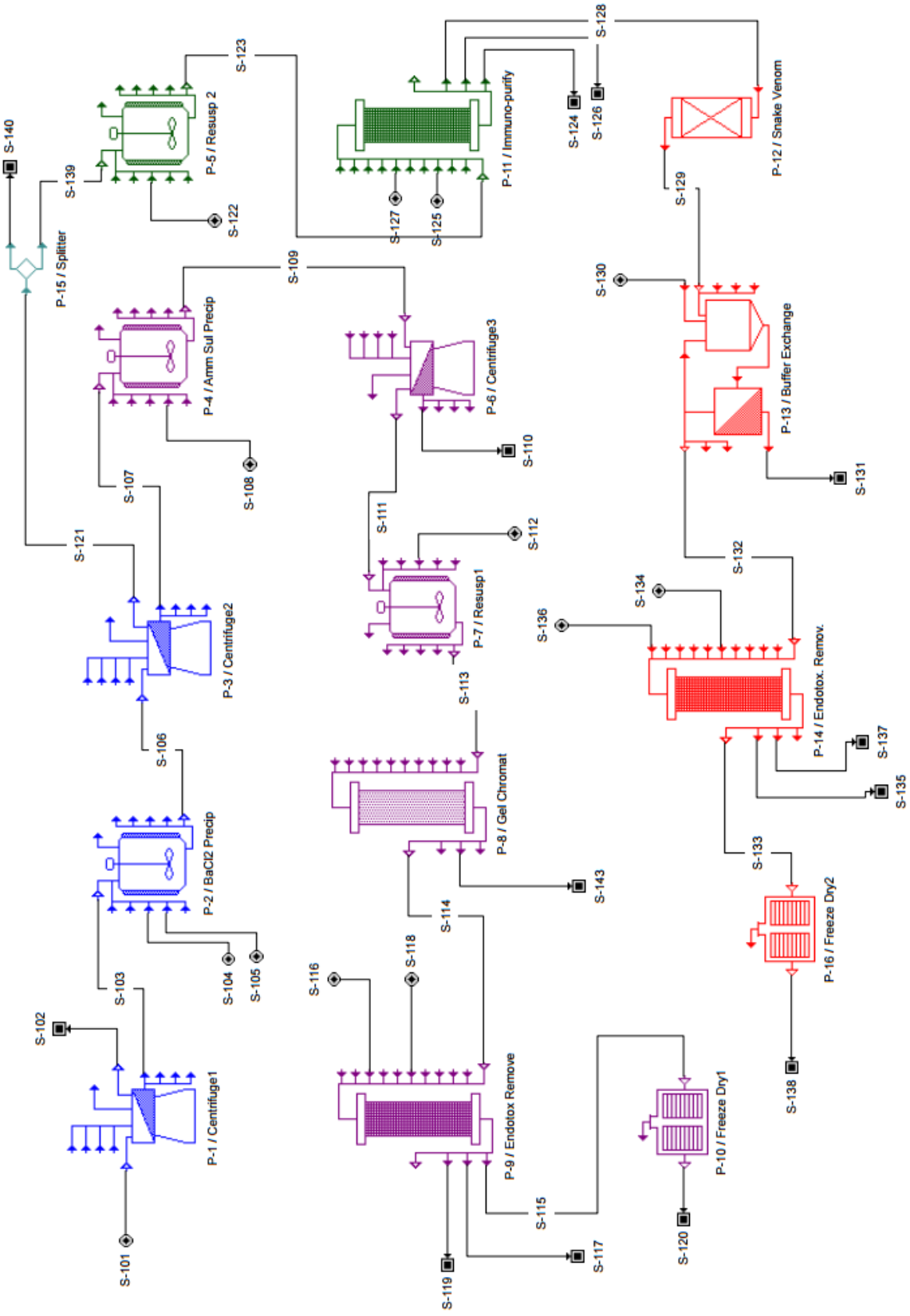


Figure 8.2 Second Process Flow Diagram

Although the second major process flow sheet was much improved from the first, there were problems associated with the affinity column. Besides having difficulty finding the appropriate antibody, it was difficult finding ways to effectively elute the prothrombin off the column without denaturing it. As a result, this column was removed, and the heparin column was added to the process once again. Prothrombin would be converted to thrombin, and then the thrombin would be purified in the heparin column. One obstacle was that any fibrinogen left in the prothrombin mixture could pose a problem. The fibrinogen molecules may coat the snake venom resin, resulting in lower reaction rates of prothrombin to thrombin. To remedy this problem, a larger snake venom column will be used. The gel permeation column to purify fibrinogen was also changed back to a diafiltration process. Gel permeation was initially needed to remove any proteins larger than fibrinogen from the mixture. However, research further into the subject showed that the ammonium sulfate precipitation would only pull fibrinogen out of solution, and negligible amounts of larger proteins. Our final flow sheet is depicted in Figure 8.3.

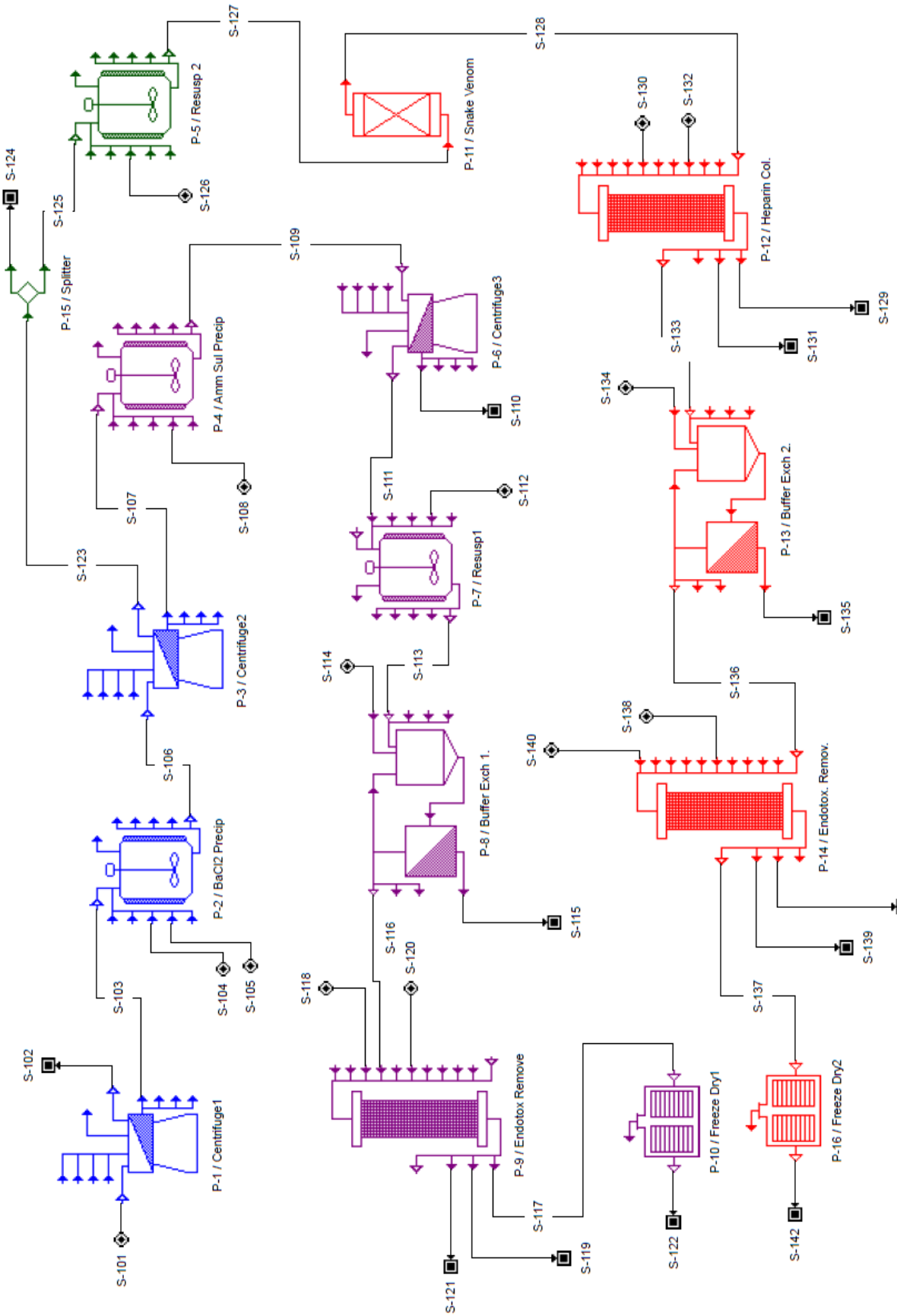


Figure 8.3 Finalized General Process Flow Diagram

9. Assembly of Database

9.1. Materials and Costs

Consult Appendix H for Material Safety Data Sheets.

Materials List						
Resins	**Annual Amount (L)**	**Manufacturer/ Catalog #**	**Unit Size (L)**	**Unit Price**	**Number of Units**	**Purchase Cost**
Heparin Sepharose 6 Fast Flow	96.4	GE Life Sciences	5	31350	20	$185,000
Detoxi-Gel Endotoxin Removing Gel	255.3	Thermo Scientific	1	3588	256	$100,000
AminoLink Plus Coupling Resin	7.5	Thermo Fisher Scientific, 20505	0.05	409	151	$8,000
Snake Venom Catalyst	**Annual Amount (g)**	**Manufacturer/ Catalog #**	**Unit Size (g)**	**Unit Price**	**Number of Units**	**Purchase Cost**
Snake Venom from Oxyuranus scutellatus	7.5	Accurate Chemical, TXL 1330	1	5667	8	$43,000
Liquids	**Annual Amount (L)**	**Manufacturer/ Catalog #**	**Unit Size (L)**	**Unit Price**	**Number of Units**	**Purchase Cost**
Pure Ammonia	43	Sigma Aldrich, QC1593	0.002	24.5	21420	$10,000
Pure Ethanol	1,469	Sigma Aldrich, E7023	16	1125	92	$104,000
Sodium Hypochlorite (12.5%)	26	Sigma Aldrich, 425044	1	103	26	$3,000
Phosphoric Acid (85%)	50,914	Sigma Aldrich, W290017	14.8368	243	3432	$32,000
Sodium Hydroxide (1 M)	434,645	Sigma Aldrich, 72082	0.1	51	4346445	$490,000
Solids	**Annual Amount (kg)**	**Manufacturer/ Catalog #**	**Unit Size (kg)**	**Unit Price**	**Number of Units**	**Purchase Cost**
Phosphate Buffered Saline Packets	3,950	Thermo Fisher Scientific, 28372	40	$150	99	$14,850
Sodium Azide	2.38	Sigma Aldrich, 438456	0.025	$107	96	$10,300

Tris	2.3	Sigma Aldrich, 252859	0.5	$89	5	$440
Sodium Cyanoborohydride	0.1	Thermo Fisher Scientific, 44892	0.002	$47	48	$2,300
Benzamidine Hydrochloride	181.2	Sigma Aldrich, 434760	0.025	$152	7250	$31,000
Sodium Citrate Dihydrate	1,059.90	Sigma Aldrich, W302600	25	$321	43	$14,000
Barium Chloride	3,614.70	Sigma Aldrich, 342920	0.25	$351	14459	$110,000
Sodium Chloride	2,456.7	Sigma Aldrich, RES0926S	25	$495	79	$49,000
Ammonium Sulfate	17151.8	Sigma Aldrich, RES1427A	25	$1,185	687	$60,000
L-Lysine	3.5	Sigma Aldrich, L5501	0.1	$268	35	$9,000
Ethylene Glycol Tetraacetic Acid	0.4	Sigma Aldrich, E4378	1	$1,860	1	$2,000
Sodium Deoxycholate	382.9	Sigma Aldrich, S1827	10	$2,875	39	$112,000
Tris Hydrochloride	60.8	Sigma Aldrich, RES3098T	50	$5,460	2	$11,000
Trisodium Citrate	11.3	Sigma Aldrich, S1804	25	$376	1	$380.00
Citric Acid	0.000227	Sigma Aldrich, 251275	0.005	$32	1	$32

For materials which will be purchased more than 100 times annually, the economies of scale were considered and the purchase cost was modified using the Sixth-Tenths Economies of Scale Rule.

9.2. Kinetic Data

The only reaction in this process involves the conversion of prothrombin to thrombin catalyzed by the snake venom from *Oxyuranus scutellatus.* The kinetic parameters for this enzyme following Michaelis-Menten kinetics are (Speijer, et al):

K_m = 166 μM

V_{max} = 2.5 μmol of prothrombin activated per minute per mg of venom

10. Process Flow Diagram and Material Balances

The general SuperPro process flow diagram as shown in Figure 8.3 will be used to do material balances on the system. This flow diagram is not comprehensive; it neglects many pieces of equipment such as pumps and holding tanks. A more detailed Visio process flow diagram is shown and discussed in Section 11. All unit operations are at 4°C and 1 atm, except for the snake venom column, which is run at 23°C, and the frozen plasma, which is at -80°C.

10.1. Stream Identification and Protein Concentrations

Stream Number	Contents	Volume (L)	Fibrinogen Mass (g)	Fibrinogen Concentration (g/L)	Prothrombin Mass (g)	Prothrombin Concentration (g/L)	Thrombin Mass (g)	Thrombin Concentration (g/L)
S-101	Crude blood + sodium citrate	520	1250	2.4	40.9	0.079	-	-
S-102	Waste blood cell pellet	225	62.5	0.28	2.05	0.009	-	-
S-103	Plasma + sodium citrate	295	1188	4.03	38.9	0.13	-	-
Then pool the plasma over 7 days and freeze		2065	8313	4.03	272	0.13	-	-
S-104	Barium Chloride (1M Stock)	365	-	-	-	-	-	-
S-105	Benzamidine Hydrochloride (1M Stock)	24.5	-	-	-	-	-	-
S-106	Plasma precipitated solution	2455	7897	3.2	258	0.105	-	-
S-107	Supernatant containing fibrinogen	2332	7818	3.4	2.58	0.001	-	-
S-108	Ammonium sulfate (100% saturation)	688	-	-	-	-	-	-
S-109	Precipitated solution	3020	7818	2.6	2.58	0.001	-	-
S-110	Supernatant-goes to waste container	2990	156	0.05	2.58	0.001	-	-
S-111	Pellet with fibrinogen	Solid	7662	-	-	-	-	-
S-112	10 mM Citrate-citric acid buffer (pH 7.3, 0.1 M NaCl, 1mM L-lysine)	501	-	-	-	-	-	-

S-113	Resuspended fibrinogen	501	7508	15	-	-	-	-
S-114	Water (diluant)	3504	-	-	-	-	-	-
S-115	Filtrate from buffer exchange	375	75.1	0.20	-	-	-	-
S-116	Retentate from buffer exchange	250	7433	29.7	-	-		
S-117	Endotoxin-free fibrinogen solution	250	6694	26.7	-	-	-	-
S-118	Elution buffer to elute endotoxins	250	-	-			-	-
S-119	Endotoxin waste from column	250	739	3.0	-	-	-	-
S-120	Wash buffer to regenerate the column	250	-	-	-	-	-	-
S-121	Wash waste	250	-	-	-	-	-	-
S-122	Freeze-dried fibrinogen product	-	**6560**	-	-	-	-	-
S-123	Centrifuge cake containing prothrombin	Solid	78.97	-	255.607	-	-	-
S-124	Waste pellet of prothrombin from splitter	Solid	63.18	-	204.485	-	-	-
S-125	Reduced prothrombin pellet from splitter	Solid	15.79	-	51.121	-	-	-
S-126	Tris resuspension buffer (20 mM Tris/HCl, pH 7.5, 0.15 M NaCl, 1 mM EGTA)	20.45	-	-	-	-	-	-
S-127	Resuspended prothrombin	20.45	15.79	20.449	51.121	2.500	-	-
S-128	Activated thrombin from snake venom column	20.45	15.79	-	-	-	25.3	1.24
S-129	Waste from heparin column- first pass	20.45	-	-	-	-	0.25	0.012
S-130	Wash buffer to wash heparin column	20.45	-	-	-	-	-	-
S-131	Waste from column wash	20.45	-	-	-	-	0.25	0.012
S-132	Elution buffer for heparin column	20.45	-	-	-	-	-	-
S-133	Eluted thrombin product	20.45	-	-	-	-	24.8	1.21
S-134	Water (diluant)	143.14	-	-	-	-	-	-
S-135	Filtrate (removed salts)	143.14	-	-	-	-	-	-

S-136	Retentate (thrombin without salts)	20.45	-	-	-	-	24.6	1.2
S-137	Endotoxin-free thrombin	20.45	-	-	-	-	**22.1**	1.1
S-138	Elution buffer to elute endotoxins	20.45	-	-	-	-	-	-
S-139	Eluted endotoxin waste	20.45	-	-	-	-	2.44	0.12
S-140	Wash buffer to regenerate the column	20.45	-	-	-	-	-	-
S-141	Wash waste	20.45	-	-	-	-	-	-
S-142	Freeze Dried Thrombin Product	-	-	-	-	-	**21.7**	-

10.2. Individual Unit Operations- Material Balances

Centrifuge 1 (P-1)			
	Input	Output	
Stream	**S-101**	**S-102**	**S-103**
Total Volume (L)	520	225	295
Fibrinogen (kg)	1.25	0.06	1.19
Prothrombin (g)	40.9	2.1	38.8
Sodium Citrate (kg)	2.68	0.03	2.66
Water (kg)	268	3	265
Blood Cells (kg)	245	245	0

Barium Chloride Precipitation (P-2)				
	Input			Output
Stream	**S-103 (1 week)**	**S-104**	**S-105**	**S-106**
Total Volume (L)	2065	368	24.5	2458
Fibrinogen (kg)	7.90	0	0	7.90
Prothrombin (g)	258.4	0	0	258.4
Sodium Citrate (kg)	18.6	0	0	18.6
Barium Chloride (kg)	0	76.7	0	76.7
Benzamidine HCl (kg)	0	0	3.84	3.84
Water (kg)	1854	368	25	2247

Centrifuge 2 (P-3)			
	Input	Output	
Stream	**S-106**	**S-107**	**S-123**
Total Volume (L)	2458	2332	-
Fibrinogen (kg)	7.90	7.82	0.08
Prothrombin (g)	258.4	2.6	255.9
Sodium Citrate (kg)	18.6	17.7	0.9
Barium Chloride (kg)	76.7	3.8	72.8
Benzamidine HCl (kg)	3.84	0.19	3.65
Water (kg)	2247	2244	2

Ammonium Sulfate Precipitation (P-4)			
	Input		Output
Stream	**S-107**	**S-108**	**S-109**
Volume (L)	2332	688	3020
Fibrinogen (kg)	7.82	0	7.82
Prothrombin (g)	2.6	0	2.6
Sodium Citrate (kg)	17.7	0	17.7
Barium Chloride (kg)	3.8	0	3.8
Benzamidine HCl (kg)	3.65	0	3.65
Ammonia (g)	0	586	586
Ammonium Sulfate (kg)	0	364	364
Sodium Chloride (kg)	0	6.03	6.03
Water (kg)	2244	688	2933

Centrifuge 3 (P-6)			
	Input	Output	
Stream	**S-109**	**S-110**	**S-111**
Total Volume (L)	3020	2990	(pellet)
Fibrinogen (kg)	7.82	0.16	7.66
Prothrombin (g)	2.6	2.6	0
Sodium Citrate (kg)	17.7	16.8	0.9
Barium Chloride (kg)	3.8	3.6	0.2
Benzamidine HCl (kg)	3.65	3.47	0.18
Ammonia (g)	586	557	29
Ammonium Sulfate (kg)	364	346	18
Sodium Chloride (kg)	6.03	5.73	0.30
Water (kg)	2933	2930	3

Fibrinogen Resuspension (P-7)			
	Input		Output
Stream	**S-111**	**S-112**	**S-113**
Total Volume (L)	(pellet)	501	501
Fibrinogen (kg)	7.66	0	7.66
Prothrombin (g)	0	0	0
Sodium Citrate (kg)	0.9	1.1	2.0
Barium Chloride (kg)	0.2	0	0.2
Benzamidine HCl (kg)	0.18	0	0.18
Ammonia (g)	29	0	29
Ammonium Sulfate (kg)	18	0	18
Sodium Chloride (kg)	0.30	2.926	3.23
Citric Acid (g)	0	0.0048	0.0048
L-lysine (g)	0	73.2	73.2
Water (kg)	3	500	503

Diafiltration 1 (P-8)				
	Input		Output	
Stream	**S-113**	**S-114**	**S-115**	**S-116**
Total Volume (L)	501	3503	3754	250
Fibrinogen (kg)	7.66	0	0.23	7.43
Prothrombin (g)	0	0	0	0
Sodium Citrate (kg)	2.0	0	2.0	0
Barium Chloride (kg)	0.2	0	0.2	0
Benzamidine HCl (kg)	0.18	0	0.18	0
Ammonia (g)	29	0	29	0
Ammonium Sulfate (kg)	18	0	18	0
Sodium Chloride (kg)	3.23	0	3.23	0
Citric Acid (g)	0.0048	0	0.0048	0
L-lysine (g)	73.2	0	73.2	0
Water (kg)	503	3503	3754	252

Endotoxin Removal Column 1 (P-9)						
	Input			Output		
Stream	**S-116**	**S-118**	**S-120**	**S-117**	**S-119**	**S-121**
Total Volume (L)	250	250	250	250	250	250
Fibrinogen (kg)	7.43	0	0	6.69	0	0.74
Prothrombin (g)	0	0	0	0	0	0
Endotoxin (mg)	1	0	0	0	1	0
Water (kg)	250	250	250	250	250	250

Prothrombin Splitter (P-15)			
	Input	Output	
Stream	**S-123**	**S-124**	**S-125**
Total Volume (L)	(Pellet)	(Pellet)	(Pellet)
Fibrinogen (g)	79	63.2	15.8
Prothrombin (g)	255.6	204.5	51.1
Sodium Citrate (kg)	0.9	0.72	0.18
Barium Chloride (kg)	72.8	58.2	14.6
Benzamidine HCl (kg)	3.65	2.92	0.73
Water (kg)	2	1.6	0.4

Prothrombin Resuspension (P-5)			
	Input		Output
Stream	**S-125**	**S-126**	**S-127**
Total Volume (L)	(pellet)	20	20
Fibrinogen (g)	15.8	0	15.8
Prothrombin (g)	51.1	0	51.1
Sodium Citrate (kg)	0.18	0	0.18
Barium Chloride (kg)	14.6	0	14.6
Benzamidine HCl (kg)	0.73	0	0.73
Tris (g)	0	48.5	48.5
Sodium Chloride (g)	0	175	175
EGTA (g)	0	7.6	7.6
Water (kg)	0.4	20	20.4

Snake Venom Column (P-11)		
	Input	Output
Stream	**S-127**	**S-128**
Total Volume (L)	20	20.4
Fibrinogen (g)	15.8	0*
Prothrombin (g)	51.1	0.5
Thrombin (g)	0	25.3
Sodium Citrate (kg)	0.18	0.18
Barium Chloride (kg)	14.6	14.6
Benzamidine HCl (kg)	0.73	0.73
Tris (g)	48.5	48.5
Sodium Chloride (g)	175	175
EGTA (g)	7.6	7.6
Water (kg)	20.4	20.4

*Note: It was assumed that the residual fibrinogen would stick to the resin as the solution passed through the column. It will be washed off after the operation is done and wash buffer is run through the column. Also, prothrombin is cleaved to yield thrombin. Half the weight of prothrombin makes up the thrombin (25 g). The other half of the weight due to the cleaved groups is assumed to be washed through the column with the salts.

Heparin Column (P-12)						
	Input			Output		
Stream	**S-128**	**S-130**	**S-132**	**S-129**	**S-131**	**S-133**
Total Volume (L)	20.4	20	20	20	20	20
Fibrinogen (g)	0	0	0	0	0	0
Prothrombin (g)	0.5	0	0	0.5	0	0
Thrombin (g)	25.3	0	0	0.252945	0.252945	24.8
Sodium Citrate (kg)	0.18	0	0	0.18	0	0
Barium Chloride (kg)	14.6	0	0	14.6	0	0
Benzamidine HCl (kg)	0.73	0	0	0.73	0	0
Tris (g)	48.5	48.5	0	48.5	48.5	0
Sodium Chloride (g)	175	175	1753	175	175	1753
EGTA (g)	7.6	7.6	0	7.6	7.6	0
Water (kg)	20.4	20	20	20	20	20

Diafiltration 3 (P-13)				
	Input		Output	
Stream	**S-133**	**S-134**	**S-135**	**S-136**
Total Volume (L)	20	143	143	20
Fibrinogen (g)	0	0	0	0
Prothrombin (g)	0	0	0	0
Thrombin (g)	24.8	0	0.25	24.5
Sodium Citrate (kg)	0	0	0	0
Barium Chloride (kg)	0	0	0	0
Benzamidine HCl (kg)	0	0	0	0
Tris (g)	0	0	0	0
Sodium Chloride (g)	1753	0	1753	0
EGTA (g)	0	0	0	0
Water (kg)	20	143	143	20

Endotoxin Removal Column 2 (P-14)						
	Input			Output		
Stream	**S-136**	**S-138**	**S-140**	**S-137**	**S-139**	**S-141**
Total Volume (L)	20	20	20	20	20	20
Thrombin (g)	24.5	0	0	22.1	2.4	0
Endotoxin (mg)	1	0	0	0	1	0
Water (g)	20	20	20	20	20	20

11. Process Description

11.1. Block Flow Diagram and Process Flow Diagram

Figure 11.1.1 depicts a general block flow diagram for the process. The process is divided and color coded according to the protein that is being purified. The block flow diagram encompasses blood collection to packaging and sterilization of the bandages. Figure 11.1.2 is a more detailed process flow diagram, made in Visio. This diagram consists of every piece of equipment needed for this process.

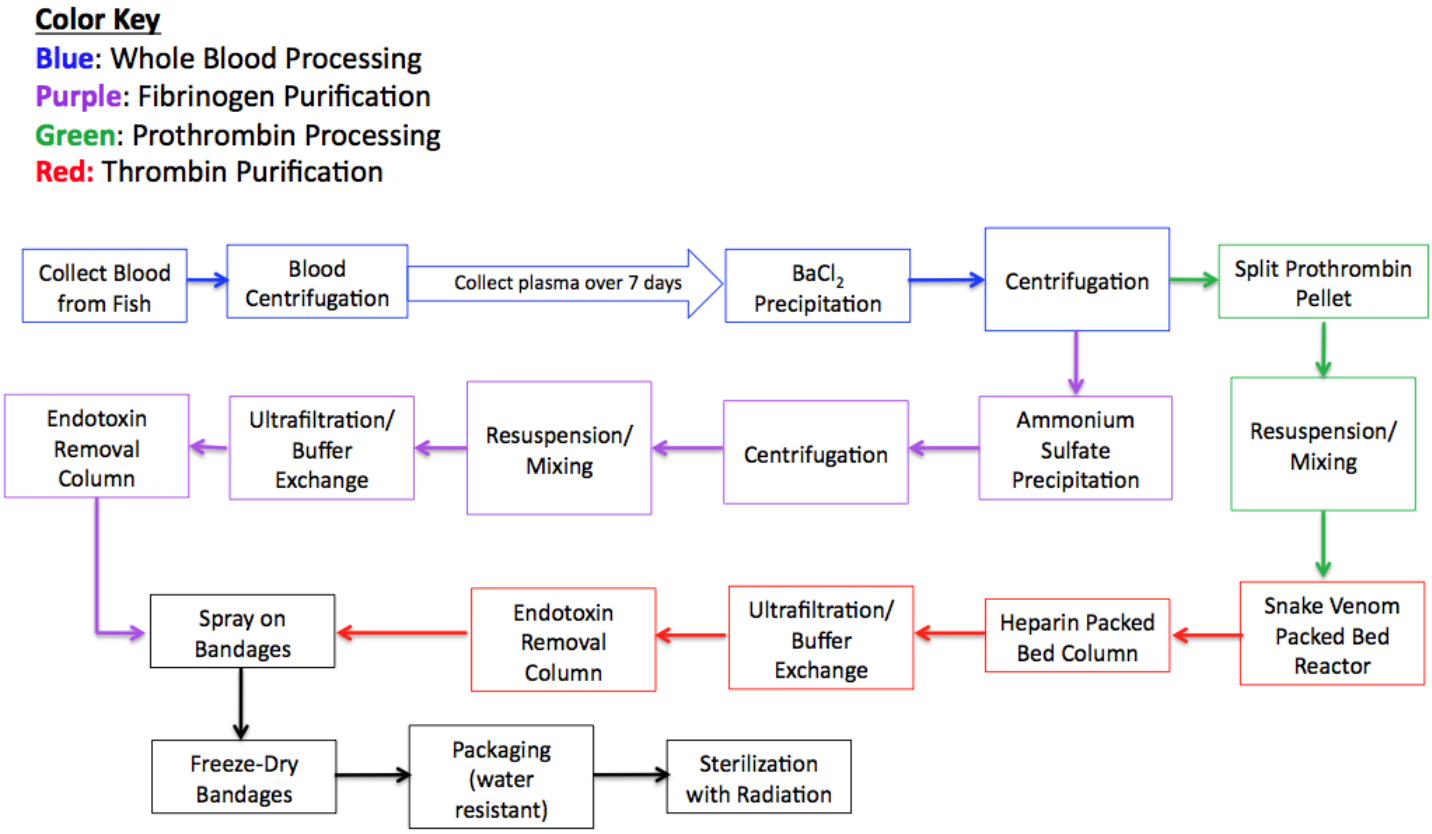


Figure 11.1.1 Block flow diagram of major process unit operations

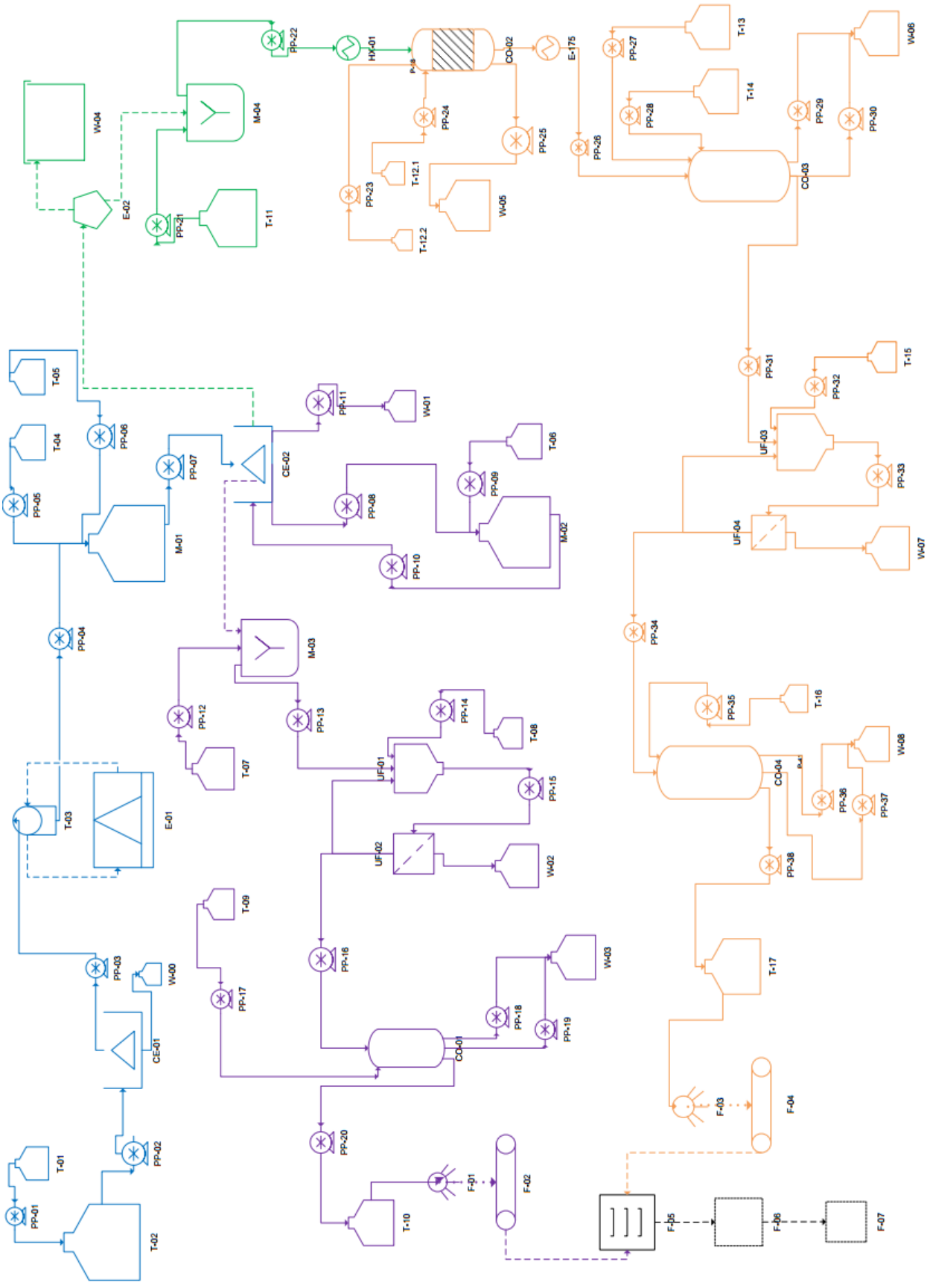


Figure 11.2 Process Flow Diagram made in Visio

11.2. Process Overview

This process aims to produce 300,000 bandages per year, assuming 330 days of operation per year. Each bandage will be 4 in. by 4 in. and will contain 10 mg/cm^2 of fibrinogen and 90 U/cm^2 of thrombin. Therefore, 310 kg of fibrinogen and 10.0 kg of thrombin must be purified per year. Fish will be bled every day of the week. The citrated blood will be centrifuged on the same day and the blood plasma will be frozen at -80°C until needed. Plasma will be pooled for 7 days to run through the remainder of the process. Note that all unit operations will occur at 4°C except for the snake venom column, which operates at 23°C.

The pooled plasma is then thawed overnight and a barium chloride precipitation and centrifugation is carried out. The pellet and supernatant are separated automatically by the centrifuge. The supernatant will contain the fibrinogen, and the solid cake from this centrifugation will contain the prothrombin.

Fibrinogen is then precipitated out of solution through an ammonium sulfate precipitation. This protein is further purified through centrifugation, resuspension, mixing, and ultrafiltration. At this point, the solution contains fibrinogen in a solution with a negligible salt concentration and no other proteins. The solution is run through an endotoxin removal column to ensure suitability for biological application. This purified solution is sprayed onto pieces of gauze and placed in a freeze dryer. The proteins are lyophilized onto the gauze.

At the same time, the prothrombin pellet is being processed to produce purified thrombin. The pellet contains much more prothrombin than is needed for the DiamondStat, so 80% of the prothrombin pellet from the barium chloride precipitation step is discarded.

The remaining prothrombin is purified through resuspension, mixing and ultrafiltration. At this point, the solution contains prothrombin, several other small proteins, and a negligible

concentration of salts. The solution is run through an immobilized snake venom-catalyzed reactor, which converts the prothrombin to thrombin. The solution, which contains thrombin and other proteins, is passed through a heparin packed bed column to separate the thrombin from the other proteins. Another ultrafiltration step occurs to remove the remaining salt. The thrombin solution is then sent through an endotoxin removal column. The solution is sprayed onto different pieces of gauze from the fibrinogen, and trays carrying these gauze pieces are placed into the aforementioned freeze dryer.

Both sets of gauze are sent to a semi-automated, sterile, and water-resistant bulk packaging system. There, the combined gauze pieces are packed into sterile, polyethylene bags to be sent to our strategic bandage manufacturing partner, who combines the gauze pieces, an adhesive backing, and a protective cover to form the DiamondStat bandage. Bandages are shipped, in bulk again, to be individually packaged in foil and sterilized through gamma irradiation.

11.3. Whole Blood Processing

11.3.1. Obtaining Blood from Salmon

Bleeding the salmon is the most demanding and labor intensive portion of this process. It requires a lot of regulation and innovation. All fish is provided from Marine Harvest, the global leader in the salmon farming industry (refer to Section 15.2 Strategic Partnership with Salmon Farming Company). Fish must be manually stunned by a blunt force to the head and bled from the caudal vein at the base of the tail using a syringe attached to a vacuum. Once bled, the fish are harvested for meat processing.

One fish provides about 50 mL of blood, containing 2.5 mg/mL of fibrinogen and 0.0825 mg/mL of prothrombin. To satisfy the yearly bandage production, 10,000 fish per day or 3.3 M

fish per year must be bled. This step requires 70 operators at a time, assuming that the bleeding process takes 5 minutes per fish and occurs over a 12 hour period every day. The bleeding process cannot be sped up, because the pressure of the vacuum must not collapse the veins within the fish.

To streamline the process we have hypothesized a large vacuum tank, 390 L in size, with 70 ports connected to syringes. As the fish are bled, anticoagulant is loaded into the syringe to prevent blood clotting. The anticoagulant of choice is 540 mM sodium citrate. There will be controls measuring calcium concentration to ensure enough citrate is added. Each day 520 L of citrated blood is collected. The blood will be transported in refrigerated trucks to the plant for centrifugation within 4 hours of blood collection. One possibility for the location of the processing plant is Chile, close to Marine Harvest's main Chilean fishery, to minimize transportation costs and time ("*Salmon Farming"*).

11.3.2. Centrifuging the Blood

Once the blood is transported to the plant, it is immediately centrifuged to separate the blood cells from the blood plasma. The plasma contains the proteins of interest. The Carr Centritech Viafuge Pilot Centrifuge will be used for this purpose. It is a continuous, solid-bowl centrifuge with low shear rates, so it is gentle on cells. *Michaud et. al*. suggest centrifuging the blood at 5,000 x g. This unit operation should take about 2 hours and 15 minutes to centrifuge the blood each day, operating at 240 L/hr. The centrifuge continuously scrapes and ejects solid over the 2 hour process. The solid blood cell pellet is collected in a waste container and disposed of in accordance to OSHA standards. The supernatant, which is the blood plasma, is continuously pumped into 200 L tanks that will be frozen over 7 days. Assuming a 1% loss of

protein to the blood pellet from the centrifugation, the plasma should contain 8.3 kg of fibrinogen and 270 g of prothrombin after 7 days.

11.3.3. $BaCl_2$ Precipitation

After one week there is a total of 2065 L of plasma, which will be thawed at room temperature overnight. It is fed into a mixing tank to be precipitated. 1 M $BaCl_2$ and 1 M benzamidine HCl are added simultaneously to the mixing tank at flow rates of 365 L/hr and 25 L/hr respectively for one hour. The plasma is pumped into the mixer at 2000 L/hr, and takes about 1 hour to charge the entire tank. After the tank is charged, the solutions are mixed for 30 minutes to ensure sufficient precipitation. The goal of this operation is to separate the prothrombin, which precipitates out of solution, from the fibrinogen.

11.3.4. Centrifugation of $BaCl_2$ Precipitate

The Carr Centritech Powerfuge-P18 is used to separate the solid prothrombin precipitate from the remaining fibrinogen solution. This is a continuous, solid-bowl centrifuge that can process a maximum of 1700 L/hr. For this process, *Michaud et. al*. recommend spinning at 2000 x g. Similar to the blood centrifuge, the Powerfuge-P18 continuously scrapes and ejects solids into a movable tank. During the centrifugation, the solids can be manually transported to a resuspension tank.

Because the $BaCl_2$ precipitation produces a solution with solids, a peristaltic pump is used to transport the solution between tanks. Peristaltic pumps have low shear rates and do not contain any internal valves or gears, decreasing the risk of clogging. Assuming a flow rate of 1500 L/hr, the centrifugation should take about 1.6 hours. After this unit operation, the process is split between two paths: fibrinogen purification and prothrombin purification and activation to thrombin.

11.4. Fibrinogen Purification Process

11.4.1. Ammonium Sulfate Precipitation

2330 L of liquid from the Powerfuge-P18 is continuously pumped at 1500 L/hr into a mixing tank. Assuming a 6% loss of protein from the precipitation and centrifugation, the solution should contain 7.8 kg of fibrinogen and residual amounts of prothrombin. 690 L of 100% saturated ammonium sulfate is added to the tank to precipitate the fibrinogen and remove any small impurities or unneeded blood proteins. The ammonium sulfate is bought in powder form and dissolved in solution at the plant. The amount of ammonium sulfate is recommended by *Manseth et. al*. The ammonium sulfate is pumped in at a flow rate of 1200 L/hr. Charging the ammonium sulfate should require a little over 30 minutes and will begin during the final 30 minutes of the previous centrifugation. The solution is mixed gently for 1 hour to ensure full precipitation.

11.4.2. Centrifugation of Ammonium Sulfate Precipitate

The same centrifuge as in Section 11.3.4., the Powerfuge-P18, is used to separate the fibrinogen solid from any other blood proteins and impurities. Once again, a peristaltic pump is used to transport the slurry between tanks. Assuming that the entire 3000 L volume is centrifuged at 1500 L/h, this operation should take about 2 hours. It is recommended that the centrifuge be operated at 12,000 x g. The fibrinogen solid is continuously scraped and ejected from the centrifuge into a transportable tank. Assuming that 1% of the protein is lost in this process, there is expected to be 6.8 kg of solid fibrinogen. The supernatant, which is about 3000 L, is transported to a waste tank.

11.4.3. Resuspension of Fibrinogen Solid

The solid fibrinogen is manually transported to a resuspension tank as it is continuously ejected from the centrifuge. It is resuspended in a 10 mM citrate-citric acid buffer, containing 0.1M NaCl and 1 mM L-lysine at a pH of 7.3 according to *Manseth et. al*. The volume of buffer needed for the resuspension was determined from the desired concentration of fibrinogen. It was found that fibrinogen concentrations above 30 mg/mL would be too saturated or remain in solution (Weisel, John). Therefore, 500 L of buffer is added to the 7500 g of fibrinogen to result in a concentration of 15 mg/mL. This way, the fibrinogen can be concentrated further downstream if needed. The flow rate of the buffer into the resuspension tank is 1000 L/hr, for a total of 30 minutes to charge the tank. The buffer is added after all the fibrinogen solid has been transferred to the tank. The tank is mixed for 15 minutes after charging to ensure full resuspension of the fibrinogen.

11.4.4. Fibrinogen Ultrafiltration/Diafiltration

At this point in the process, fibrinogen is the major protein component due to the high specificity of the ammonium sulfate precipitation. The molecular weight cutoff (MWCO) of 100 kDa allows all the salts from the precipitation and resuspension steps, as well as any protein fragments not removed during the precipitation to pass through the membrane while the 340 kDa fibrinogen is retained by the membrane. The cassettes are prepped with a water for injection (WFI) flush before running the protein solution. The ultrafiltration unit is operated first in diafiltration mode to remove the contaminants and then in concentration mode. These operation modes are typically run in the reverse order, but at 15 g/L, the fibrinogen concentration is high enough to cause concern about excessive membrane fouling, so concentrating is the very last step.

In diafiltration mode, 500 L of protein solution is charged into the feed tank with an equal volume of WFI. The pump circulates this solution through the cassettes. This process is repeated so that a total of 7 diafiltration volumes of WFI is added to the tank at the same rate that the filtrate is withdrawn, removing 99.9% of the contaminants, over the course of about 4 hours. The diafiltration unit is operated at a differential pressure of 0.4 bar and a flow rate of 15 L/min. In the concentration mode the protein solution is circulated through without adding any additional WFI for about 17 minutes. The unit is cleaned between batches with standard CIP procedure as explained in Appendix C.

11.4.5. Fibrinogen Endotoxin Removal

After ultrafiltration, the fibrinogen solution only contains about 6.7 kg of fibrinogen with very little salt. The last step is to remove any possible endotoxins. This is a common procedure in many pharmaceutical processes. The column purchased will be 140 L, but the packed bed containing Detoxi-Gel endotoxin removal resin will be 50 L. The fibrinogen solution is run through the column at 1250 L/hr, taking only 12 minutes to process the entire solution. After the fibrinogen solution is run through, wash and elution buffers are run through the column to elute any endotoxin off the column and to regenerate the resin for the next batch. The wash buffer and elution buffer are the same and contain 1% sodium deoxycholate. The column is washed with 250 L of wash buffer twice at 30 min for each wash.

11.5. Prothrombin Processing

11.5.1. Splitting Prothrombin Pellet

After the barium chloride precipitation and centrifugation, there should be a prothrombin pellet of about 256 g. This is much more prothrombin than needed for the bandages. Prothrombin is not usually sold by itself. It would first have to be converted to

thrombin if the decision were to be made to sell the extra protein for added revenue. Nonetheless, this would require equipment downstream in the process to be about ten times larger than needed. Instead, 80% of the prothrombin solid obtained from the centrifugation is thrown out. The resulting pellet is about 51 grams and requires much smaller volume equipment and buffers. The unneeded pellet is disposed of according to OSHA standards.

11.5.2. Resuspension of Prothrombin Pellet

The prothrombin solid that is not sent to waste is manually sent to a resuspension tank. The prothrombin is resuspended in tris buffer, containing 20 mM Tris HCl, 1 mM EGTA, and 0.1 M NaCl at pH 7.5 (Michaud, et al). As with the fibrinogen, the amount of buffer needed was determined by the desired concentration of prothrombin. Prothrombin is rarely concentrated beyond 3 mg/mL(Weisel, John); therefore, 20 L of tris buffer is added to give a final concentration of 2.5 mg/mL. The buffer is charged at a flow rate of 2 L/min, for a total of 10 minutes. Once charged, the solution will be mixed for 15 minutes to ensure full resuspension of the protein.

11.5.3. Prothrombin Solution Heating Heat Exchanger

Following resuspension, the 4℃ prothrombin solution must be heated to 23°C to optimize the kinetics in the snake venom column. The solution is run through a countercurrent double-pipe heat exchanger. Prothrombin solution flows through the inner pipe while hot water (with an inlet temperature of 93°C) flows through the annular area between the inner and outer pipes. The pressure drops for the prothrombin solution and the hot water are 0.73 bar (10.6 psi) and 0.29 bar (4.25 psi), respectively. This heat exchanger brings the prothrombin solution to its optimal reaction temperature in 4 minutes.

11.6. Thrombin Purification

11.6.1. Snake Venom Packed Bed Reactor

Prothrombin can be converted to thrombin by the Factor XaVa complex in the blood. However, it has been found that the snake venom from *Oxyuranus scutalletus*, more commonly known as a coastal taipan snake, can also cleave prothrombin into thrombin. The thrombin is half the weight of prothrombin, and the cleavage byproduct is left for disposal. Because the snake venom is relatively expensive, the prothrombin solution is run through a column containing resin with immobilized snake venom that can be reused up to 10 times. Calculations to determine the size of the column are found in Appendix A.1. The snake venom is covalently immobilized onto the outside of beads, so no internal diffusion limitations were considered. Additionally, it was assumed that there were no external mass transfer limitations within the bed. Under these conditions, it was found that the packed bed would have to be about 400 mL. As noted previously, residual fibrinogen in the prothrombin mixture may deposit onto the beads and sterically hinder the enzyme. To account for this and for possible mass transfer limitations, the packed bed size is increased to 1.6 L. The solution is continuously run through the column at 40 L/min for 30 minutes. The column is washed after operation with phosphate buffered saline for one hour before the next batch.

11.6.2. Thrombin Solution Cooling Heat Exchanger (HX-02)

Before the thrombin solution reaches the heparin column, it must be cooled from its reaction temperature of 23℃ to the processing temperature of 4℃. This will be accomplished with a double-pipe heat exchanger with countercurrent flow. The thrombin solution will flow through the inner pipe, experiencing a pressure drop of 0.58 bar (8.43 psi). The thrombin will be cooled by 102.25 L per batch of chilled brine (inlet temperature of 0℃), which flows through the

annular region between the inner and outer pipes and has a pressure drop of 4.76 psi. This cooling process takes 3.5 minutes.

11.6.3. Heparin Packed Bed Column

Heparin immobilized resin can bind to thrombin by electrostatic interactions. A packed bed heparin column is used to bind thrombin and separate it from any unreacted prothrombin, residual fibrinogen, or other blood proteins. Heparin columns are a common type of ion exchange chromatography, and the column and resin are purchased from GE Life Sciences. The size of the column is about 30 L to bind about 25 g of thrombin. The thrombin solution is run through the column at 170 L/hr and should take about 10 minutes. It will be circulated through the column 3 times for a total of 30 minutes. The resin must be replaced every 10 batches. After running through, the column is washed with tris buffer to remove any unwanted proteins from the column. The thrombin is then eluted off the column with a concentrated salt solution (2 M NaCl). This will take an additional 30 minutes. The column is washed and regenerated before the next batch with tris buffer for an hour.

11.6.4. Thrombin Ultrafiltration/Diafiltration

Following elution from the heparin column thrombin should be the only protein in the solution along with the salts from the elution buffer. A membrane with a MWCO of 10 kDa allows the salts to pass through while retaining the thrombin. WFI is circulated first to prepare the cassettes. This unit is only used in the diafiltration mode because the concentration of thrombin is already near saturation. The feed tank will be charged with 20.5 L of thrombin solution and an equal volume of WFI before being circulated through the cassettes by a pump. Seven diafiltration volumes total will replace the filtrate volume that leaves. This ensures that 99.9% of the salts from the elution buffers leave in the filtrate. The unit is operated at 1.4 bar

with a flow rate of 4 L/min. This process takes 35 minutes and is followed by standard CIP procedure as detailed in Appendix C.

11.6.5. Thrombin Endotoxin Removal

The column to remove any endotoxins from the thrombin solution is only 4 L. The solution will flow through the column at 82 L/min, and should only take 15 minutes to process the entire volume. Elution and wash buffers are run through the column for another hour to regenerate the column for the next batch.

11.7. Finishing Steps

11.7.1. Conveyor Belt and Sprayer Systems

Because the fibrinogen and thrombin cannot come into contact in the presence of water, two separate but identical conveyor belt-sprayer systems are needed. Each system consists of a conveyor belt, trays with gauze, spray nozzles, spray nozzle manifold and control system. Fibrinogen and thrombin solutions are sprayed onto the appropriate trays with gauze on them moving down a conveyor belt.

The final solution of fibrinogen is 250 L with 6.6 kg of fibrinogen. The thrombin solution is only 20 L and contains 22 g of thrombin. The spraying of the fibrinogen and thrombin should begin at the same time, so that the trays are ready to be loaded into the freeze dryer at the same time. This will be immediately after the purified thrombin solution holding tank has been filled following endotoxin removal. The fibrinogen solution holding tank will already be filled at this point, as its purification process is quicker.

Spraying should not begin before this step, in case there is a delay in one of the steps upstream. Storing the protein solutions in holding tanks rather than as solutions on gauze is more sterile, better for product stability and logistically easier. Because the trays cannot go into the

freeze dryer unless there is a balanced number of fibrinogen and thrombin trays, it is important to wait until balanced production can be guaranteed.

11.7.1.1. Conveyor Belt and Trays

Gauze pieces (provided by our strategic bandage manufacturing partner, such as Johnson & Johnson) are placed on stainless steel (316L) rectangular trays using a robotic system. Each tray holds 154 pieces of gauze. Two identical conveyor belts carry trays to be sprayed with their respective protein solution. Two operators per belt then manually place these bandage-holding trays onto the conveyor belts.

The gauze is sprayed with protein solution as the conveyor belt passes them underneath the spray nozzles. The fibrinogen and thrombin solutions are sprayed onto different pieces of gauze, which are later combined into the finished bandage product. In order to produce 6,363 bandages per batch (for a total of 300,000 bandages per year), 84 total trays are needed. Forty-two of them hold gauze sprayed with 39.3 mL of fibrinogen solution, and forty-two hold gauze sprayed with 3.15 mL of thrombin solution.

The conveyor belt moves at a speed of 2.13 m/min, which gives a spraying time of 30 minutes for each protein solution. In addition to the operators at the front end of the belt, each belt requires two operators at back end to remove the sprayed trays from the conveyor belt and load them into the freeze dryer. This gives a total of 8 operators for the spraying step.

11.7.1.2. Sprayer Systems

The spraying systems for the fibrinogen and thrombin solutions are identical, except for their specified flow rate of solution to the nozzles. Each sprayer system uses 11 PulsaJet automatic spray nozzles evenly spaced along a 63600 Hydraulic Sanitary Jacketed PulsaJet

Manifold. An example sketch is seen in Figure 11.7.1. The fibrinogen system operates at a flow rate of 0.2 gpm per nozzle, and the thrombin operates at a flow rate of 0.016 gpm per nozzle.

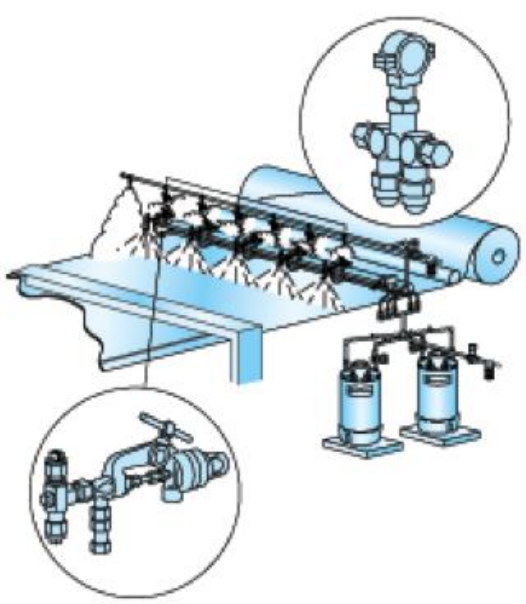


Figure 11.7.1. A row of spray nozzles is connected to spray manifold. For both protein spray systems, there will be 11 PulsaJet automatic spray nozzles will be connected to the manifold as the conveyor belt carry bandage trays passes underneath.

Each sprayer system is controlled by an AutoJet Model 2008+ Spray Control Panel to ensure precision sprays. The control system can be set such that solution is only sprayed onto bandages, and not onto the gaps in the trays between the bandages, thereby minimizing waste in this step, as shown in Figure 11.7.2. Because of the precision guaranteed by Spraying Systems Co., a 99% protein yield is assumed for the spraying step.

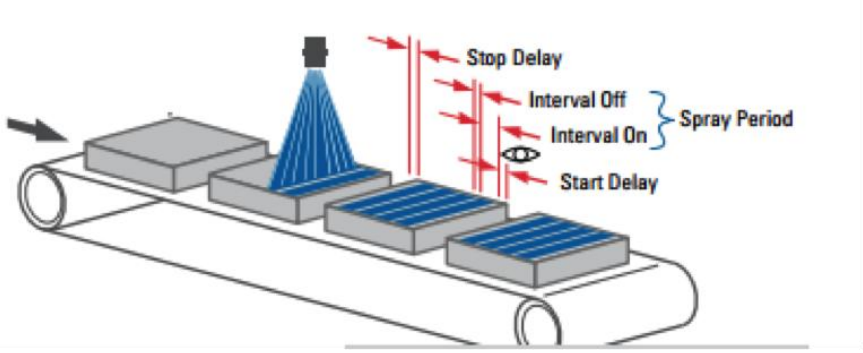


Figure 11.7.2. The spray control system turns the nozzle on and off as bandages pass beneath, signaling to the nozzle to spray only when bandages are underneath.

11.7.2. Lyophilization

After the trays pass underneath the spray system, they are manually moved from the conveyor belt to the freeze dryer. We will use three GEA SmartLyo SL-400 freeze dryers for this process.

The freeze dryer needs to remove much more water from the fibrinogen gauze trays than from the thrombin trays. To optimize the lyophilization process, it is important to ensure that an equal amount of water is being removed by each freeze dryer. To do this, equal amounts of thrombin trays and fibrinogen trays should be placed in each freeze dryer. Given the 270.36 kg of total water in the sprayed solutions, each freeze dryer will need to remove 90.1 kg of water from its contents. The entire freeze drying process will take 10 hours per freeze dryer and use 3,150 kWh of electricity per batch. We assume that 1% of protein content will be denatured during this process.

Once all trays are loaded, the freeze drying process can begin. At plant startup, pilot tests will need to be run to ensure that the freeze drying process has been optimized. Current conditions and water content numbers have been based on industry standards. The dryer temperature will drop from 4 °C to -20 °C at 1 bar, which freezes the water molecules in the protein solutions. The ice crystals are liberated from the proteins and gauze through sublimation. A vacuum brings the pressure of the chamber to 0.001 bar. The steam rises to the top of the chamber, where it is pulled into the condenser chamber. At the end of this sublimation step, there is still 3% residual water content. The vacuum is then partially released. The steam is condensed to water at -1°C and 1 bar. At the same time that the water is being condensed in the condenser chamber, a secondary drying is occurring in the main chamber to evaporate some of the residual water content. The main chamber is brought to 37°C, at a pressure of 0.006 bar until

the water content in the freeze dried protein contains, at maximum, 0.5% water content. While the secondary drying process would be faster at a higher temperature, it is not worth the risk of denaturing a significant amount of our product. 37 °C, average human body temperature, was chosen as a tolerable temperature upper limit for the proteins at this step, because they thrive and function at in the human body, which essentially eliminates the risk of denaturing during the secondary drying.

The end products of the lyophilization process are trays that hold proteins that are freeze dried onto gauze pieces. The freeze-dried proteins will not have more than 0.5% residual water content. Two operators manually move these freeze drying trays to the automatic packaging system.

11.7.3. Semi-Automated Bulk Packaging of Bandages

The gauze pieces containing fibrinogen are individually placed on top of the gauze pieces containing thrombin using the same robotic gauze-application system implemented to set the trays for spraying (see Section 11.7.1 Conveyor Belt and Sprayer Systems). Five operators are required to move the double-layered gauze pads from the stainless steel rectangular trays into 564 ounce sterile polyethylene bags. A total of 126 bandages fit into each bag as seven layers of three bandages by six bandages, with gauze layers separated by six millimeter sheets of polyethylene to prevent sticking. The bags must remain flat during the entire bagging and transportation process. Each batch requires 50.5 bags, and the total bagging process takes about two hours per batch. These bulk-packs are shipped to our strategic bandage manufacturing partner for application to the adhesive portion of the DiamondStat bandage to the thrombin-gauze side, as well as a peelable protective layer on top of the adhesive and fibrinogen-gauze

side to prevent early adhesion or contamination. DiamondStat bandages are then placed into new sterile polyethylene bags and sent to Steripack for individual packaging and sterilization.

11.7.4. Outsourcing of Individual Packaging and Sterilization of Finished Product

DiamondStat bandages are packaged individually in a peelable, foil wrapper by SteriPack. Specifically, the bandages are sealed within two layers of foil 1452, comprising 42 gauge PET, adhesive, 35 gauge foil, and a peelable sealant from outside to inside, to make an easily opened package. The bandages are then sent to Sterigenics, our sterilization partner, to be sterilized using gamma irradiation. Finally, the completed DiamondStat bandages are delivered to our strategic bandage manufacturing partner.

11.8. Gantt Chart

Figure 11.8.1 depicts the Gantt chart for the system for one batch. The Gantt chart also does not show that blood is centrifuged seven days before each batch begins. Effectively, the timeline of the chart begins on the seventh day, when all blood has been centrifuged for the week. Lastly, due to the limitations of SuperPro Designer, it is important to note that "centrifuge 2" and "centrifuge 3" are the same centrifuge and represent only 1 piece of equipment. As can be seen from the Gantt chart, freeze-drying is the bottleneck of the process. However, this is acceptable because our process is only run once a week, allowing for plenty of time to prepare equipment in between batches.

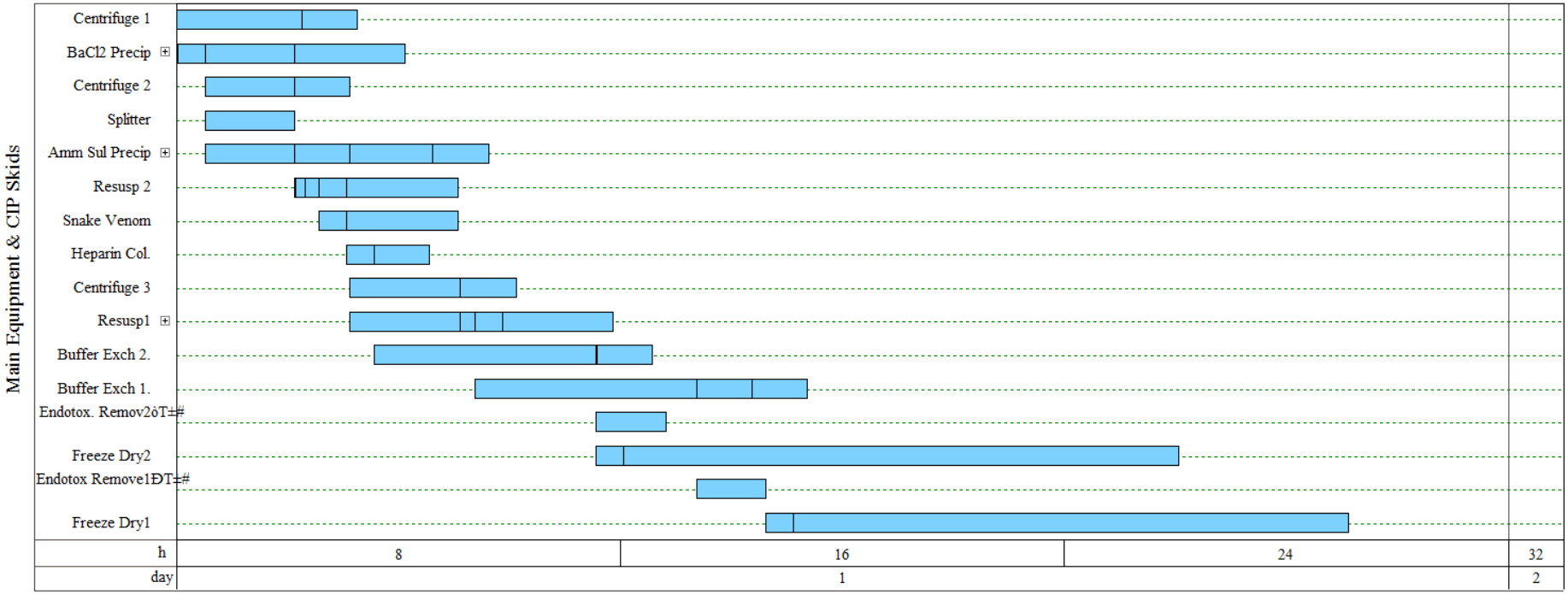


Figure 11.8.1. Gantt Chart for single batch starting after pooling of plasma

12. Energy Balance and Utility Requirements

The major utility for this process will be the refrigeration required to maintain most of the equipment at 4°C. In addition to refrigeration, utilities for heat exchangers as well as electricity costs to run the pumps, centrifuges, mixers, vacuum, and freeze-dryers must also be considered.

The area of the plant is estimated to be about 2300 square feet. Assuming a power requirement of 50 kWh per square foot per year for the refrigeration and freezer system, the electric usage for cooling is 241 MWh/yr. The combined electric usage for the heat exchangers, pumps, mixers, centrifuges, vacuum, and freeze dryers is 155 MWh/yr. The cost of electricity is $0.07/kWh, leading to a total yearly cost of $27,800.

Utilities, including steam for SIP and heat exchangers and WFI for CIP and in buffers will also affect overall plant expenses. Assuming that all tanks and centrifuges will undergo SIP after each operation, 3035 lb of low pressure steam will be needed for each batch. At $6 per 1000 lb of steam, the yearly cost becomes $860. WFI is needed for all cleaning in place procedures, as well as to make all buffers for precipitations and resuspensions throughout the process. It was calculated that about 6.5 million liters of water for injection will be needed per year to satisfy these requirements. This totals to about $979,000 per year.

13. Equipment List and Unit Descriptions

13.1. Equipment List

Equipment List Holding Tanks	Item Number	Manufacturer	Model	No. of Units	Total Bare Module Cost
Sodium Citrate Holding Tank	T-01	Sharpsville Container	Custom	1	$2,300
Blood Collection Vacuum Tank System	T-02	Sharpsville Container	Custom	2	$233,200
Plasma Storage Container	T-03	Sharpsville Container	Custom	14	$36,700
Barium Chloride Holding Tank	T-04	Sharpsville Container	Custom	1	$13,000
Benzamidine HCl Holding Tank HCl Stock	T-05	Sharpsville Container	Custom	1	$2,600
Ammonium Sulfate Holding Tank	T-06	Sharpsville Container	Custom	1	$19,000
Fibrinogen Resuspension Buffer Holding Tank	T-07	Sharpsville Container	Custom	1	$15,700
Fibrinogen Ultrafiltration Dilutant Holding Tank	T-08	Sharpsville Container	Custom	1	$50,400
Fibrinogen Endotoxin Removal Holding Tank (elution and wash buffer)	T-09	Sharpsville Container	Custom	1	$15,700
Purified Fibrinogen Solution	T-10	Sharpsville	Custom	1	$10,300

Holding Tank		Container			
Prothrombin Resuspension Buffer Holding Tank	T-11	Sharpsville Container	Custom	1	$2,300
Reactor Wash Buffer Holding Tank	T-12.1	Sharpsville Container	Custom	1	$2,200
Reactor Sodium Azide Solution Holding Tank	T-12.2	Sharpsville Container	Custom	1	$1,100
Heparin Wash Buffer Holding Tank	T-13	Sharpsville Container	Custom	1	$2,300
Heparin Elution Buffer Holding Tank	T-14	Sharpsville Container	Custom	1	$2,300
Thrombin Ultrafiltration Dilutant Holding Tank	T-15	Sharpsville Container	Custom	1	$7,400
Thrombin Endotoxin Removal Holding Tank (elution and wash buffer)	T-16	Sharpsville Container	Custom	1	$3,500
Purified Thrombin Solution Holding Tank	T-17	Sharpsville Container	Custom	1	$2,300
Waste Tanks					
	Item Number	**Manufacturer**	**Model**	**No. of Units**	**Total Bare Module Cost**
Blood Waste Tank	W-00	Sharpsville Container	Custom	1	$9,700
Centrifuge Waste Tank	W-01	Sharpsville Container	Custom	1	$45,800
Fibrinogen Ultrafiltration Waste Tank	W-02	Sharpsville Container	Custom	1	$52,500
Fibrinogen Endotoxin Waste Tank	W-03	Sharpsville Container	Custom	1	$15,700

Excess Prothrombin Pellet Waste Tank	W-04	Sharpsville Container	Custom	1	$4,400
Reactor Waste Tank	W-05	Sharpsville Container	Custom	1	$2,600
Heparin Waste Tank	W-06	Sharpsville Container	Custom	1	$3,500
Thrombin Ultrafiltration Waste Tank	W-07	Sharpsville Container	Custom	1	$7,400
Thrombin Endotoxin Waste Tank	W-08	Sharpsville Container	Custom	1	$3,500
Mixing Tanks					
	Item Number	**Manufacturer**	**Model**	**No. of Units**	**Total Bare Module Cost**
Barium Chloride Precipitation Tank	M-01	Sharpsville Container	Custom	1	$293,400
Ammonium Sulfate Precipitation Tank	M-02	Sharpsville Container	Custom	1	$316,100
Fibrinogen Resuspension Tank	M-03	Sharpsville Container	Custom	1	$154,500
Prothombin Resuspension Tank	M-04	Sharpsville Container	Custom	1	$75,600
Centrifuges					
	Item Number	**Manufacturer**	**Model**	**No. of Units**	**Total Bare Module Cost**
Blood Centrifuge	CE-01	Carr Centritech	Viafuge Pilot Centrifuge	1	$362,500
Solution Centrifuge	CE-02	Carr Centritech	Powerfuge P18	1	$374,900
Columns					
	Item	**Manufacturer**	**Model**	**No. of**	**Total Bare Module**

Number				Units	Cost
Fibrinogen Endotoxin Removal Column	CO-01	GE Life Sciences	AxiChrom 600/500 & AxiChrom Master	1	$499,200
Snake Venom Reactor	CO-02	GE Life Sciences	BPG 100/500	1	$22,500
Heparin Column	CO-03	GE Life Sciences	BPG 300/500	1	$83,000
Thrombin Endotoxin Removal Column	CO-04	GE Life Sciences	AxiChrom 140/300	1	$70,700
Finishing Equipment					
	Item Number	**Manufacturer**	**Model**	**No. of Units**	**Total Bare Module Cost**
Fibrinogen Sprayer System	F-01	Spraying Systems Co.	AutoJet 2008+ Modular Spray System	1	$45,000
Fibrinogen Conveyor Belt	F-02	Bastian Solutions	Custom	1	$84,600
Thrombin Sprayer System	F-03	Spraying Systems Co.	AutoJet 2008+ Modular Spray System	1	$72,100
Thrombin Conveyor Belt	F-04	Bastian Solutions	Custom	1	$84,600
Freeze Dryer	F-05	GEA	GEA-SMART LYO SL-400	3	$618,000
Automated Packaging	F-06	SteriPack	Custom	1	$1.45 per bandage
Gamma Irradiation Sterilization	F-07	SteriGenics	Custom	1	$30,000 (one-time fee), $1.00 per bandage
Trays for Spray/Conveyor System	--	Stainless Supply	Custom-sized 316L SS sheets	84	$17,100
Ultrafiltration					
	Item Number	**Manufacturer**	**Model**	**No. of Units**	**Total Bare Module Cost**
Fibrinogen Ultrafiltration Feed Tank	UF-01	Sharpsville Container	Custom	1	$54,600

Fibrinogen Ultrafiltration Cassettes	UF-02	EMD Millipore	P2B100C25-Pellicon 2 Maxi Ultrafiltration Module Biomax	60	$289,800
Thrombin Ultrafiltration Feed Tank	UF-03	Sharpsville Container	Custom	1	$8,000
Thrombin Ultrafiltration Cassettes	UF-04	EMD Millipore	P2B010A25-Pellicon 2 Maxi Ultrafiltration Module Biomax	3	$74,500
Fibrinogen Cassette Holders	--	EMD Millipore	Pellicon 2 Holder	6	$120,000
Thrombin Cassette Holders	--	EMD Millipore	Pellicon 2 Holder	1	$15,800
Miscellaneous					
	Item Number	**Manufacturer**	**Model**	**No. of Units**	**Total Bare Module Cost**
Freezer	E-01	Budzar Industries, Inc.	Low Temperature Cold Room	1	$151,900
Pellet Splitter	E-02	Measuretek	Shipping Scale, 12R979	1	$200
CIP System	--	GEA Niro	Custom	1	$1,085,000
Pumps					
	Item Number	**Manufacturer**	**Model**	**No. of Units**	**Total Bare Module Cost**
All Pumps	PP-1 – PP-38	Cole-Parmer	77111-60-Masterflex B/T Variable-Speed Wash-Down Pump, 12-321 RPM, 115V	38	$562,000
Heat Exchangers					
	Item Number	**Manufacturer**	**Model**	**No. of Units**	**Total Bare Module Cost**
Prothrombin Heating Heat Exchanger	HX-01	--	Double Pipe Heat Exchanger	1	$8,460
Thrombin Cooling Heat Exchanger	HX-02	--	Double Pipe Heat Exchanger	1	$11,160

13.2. Whole Blood Processing Equipment

13.2.1. Obtaining Blood from Salmon

Originally, fish were to be bled into vacuum-sealed 15 mL syringes, similar to human phlebotomy. However, the number of vacuum tubes needed to bleed 10,000 fish a day would be costly, and it would be difficult to centrifuge such a high volume of blood in individual tubes. Instead, a large vacuum tank will be created. Two vacuum tanks (T-02) will be purchased for the collection of 520 L of citrated blood per day.

Each 390 L tank will be made of 316 L stainless steel and manufactured by Sharpsville Container for $5,300. Each tank will have 70 syringe ports. One syringe will be attached to each port by a rubber tube (0.5 m long, 1 cm inner diameter). The sodium citrate will be fed from the holding tank (T-01) into the syringes. The sodium citrate holding tank is a 30 liter, 316L stainless steel tank purchased from Sharpsville Container for $1,100. A control system will monitor calcium levels in the tank to ensure enough sodium citrate is added to prevent blood coagulation.

A one-stage water sealed liquid-ring pump vacuum system will be attached to each tank. The vacuum system will lower the pressure inside the tank to 0.125 bar, which allows blood to be collected at an average flow rate of 43.3 L/h without collapsing the veins of the fish. This will use 34.2 kWh of electricity per tank per batch. The vacuum systems will cost $53,000 each. (For detailed calculations on the vacuum system, refer to Appendix A.2).

13.2.2. Centrifuging the Blood

The ViaFuge Pilot Centrifuge (CE-01) is a continuous, solid-bowl centrifuge that has low shear rates, so that it does not lyse any cells in the process of centrifugation. This Carr Centritech centrifuge can have flow rates of 0.1 to 4 L/min and can spin at 500-10,000 x g. It is made of 316L stainless steel, and has a bowl size of 1.3 L. When the solid in the bowl reaches a

certain weight, the centrifuge automatically scrapes and ejects the solid into a small tank. In this case, the solid is the blood cells that will be transferred to a waste tank (W-00) for special disposal. For this process, the centrifuge will be operated at 4 L/min and 5,000 x g. It will take approximately 2 hours to centrifuge the entire volume of blood each day. The centrifuge costs $179,000.

During centrifugation, the plasma supernatant is continuously pumped into the plasma storage containers (T-03). Each day, two 220 L tanks of 316L stainless steel are filled, for a total of 14 identical plasma storage containers needed per batch. These tanks will be purchased from Sharpsville Container for $1,300 each.

Once the plasma storage tank is filled, it is manually transferred to the freezer unit (E-01), the Low Temperature Freezer Room from Budzar Industries. The purchase cost for the freezer unit is $600,000. The freezer stores the plasma at -80 ℃ until 7 days' worth of plasma have accumulated. The plasma is then thawed for further processing. This low temperature cold room uses 50kWh/sq.ft.-yr, giving a total electric bill $9,092/yr.

13.2.3. $BaCl_2$ Precipitation

To precipitate the prothrombin out of solution, a mixing tank (M-01) is needed to hold and mix the blood plasma, barium chloride, and benzamidine hydrochloride. The tank will be custom made by Sharpsville Container. It will be 316L stainless steel with a total volume of 3700 L for a cost of about $66,000. The agitator will be purchased separately from Dynamix Inc. for $9,000. The mixer has a power of 5 hp per 1000 gal of solution. After the tank is charged with all reagents, the solution will be mixed for 15 minutes.

13.2.4. Centrifugation of $BaCl_2$ Precipitate

A second centrifuge from Carr Centritech (CE-02) will be purchased to separate the solid precipitate containing prothrombin from the supernatant. The specific model is the Powerfuge-P18, a 316L stainless steel continuous centrifuge. It can handle flow rates up to 1700 L/hr and spin at a force of up to 20,000 x g. For the barium chloride precipitate, the centrifuge will be operated at 1500 L/hr and 2000 x g for 1.6 hours. Similar to the ViaFuge Pilot centrifuge, this centrifugation continuously scrapes and removes solids when the bowl within the centrifuge reaches a certain weight. The maximum solids space is around 32 L. Power for the centrifuge is 30 hp. This centrifuge will cost $185,000.

13.3. Fibrinogen Purification Process Equipment

13.3.1. Ammonium Sulfate Precipitation

Similar to the barium chloride precipitation, the ammonium sulfate precipitation will take place in a large, 316L stainless steel tank custom made by Sharpsville Container. The tank (M-02) will be 4500 L and will cost around $70,600. Again, the agitator will be bought from Dynamix Inc. for $9,000 and will have a power of 5 hp per 1000 gal of solution. The tank will be mixed for 15 minutes.

13.3.2. Centrifugation of Ammonium Sulfate Precipitate

The same exact centrifuge (CE-02) that was used to centrifuge the barium chloride precipitation will be used to centrifuge the ammonium sulfate precipitate. It will be operated at 1500 L/hr and 12,000 x g for about 2 hours.

13.3.3. Resuspension of Fibrinogen Solid

The fibrinogen will be resuspended in a 750 liter, 316L stainless steel mixing tank (M-03) purchased from Sharpsville Container for $34,000. The agitator will have a power of 10 hp

per 1000 gal of solution and will be purchased from Dynamix Inc. for $5,500. The solution will be mixed for 15 minutes.

13.3.4. Fibrinogen Ultrafiltration

Sixty Pellicon 2 Maxi cassettes (UF-02) each with 2.5 m^2 membrane area will be purchased from EMD Millipore to remove salts from the fibrinogen solution. This quantity was chosen according the manufacturer's recommendation to use one cassette per 10 L of process liquid plus a 20% area safety factor. The Biomax membrane made of modified polyethersulfone was selected because of its high flux even at high protein concentrations and resistance to fouling because of hydrophilic modification. The C (coarse) screen type, which induces mixing to minimize concentration gradients, was selected because of the high concentration of fibrinogen. The MWCO of 100 kDa was chosen based on the rule of thumb that the MWCO should be one-third the molecular weight of the retained protein product, that is one-third of 340 kDa. This unit will be operated at a differential pressure of 0.4 bar and a flow rate of 15 L/min according to the manufacturer's recommendations. The purchase cost for sixty cassettes will be $624,600. Six Pellicon cassette holders with a capacity of ten cassettes will also be purchased from EMD Millipore for a total of $120,000. A 1,200-L feed tank (UF-01) for holding the recirculating solution will be purchased from Sharpsville Container for $27,000.

13.3.5. Fibrinogen Endotoxin Removal

The AxiChrom 500/600 is a 140 L stainless steel 316L column (CO-01) used to remove endotoxins made by GE Life Sciences for $75,000. The column will be packed with Detoxi-Gel Endotoxin Removing Gel from Thermo Scientific for a packed bed volume of 50 L. The resin beads are cross-linked, 6% agarose beads with a wet bead diameter of 45-165 μm. The resins are sold in 1 L units, and last for ten batches. At a bulk-discount price of $390 per liter, our annual

fibrinogen endotoxin removal resin cost will be $92,250. Because of the large size of the column, an automatic packing and maintenance accessory, the AxiChrom Master, is also necessary. The AxiChrom Master (also from GE Life Sciences) will be an additional $45,000.

13.4. Prothrombin Processing Equipment

13.4.1. Splitting Prothrombin Pellet

The barium chloride precipitation produces about 256 g of prothrombin. To remove 205 g of unneeded prothrombin, a "pellet splitter" (E-02) is needed. To complete the job a digital shipping scale (model 12R979) will be purchased from Measuretek for $153. An operator will measure out prothrombin ejected from the centrifuge and discard the undesired quantity.

13.4.2. Resuspension of Prothrombin Pellet

The prothrombin will be resuspended in a 90 liter, 316L stainless steel mixing tank (M-04) purchased from Sharpsville Container for $17,300. The agitator will have a power of 10 hp per 1000 gal of solution and will be purchased from Dynamix Inc. for $1700. The solution will be mixed for 15 minutes.

13.4.3. Prothrombin Solution Heating Heat Exchanger

A countercurrent double-pipe heat exchanger (HX-01) is used to bring the prothrombin solution from 4℃ to 23°C. The prothrombin solution flows through the inner pipe while hot water (with an inlet temperature of 93°C) flows through the annular area between the inner and outer pipes. The inner pipe is a Schedule- 40, 1-inch pipe and the outer pipe is a Schedule 40, 2-in pipe. Both pipes are constructed out of 316L stainless steel. The heat exchanger is 0.67 ft long. This heat exchanger will be purchased for $4,700 and will use 20.45 L of hot water per batch, for a total utility cost of $150.

13.5. Thrombin Purification Equipment

13.5.1. Snake Venom Packed Bed Reactor

The BPG 100/500 column (CO-02) will be purchased from GE Life Sciences to hold the snake venom immobilized resins for $5400. The column will have a maximum volume of 2 L with a diameter of 0.1 m and a height of 0.5 m. The resin is called AminoLink Plus and is purchased from Thermo Fischer Scientific. The bed will be packed to take up a volume of 1.6 L of the column, which will cost $13,100 and should be replaced every ten batches. Manufacturer specifications indicated that 1 mL of resin can bind 1 mg of snake venom. Therefore, 1.6 g of snake venom will be purchased from Accurate Chemical for $10,100. The snake venom will also have to be repurchased every 10 batches. Aldehyde groups on the resin react with primary amines on the venom to covalently link them together. This resin was chosen because amines are not involved in the active site of the resin which is a serine protease, so the reaction rate should not be significantly affected.

13.5.2. Thrombin Solution Cooling Heat Exchanger

Following the prothrombin to thrombin activation reaction in the snake venom column, the product stream will need to be cooled from 23 °C to 4 °C before subsequent processing steps, which must occur at 4 °C. A second countercurrent double-pipe heat exchanger (HX-02) will be used to lower the temperature of this product stream. It will be constructed of 316L stainless steel. The outer pipe will be a Schedule 40 4-in pipe and the inner pipe will be a Schedule 40 1.25-in pipe. The thrombin solution flows through the inner pipe and the chilled brine flows through the annular region between the pipes. It requires 4,820 L of chilled brine per year. The heat exchanger will be 3 ft long. It will cost $6,200 to buy.

13.5.3. Heparin Packed Bed Column

Similarly to the snake venom column, the heparin column will utilize the BPG 300/500 28.2-L column (CO-03) from GE Life Sciences for $20,000. 20.5 L of Heparin Sepharose 6 Fast Flow resin will also be purchased from GE Life Sciences for $157,000. The linear operating velocity is 2.5 m/hr. Batches are run through the column three times each, and the resin must be replaced after every 10 batches (or 30 total runs).

13.5.4. Thrombin Ultrafiltration/Diafiltration

Three Pellicon 2 Maxi Cassettes (UF-04) with 2.5 m^2 of membrane area will be purchased from EMD Millipore to process 20.5 L. This is based on the recommendation of the manufacturer to use one cassette per 10 L of process volume plus a 20% area safety factor. A Biomax membrane made of modified polyethersulfone was selected again because of the high flux and resistance to fouling. A type A (tight) screen is used with smaller MWCO's. The MWCO of 10 kDa was chosen based on one-third of the molecular weight of thrombin, 32 kDa. The unit will be operated at 1.4 bar with a flow rate of 4 L/min. Three cassettes will cost $32,130 and the appropriate holder will cost $15,840, all from EMD Millipore. A 245 L feed tank (T-15) for recirculating fluid will be purchased from Sharpsville Container for $4,000.

13.5.5. Thrombin Endotoxin Removal

The AxiChrom 140/300, a 4.6 L 316L stainless steel column (CO-04) from GE Life Sciences, will be purchased for $17,000 to remove endotoxins from the thrombin solution. The column will be packed to a volume of 4.1 L using the Detoxi-Gel Endotoxin Removing Gel. Like the Detoxi-Gel used in the fibrinogen endotoxin removal, the resin in the thrombin endotoxin removal column will be replaced after every ten uses. The resin will cost $7,500 annually. Because this column is much smaller than the one used for the fibrinogen endotoxin removal, it

does not require automated packing assistance. For this unit, the resin slurry is introduced to the column by hand and adjusted by the internal hydraulics of the column.

13.6. Finishing Steps Equipment

13.6.1. Conveyor Belt and Sprayer Systems

13.6.1.1. Trays

The trays are 121.7 cm by 152.2 cm, which allows them to fit into the freeze dryer. The trays are 11 bandages wide and 14 bandages long. Between each bandage there is 0.83 cm spacing horizontally and 0.66 cm spacing vertically, as shown in Figure 13.6.1.

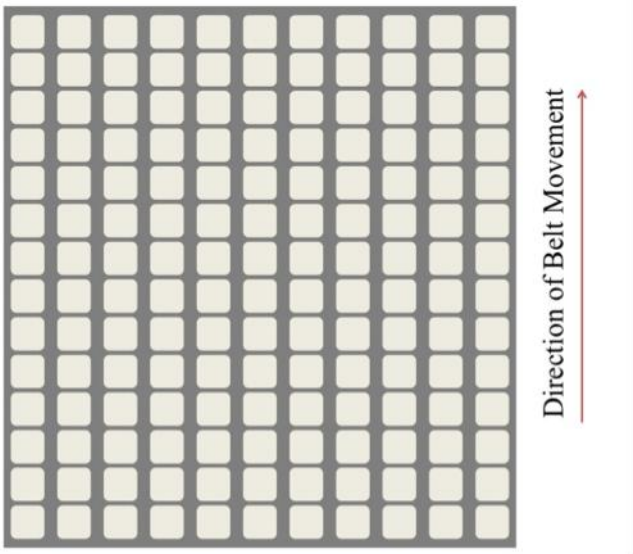


Figure 13.6.1. Bandage layout on each tray of conveyor belt.

The trays will be purchased from Stainless Supply Architectural Metal Solutions (Monroe, NC). Each tray will be 0.3 cm thick and weigh 20.19 lbs. An order of 84 sheets allows us to receive a 30% discount for high volume orders, giving a price per piece of $203.55, for a total purchase cost of $17,100. These trays should be sterilized by steam after each use.

13.6.1.2. Conveyor Belt

The conveyor belt systems (F-02, F-04) for both protein solutions are identical. The belts are 1.6 m wide and 6 m long, and move at speed of 2.13 m/min. We will purchase two custom conveyor belt systems from Bastian Solutions. Each system, which includes belt, motor, supports and other accessories, will be purchased for a price of $25,625.

13.6.1.3. Spray System

Both spray systems (F-01, F-03) will be purchased from Spraying Systems Co. (Wheaton, IL). Each sprayer system uses 11 PulsaJet automatic spray nozzles, a 63600 Hydraulic Sanitary Jacketed PulsaJet Manifold and an AutoJet Model 2008+ Spray Control Panel. All materials are constructed with 316L stainless steel. Each spray system, which includes the nozzle, nozzle manifold, control system, related accessories, and support structures, costs approximately $21,900.

The holding tanks for purified protein solutions (T-10, T-17) will be located immediately next to the spray system. The spray system will pump the solutions directly from the holding tanks to the spray nozzles.

The AutoJet Model 2008+ Spray Control Panel is essential for minimizing waste and for hedging against the risk of operational difficulties. Because of the system's spray precision, it will ensure that the exact amount of protein necessary for proper dosage is sprayed on each bandage. Because of the system's monitoring system, it is able to adjust the spray flow rate and speed of the belt, ensuring that protein is always being sprayed on the bandage and not on the trays. For plant startup, calibration runs will need to be performed with the control system to ensure that it is minimizing the amount of protein the sprayer system is spraying onto the trays.

13.6.2. Lyophilization

We will purchase three GEA SmartLyo SL-400 units (F-05, F-06, F-07). This freeze dryer comes standard with 12 trays. The SmartLyo is designed to freeze dry protein solutions held in vials. We do not need as much clearance between the trays, because our bandages lie flat on the trays. Thus, we will purchase a custom model that has 36 trays instead. Each shelf in the freeze dryer will hold one tray from the conveyor belt-spray system.

Each unit will cost $100,000 for a total purchase cost of $300,000. This price includes the freeze dryer, vacuum skid, drain, venting system, refrigeration skid, electrical cabinet, and maintenance area, which all come standard with the unit. Each unit occupies 6.5 m x 3.4 m of floor space.

Each unit uses 105 kW of electrical energy and runs for 10 hours per batch. This gives a total electricity use of 3150 kWh per batch (0.495 kWh per bandage). At a price of $0.70 per kWh, this amounts to $2,205 in electricity costs per batch.

13.6.3. Semi-Automated Bulk Packaging of Bandages

The same robotic system used in layering gauze on trays is implemented to place the fibrinogen gauze on top of the thrombin gauze. Then, five operators manually place the bandages in seven stacked layers of three bandages by six bandages with each layer separated by Husky Clear 6 mil Polyethylene Sheeting that was cut in 15” x 24” sheets by the operators. Each LabPas TWIRL’EM Sterile Sampling Bag (564 oz, 15” x 24”) will require seven polyethylene sheets, and each batch requires 50.5 bags. This results in needing less than one roll (10’ by 100’) of Husky Clear 6 mil Polyethylene Sheeting per batch and about 41.7 rolls per year, as well as about 2380 LabPas TWIRL’EM Sterile Sampling Bags (or about 9.52 packs of 250 bags) per year. The polyethylene sheeting costs $2,500 per year from a typical hardware store, and the

LabPas TWIRL'EM Sterile Sampling Bags cost $2,200 per year from Thomas Scientific. Transportation from our plant to our strategic bandage manufacturing partner is included in the partnership mentioned in Section 15.1.

13.6.4. Outsourced Individual Packaging and Sterilization of Finished Product

The adhesive and protective layers of the bandage are provided by our strategic bandage manufacturing partner as part of our partnership agreement (see Section 15.1 Strategic Partnership with Existing Bandage Company). Another set of LabPas TWIRL'EM Sterile Sampling Bags must be purchased for our strategic bandage manufacturing partner to use in transporting the bandages to SteriPack for packaging, costing $2,500 per year. Transportation from our strategic bandage manufacturing partner to the SteriPack packaging center is included in the cost of packaging each individual bandage between two layers of 1452 foil (48ga PET/Adh/35ga Foil/2mil Peelable Sealant), which is $0.37 per bandage ($111,000 per year). Sterilization via gamma irradiation, completed by Sterigenics, costs $1.00 per bandage ($300,000 per year), including transportation from SteriPack to Sterigenics and from Sterigenics to our strategic bandage manufacturing partner. There is also a one-time $8,000 sterilization validation fee at the beginning of production.

13.7. Pumps

All pumps in this process will be purchased from Cole-Palmer. The particular type of pump used is a peristaltic pump, which has low shear forces for gentle handling of blood cells and to avoid denaturation of proteins. There are also no internal gears or valves, so clogging of the pump will not be a problem with some of the more viscous protein solutions. The particular model is the Masterflex B/T Variable-Speed Pump. It utilizes Masterflex B/T 91 tubing, which comes in different types of materials and have ¾ in. inside diameter. It can have a maximum

flow rate of up to 42 L/min, which is larger than any of the flow rates in this process. It has a power of 747.5 W. The purchase cost of each pump is $4,940. A total of 38 pumps will be purchased for $188,000.

13.8. Holding Tanks

All holding tanks purchased for this process will be purchased from Sharpsville Container, which specializes in customized tank construction. The holding tanks hold buffers and chemical reagents used for each of the processes, as well as the waste products of each step. All holding and waste tanks will be made of 316L stainless steel. For more information on cost of holding tanks, consult Section 14. Specification Sheets.

13.9. CIP/SIP Equipment

A Cleaning-In-Place/ Sterilization-In-Place System will be purchased from GEA Process Engineering, Inc. to streamline the upkeep of the process equipment. This system's matrix of piping allows distribution of steam and CIP buffers at velocities of up to 3 m/s. This system will be purchased for $250,000.

14. Specification Sheets

14.1. Holding Tanks

Sodium Citrate Holding Tank (T-01)

Description and Function	Holds the sodium citrate solution that is added to the blood to prevent coagulation	
Vendor	Sharpsville Container	
PFD Reference	T-01	
Operation	Batch	
Materials Handled		**Input (per day)**
	Sodium Citrate (kg)	3
	Water (kg)	20
	Total Volume (L)	20
Characteristics	Material:	Stainless Steel 316L
	Finish:	Electropolished
	Volume:	30 L
	Diameter:	0.95 ft
	Height:	1.5 ft
Operating Conditions	Temperature:	4°C
	Pressure:	1 atm
Purchase Cost:	$1,150	

Ammonium Sulfate Holding Tank (T-06)

Description and Function	Holds Ammonium Sulfate buffer for the Ammonium Sulfate Precipitation	
Vendor	Sharpsville Container	
PFD Reference	T-06	
Operation	Batch	
Materials Handled		**Input (per batch)**
	Ammonium Sulfate (kg)	364
	Ammonia (g)	586
	Sodium Chloride (g)	6034
	Water (kg)	688
Characteristics	Material:	Stainless Steel 316L
	Finish:	Electropolished
	Volume:	1030 L
	Diameter:	4.5 ft
	Height:	3.2 ft
	Sterilization:	CIP
Operating Conditions:	Temperature:	4°C
	Pressure:	1 atm
Purchase Cost	$9,500	

Barium Chloride Holding Tank (T-04)

Description and Function	Stores barium chloride for the barium chloride/plasma precipitation	
Vendor	Sharpsville Container	
PFD Reference	T-04	
Operation	Batch	
Materials Handled		**Input (per batch)**
	BaCl2 (kg)	76.7
	Water (kg)	368
Characteristics	Material:	Stainless Steel 316L
	Finish:	Electropolished
	Volume:	550 L
	Diameter:	3.5 ft
	Height:	2.7 ft
	Sterilization:	CIP
Operating Conditions	Temperature:	4°C
	Pressure:	1 atm
Purchase Cost	$6,500	

Benzamidine HCl Holding Tank (T-05)

Description and Function	Stores benzamidine HCl for the barium chloride/plasma precipitation	
Vendor	Sharpsville Container	
PFD Reference	T-05	
Operation	Batch	
Materials Handled		**Input (per batch)**
	Benzamidine HCl (kg)	3.84
	Water (kg)	24.5
Characteristics	Material:	Stainless Steel 316L
	Finish:	Electropolished
	Volume:	37 L
	Diameter:	1 ft
	Height:	1.5 ft
	Sterilization:	CIP
Operating Conditions:	Temperature:	4°C
	Pressure:	1 atm
Purchase Cost	$1,300	

Blood Collection Vacuum Tank (T-02)

Description and Function	Vacuum tank attached to 70 syringe tubes to bleed the fish. Sodium Citrate can also be charged into the tank simultaneously with the blood to prevent coagulation	
Vendor	Sharpsville Container	
PFD Reference	T-02	
Operation	Batch	
Materials Handled		**Input (per day)**
	Blood (L)	500
	20 mM Sodium Citrate (L)	20
Characteristics	Material:	Stainless Steel 316:
	Finish:	Electropolished
	Volume:	390 L
	Diameter:	2.2 ft
	Height:	3.5 ft
Operating Conditions	Temperature:	4°C
	Pressure:	1 atm
Purchase Cost	$5,300 per tank $53,000 per vacuum system $116,600 total	(2 needed)

Fibrinogen Endotoxin Elution/Wash Buffer Holding Tank (T-09)

Description and Function	Stores elution buffer and wash buffer for Fibrinogen Endotoxin Column	
Vendor	Sharpsville Container	
PFD Reference	T-09	
Operation	Batch	
Materials Handled		**Input (per batch)**
	Elution Buffer	250 L
	Wash Buffer	250 L
Characteristics	Material:	Stainless Steel 316L
	Finish:	Electropolished
	Volume:	750 L
	Diameter:	2.9 ft
	Height:	4 ft
	Sterilization:	CIP
Operating Conditions:	Temperature:	4°C
	Pressure:	1 atm
Purchase Cost	$7,800	

Citrate-Citric Acid Buffer Holding Tank (T-07)

Description and Function	Holds the buffer for the is used to resuspend fibrinogen after the ammonium sulfate precipitation and centrifugation	
Vendor	Sharpsville Container	
PFD Reference	T-07	
Operation	Batch	
Material Handled		**Input (per Batch)**
	Fibrinogen (g)	7662
	Citrate (kg)	1.1
	Citric Acid (g)	0.005
	Sodium Chloride (kg)	2.9
	L-lysine (g)	73
	Water (kg)	500
Characteristics:	Material	Stainless Steel
	Finish	Electropolished
	Volume	750 L
	Diameter	2.9 ft
	Height	4 ft
	Sanitation	CIP/SIP
Operating Conditions	Temp	4°C
	Pressure	1 atm
Purchase Cost	$7,800	

Heparin Elution/Wash Buffer Holding Tank (T-13/T-14)

Description and Function	Stores wash/regeneration buffer for fibrinogen endotoxin column	
Vendor	Sharpsville Container	
PFD Reference	T-13 and T-14	
Operation	Batch	
Materials Handled		**Input (per batch)**
	Elution/Wash Buffer	20.5 L
Characteristics	Material:	Stainless Steel 316L
	Finish:	Electropolished
	Volume:	31 L
	Diameter:	0.95 ft
	Height:	1.5 ft
	Sterilization:	CIP
Operating Conditions:	Temperature:	4°C
	Pressure:	1 atm
Purchase Cost	$1,150 each	
	$2,300 Total	

Plasma Storage Tanks (T-03)

Description and Function	Stores blood plasma to be frozen for 7 days before being processed and proteins extracted. After 7 days, there will be a total of 2065 liters of plasma. This will be split into 14 containers to aid in the thawing process.	
Vendor	Sharpsville Container	
PFD Reference	T-03	
Operation	Batch	
Materials Handled		**Input (14 per batch)**
	Blood Plasma	147.5 L
	Fibrinogen	593.75 g
	Prothrombin	19.43 g
Characteristics	Material:	Stainless Steel 316-L
	Finish:	Electro-polished
	Volume:	220 L
	Height:	2.5 ft
	Diameter:	2 ft
	Sterilization:	SIP/CIP
Operating Conditions	Temp:	-80°C
	Pressure:	1.0 atm
Purchase Costs	$3,750 each	14 containers needed
	$52,500 total	

Prothrombin Resuspension Buffer Holding Tank (T-11)

Description and Function	Holds Tris resuspension buffer for prothrombin	
Vendor	Sharpsville Container	
PFD Reference	T-11	
Operation	Batch	
Materials Handled		**Input (per batch)**
	Tris HCl (g)	49.5
	Sodium Chloride (g)	174
	EGTA (g)	7.6
	Water (kg)	20.4
Characteristics	Material	Stainless Steel
	Finish:	Electropolished
	Volume:	31 L
	Diameter:	0.95 ft
	Height:	1.5 ft
	Sterilization:	SIP/CIP
Operating Conditions	Temperature	4°C
	Pressure	1 atm
Purchase Cost	$1,150	

Purified Fibrinogen Holding Tank (T-10)

Description and Function	Stores the final purified solution of fibrinogen	
Vendor	Sharpsville Container	
PFD Reference	T-10	
Operation	Batch	
Materials Handled		**Input (per batch)**
	Fibrinogen (g)	6694
	Water (kg)	250
	Volume (L)	250
Characteristics	Material:	Stainless Steel 316L
	Finish:	Electropolished
	Volume:	375 L
	Diameter:	2.3 ft
	Height:	3.3 ft
	Sterilization:	CIP
Operating Conditions:	Temperature:	4°C
	Pressure:	1 atm
Purchase Cost	$5,200	

Purified Thrombin Holding Tank (T-17)

Description and Function	Stores final purified thrombin solution before being sprayed on bandages	
Vendor	Sharpsville Container	
PFD Reference	T-17	
Operation	Batch	
Materials Handled		**Input (per batch)**
	Thrombin (g)	22
	Water (kg)	20
	Volume (L)	20
Characteristics	Material:	Stainless Steel 316L
	Finish:	Electropolished
	Volume:	31 L
	Diameter:	0.95 ft
	Height:	1.5 ft
	Sterilization:	CIP
Operating Conditions:	Temperature:	4°C
	Pressure:	1 atm
Purchase Cost	$1,500	

Thrombin Endotoxin Elution/Wash Buffer Holding Tanks (T-16)

Description and Function	Stores elution/wash buffer for thrombin endotoxin removal column	
Vendor	Sharpsville Container	
PFD Reference	T-16	
Operation	Batch	
Materials Handled		**Input (per batch)**
	Elution/Wash Buffer (L)	40.9
Characteristics	Material:	Stainless Steel 316L
	Finish:	Electropolished
	Volume:	61 L
	Diameter:	1.26 ft
	Height:	1.75 ft
	Sterilization:	CIP
Operating Conditions:	Temperature:	4°C
	Pressure:	1 atm
Purchase Cost	$1,740	

Reactor Wash Buffer Holding Tank (T-12.1)

Description and Function	Holds the wash buffer to wash the snake venom packed bed reactor after operating.	
Vendor	Sharpsville Container	
PFD Reference	T-12.1	
Operation	Batch	
Materials Handled		**Input (per batch)**
	Wash buffer (L)	17.4
Characteristics	Material:	Stainless Steel 316L
	Finish:	Electropolished
	Volume:	29 L
	Diameter:	1.08 ft
	Height:	1.25 ft
	Sterilization:	CIP
Operating Conditions::	Temperature:	4°C
	Pressure:	1 atm
Purchase Cost	$1,100	

Reactor Sodium Azide Holding Tank (T-12.2)

Description and Function	Holds sodium azide solution, used to regenerate the snake venom column after operation	
Vendor	Sharpsville Container	
PFD Reference	T-12.2	
Operation	Batch	
Materials Handled		**Input (per batch)**
	Sodium Azide Solution (L)	5.7
Characteristics	Material:	Stainless Steel 316L
	Finish:	Electropolished
	Volume:	9.6 L
	Diameter:	0.71 ft
	Height:	0.85 ft
	Sterilization:	CIP
Operating Conditions	Temperature:	4°C
	Pressure:	1 atm
Purchase Cost	$570	

Fibrinogen Ultrafiltration Dilutant Holding Tank (T-08)

Description and Function	Holds the water that is to be added to the retentate during ultrafiltration	
Vendor	Sharpsville Container	
PFD Reference	T-08	
Operation	Batch	
Materials Handled		**Input (per batch)**
	Water (L)	3504
Characteristics	Material:	Stainless Steel 316L
	Finish:	Electropolished
	Volume:	5,250 L
	Diameter:	5.4 ft
	Height:	8 ft
	Sterilization:	CIP
Operating Conditions	Temperature:	4°C
	Pressure:	1 atm
Purchase Cost	$25,200	

Thrombin Ultrafiltration Dilutant Holding Tank (T-15)

Description and Function	Holds the water that is to be added to the retentate during ultrafiltration	
Vendor	Sharpsville Container	
PFD Reference	T-15	
Operation	Batch	
Materials Handled		**Input (per batch)**
	Water (L)	143
Characteristics	Material:	Stainless Steel 316L
	Finish:	Electropolished
	Volume:	215 L
	Diameter:	1.9 ft
	Height:	2.75 ft
	Sterilization:	CIP
Operating Conditions	Temperature:	4°C
	Pressure:	1 atm
Purchase Cost	$3,700	

14.2. Waste Tanks

Centrifuge Waste Tank (W-01)

Description and Function	Holds waste from both centrifugations	
Vendor	Sharpsville Container	
PFD Reference	W-01	
Operation	Batch	
Materials Handled		**Input (per batch)**
	Total Volume (L)	2990
	Fibrinogen (kg)	0.16
	Prothrombin (g)	2.6
	Sodium Citrate (kg)	16.8
	Barium Chloride (kg)	3.6
	Benzamidine HCl (kg)	3.47
	Ammonia (g)	557
	Ammonium Sulfate (kg)	346
	Sodium Chloride (kg)	5.73
	Water (kg)	2930
Characteristics	Material:	Stainless Steel 316L
	Finish:	Electropolished
	Volume:	4,485 L
	Diameter:	5.2 ft
	Height:	7.5 ft
	Sterilization:	CIP
Operating Conditions	Temperature:	4°C
	Pressure:	1 atm
Purchase Cost	$22,900	

Fibrinogen Endotoxin Waste Tank (W-03)

Description and Function	Stores any endotoxin waste from the fibrinogen solution	
Vendor	Sharpsville Container	
PFD Reference	W-03	
Operation	Batch	
Materials Handled		**Input (per batch)**
	Wash buffer (L)	250
	Elution Buffer (L)	250
	Endotoxin (mg)	1
	Fibrinogen (g)	740
Characteristics	Material:	Stainless Steel 316L
	Finish:	Electropolished
	Volume:	750 L
	Diameter:	2.9 ft
	Height:	4 ft
	Sterilization:	CIP
Operating Conditions	Temperature:	4°C
	Pressure:	1 atm
Purchase Cost	$7,800	

Heparin Column Waste Tank (W-06)

Description and Function	Stores waste from the heparin column	
Vendor	Sharpsville Container	
PFD Reference	W-06	
Operation	Batch	
Materials Handled		**Input (per batch)**
	Total Volume (L)	40.9
	Prothrombin (g)	0.5
	Thrombin (g)	0.5
	Sodium Citrate (kg)	0.18
	Barium Chloride (kg)	14.6
	Benzamidine HCl (kg)	0.73
	Tris (g)	97
	Sodium Chloride (g)	350
	EGTA (g)	15.2
	Water (kg)	40.9
Characteristics	Material:	Stainless Steel 316L
	Finish:	Electropolished
	Volume:	61 L
	Diameter:	1.25 ft
	Height:	1.75 ft
	Sterilization:	CIP
Operating Conditions	Temperature:	4°C
	Pressure:	1 atm
Purchase Cost	$1,700	

Prothrombin Excess Pellet Waste Tank (W-04)

Description and Function	Stores excess prothrombin solid for disposal	
Vendor	Sharpsville container	
PFD Reference	W-04	
Operation	Batch	
Materials Handled		**Input (per batch)**
	Fibrinogen (g)	63.2
	Prothrombin (g)	204.5
	Sodium Citrate (kg)	0.72
	Barium Chloride (kg)	58.2
	Benzamidine HCl (kg)	2.92
	Water (kg)	1.6
	Volume (L)	60
Characteristics	Material:	Stainless Steel 316L
	Finish:	Electropolished
	Volume:	90 L
	Diameter:	1.4 ft
	Height:	2 ft
	Sterilization:	CIP
Operating Conditions	Temperature:	4°C
	Pressure:	1 atm
Purchase Cost	$2,200	

Reactor Waste Tank (W-05)

Description and Function	Stores waste from the snake venom reactor for disposal	
Vendor	Sharpsville container	
PFD Reference	W-05	
Operation	Batch	
Materials Handled		**Input (per batch)**
	Wash buffer (L)	22.72
	Fibrinogen (g)	15.8
	Cleaved Prothrombin (g)	25
Characteristics	Material:	Stainless Steel 316L
	Finish:	Electropolished
	Volume:	38 L
	Diameter:	1 ft
	Height:	1.5 ft
	Sterilization:	CIP
Operating Conditions	Temperature:	4°C
	Pressure:	1 atm
Purchase Cost	$1,300	

Thrombin Endotoxin Waste Tank (W-08)

Description and Function	Stores any endotoxin waste from the fibrinogen solution	
Vendor	Sharpsville Container	
PFD Reference	W-08	
Operation	Batch	
Materials Handled		**Input (per batch)**
	Wash buffer (L)	20
	Elution Buffer (L)	20
	Endotoxin (mg)	1
	Thrombin (g)	2.4
Characteristics	Material:	Stainless Steel 316L
	Finish:	Electropolished
	Volume:	61 L
	Diameter:	1.2 ft
	Height:	1.8 ft
	Sterilization:	CIP
Operating Conditions	Temperature:	4°C
	Pressure:	1 atm
Purchase Cost	$1,750	

Fibrinogen Ultrafiltration Waste Tank (W-02)

Description and Function	Stores the filtrate from the fibrinogen ultrafiltration for disposal	
Vendor	Sharpsville Container	
PFD Reference	W-02	
Operation	Batch	
Materials Handled		**Input (per batch)**
	Total Volume (L)	3754
	Fibrinogen (kg)	0.23
	Prothrombin (g)	0
	Sodium citrate (kg)	2
	Barium Chloride (kg)	0.2
	Benzamidine HCl (kg)	0.18
	Ammonia (g)	29
	Ammonium Sulfate (kg)	18
	Sodium Chloride (kg)	3.23
	Citric Acid (g)	0.0048
	L-lysine (g)	73.2
	Water (kg)	3754
Characteristics	Material:	Stainless Steel 316L
	Finish:	Electropolished
	Volume:	5630 L
	Diameter:	5.6 ft
	Height:	8 ft
	Sterilization:	CIP
Operating Conditions	Temperature:	4°C
	Pressure:	1 atm
Purchase Cost	$26,300	

Thrombin Ultrafiltration Waste Tank (W-07)

Description and Function	Stores the filtrate from the thrombin ultrafiltration for disposal	
Vendor	Sharpsville Container	
PFD Reference	W-07	
Operation	Batch	
Materials Handled		**Input (per batch)**
	Total Volume (L)	143
	Sodium Chloride (g)	1753
	Water (kg)	143
Characteristics	Material:	Stainless Steel 316L
	Finish:	Electropolished
	Volume:	215 L
	Diameter:	2 ft
	Height:	2.5 ft
	Sterilization:	CIP
Operating Conditions	Temperature:	4°C
	Pressure:	1 atm
Purchase Cost	$3,700	

Blood Cell Centrifuge Waste Tank (W-00)

Description and Function	Stores blood waste from centrifugation of crude salmon blood.	
Vendor	Sharpsville Container	
PFD Reference	W-00	
Operation	Batch	
Materials Handled		**Input (per batch)**
	Total Volume (L)	225
	Blood Cells and Other Blood Waste (L)	225
Characteristics	Material:	Stainless Steel 316L
	Finish:	Electropolished
	Volume:	340 L
	Diameter:	2.3 ft
	Height:	3 ft
	Sterilization:	CIP
Operating Conditions	Temperature:	4°C
	Pressure:	1 atm
Purchase Cost	$4,850	

14.3. Mixing/Resuspension Tanks

Ammonium Sulfate Precipitation/Mixing Tank (M-02)

Description and Function	Mixes fibrinogen solution and ammonium sulfate to precipitate fibrinogen out of solution	
Vendor	Sharpsville Container/ Dynamix Inc.	
PFD Reference	M-02	
Operation	Batch	
Materials Handled		**Input (per batch)**
	Volume (L)	3020
	Fibrinogen (kg)	7.82
	Prothrombin (g)	2.6
	Sodium Citrate (kg)	17.7
	Barium Chloride (kg)	3.8
	Benzamidine HCl (kg)	3.65
	Ammonia (g)	586
	Ammonium Sulfate (kg)	364
	Sodium Chloride (kg)	6.03
	Water (kg)	2933
Characteristics	Material:	Stainless Steel 316L
	Finish:	Electropolished
	Volume:	4530 L
	Diameter:	5.2 ft
	Height:	7.5 ft
	Type of Agitator:	propeller
	Agitator HP:	6
Purchase Cost	Tank:	$70,600
	Agitator:	$10,400

Barium Chloride Precipitation/Mixing Tank (M-01)

Description and Function	Mixes blood plasma, barium chloride, and benzamidine HCl to separate fibrinogen from prothrombin	
Vendor	Sharpsville Container/ Dynamix Inc.	
PFD Reference	M-01	
Operation	Batch	
Materials Handled		**Input (per batch)**
	Total Volume (L)	2458
	Fibrinogen (kg)	7.9
	Prothrombin (g)	258.4
	Sodium Citrate (kg)	18.6
	Barium Chloride (kg)	76.7
	Benzamidine HCl (kg)	3.84
	Water (kg)	2247
Characteristics	Material:	Stainless Steel 316L
	Finish:	Electropolished
	Volume:	3680 L
	Diameter:	4.9 ft
	Height:	7 ft
	Type of Agitator	propeller
	Agitator HP	4.9
Purchase Cost	Tank:	$65,800
	Agitator:	$9,200
	Total:	$75,000

Fibrinogen Resuspension Tank (M-03)

Description and Function	Fibrinogen solid from the ammonium sulfate precipitation is moved to this tank and resuspended in citrate-citric acid buffer.	
Vendor	Sharpsville Container/ Dynamix Inc.	
PFD Reference	M-03	
Operation	Batch	
Materials Handled		**Input (per batch)**
	Total Volume (L)	503
	Fibrinogen (kg)	7.66
	Sodium citrate (kg)	2
	Barium Chloride (kg)	0.2
	Benzamidine HCl (kg)	0.18
	Ammonia (g)	29
	Ammonium Sulfate (kg)	18
	Sodium Chloride (kg)	3.23
	Citric Acid (g)	0.0048
	L-lysine (g)	73.2
	Water (kg)	503
Characteristics	Material:	Stainless Steel 316L
	Finish:	Electropolished
	Volume:	750 L
	Diameter:	2.9 ft
	Height:	4 ft
	Type of Agitator	propeller
	Agitator HP	2
Purchase Cost	Tank:	$34,300
	Agitator:	$5,500
	Total:	$39,800

Prothrombin Resuspension Mixing Tank (M-04)

Description and Function	Prothrombin solid is transferred to this tank after the barium chloride precipitation and resuspended in tris buffer	
Vendor	Sharpsville Container/ Dynamix Inc.	
PFD Reference	M-04	
Operation	Batch	
Materials Handled		**Input (per batch)**
	Total Volume (L)	60
	Fibrinogen (g)	15.8
	Prothrombin (g)	51.1
	Sodium Citrate (kg)	0.18
	Barium Chloride (kg)	14.6
	Benzamidine HCl (kg)	0.73
	Tris (g)	48.5
	Sodium Chloride (g)	175
	EGTA (g)	7.6
	Water (kg)	20.4
Characteristics	Material:	Stainless Steel 316L
	Finish:	Electropolished
	Volume:	90 L
	Diameter:	1.6 ft
	Height:	1.5 ft
	Type of Agitator	propeller
	Agitator HP	0.24 ft
Purchase Cost	Tank:	$17,300
	Agitator:	$1,700
	Total:	$19,000

14.4. Centrifuges

Blood Centrifuge (CE-01)

Description and Function	Separates red and white blood cells from the plasma, which contains the proteins of interest	
Vendor	Carr Centritech	
PFD Reference	CE-01	
Operation	Continuous	
Materials Handled		**Input (per day)**
	Total Volume (L)	520
	Fibrinogen (kg)	1.25
	Prothrombin (g)	40.9
	Sodium Citrate (kg)	2.68
	Water (kg)	268
	Blood Cells (kg)	245
Characteristics	Model:	Viafuge Pilot
	Centrifuge Type:	Continuous solid-bowl
	Material:	Stainless Steel 316L
	Capacity Range:	6-240 L/hr
	G-Force Range:	500-10,000 x g
	Sterilization:	SIP/CIP
Operating Conditions	Temperature:	4°C
	Pressure:	1.0 atm
	Flow Rate:	240 L/hr
Purchase Cost	$178,600	

Precipitation Centrifuge (CE-02)

Description and Function	This is a continuous centrifuge used to separate the solids from the $BaCl_2$ precipitation and the ammonium sulfate precipitation.	
Vendor	Carr Centritech	
PFD Reference	CE-02	
Operation	Continuous	
Material Handled		**Input (per Batch)**
	Precipitated Solution	3000L
	Fibrinogen:	7897 g
	Prothrombin:	269 g
Characteristics	Model:	Powerfuge P18
	Centrifuge Type:	Continuous solid-bowl
	Material	Stainless Steel 316L
	Capacity Range:	100-1700 L/hr
	G-Force Range:	500-20000 x g
	Sterilization:	SIP/CIP
Operating Conditions	Temp	4°C
	Pressure	1 atm
	Flow Rate	1500 L/hr
	G-force	12,000 g
Purchase Cost	$184,700	

14.5. Ultrafiltration Equipment

Fibrinogen Ultrafiltration Feed Tank (UF-01)

Description and Function	Holds the solution as it recirculates the ultrafiltration cassettes and allows for buffer exchange	
Vendor	Sharpsville Container	
PFD Reference	UF-01	
Operation	Batch	
Materials Handled		**Input (per Batch)**
	Fibrinogen Solution (L)	501
	Water (L)	3504
Characteristics	Material:	Stainless Steel 316L
	Finish:	Electropolished
	Volume:	6007 L
	Diameter:	5.8 ft
	Height:	8 ft
	Sterilization:	CIP
Operating Conditions	Temperature:	4°C
	Pressure:	1 atm
Purchase Cost	$24,100	

Thrombin Ultrafiltration Feed Tank (UF-03)

Description and Function	Holds the solution as it recirculates the ultrafiltration cassettes and allows for buffer exchange	
Vendor	Sharpsville Container	
PFD Reference	UF-03	
Operation	Batch	
Materials Handled		**Input (per Batch)**
	Thrombin Solution (L)	20.5
	Water (L)	143
Characteristics	Material:	Stainless Steel 316L
	Finish:	Electropolished
	Volume:	245 L
	Diameter:	1.9 ft
	Height:	3 ft
	Sterilization:	CIP
Operating Conditions	Temperature:	4°C
	Pressure:	1 atm
Purchase Cost	$3,530	

Fibrinogen Ultrafiltration Cassettes (UF-02)

Description and Function	Filters out salts and other small impurities from the fibrinogen solution		
Vendor	EMD Millipore		
PFD Reference	UF-02		
Operation	Batch		
Materials Handled		**Input (per batch)**	
	Fibrinogen Solution (L)	501	
	Fibrinogen (g)	7510	
Characteristics:	Model:	Pellicon 2 Maxi Cassettes with Biomax Membrane	
	Material:	Polypropylene	
		Polyethylene	
		Polyethersulfone	
		Stainless steel	
	MWCO:	100 kDa	
	Area of membrane per cassette:	2.5 m^2	
	Length:	8.3 in	
	Width:	7 in	
	Thickness:	3 in	
	Screen type:	C (Coarse)	
Operating Conditions	Temperature:	4°C	
	Recirculation Rate:	15 L/min	
	Pressure Drop:	0.4 bar	
Purchase Cost	Cassettes:	$10,710	(60)
	Holders:	$20,000	(6)
	Total:	$762,600	

Thrombin Ultrafiltration Cassettes (UF-04)

Description and Function	Filters out salts and other small impurities from the thrombin solution		
Vendor	EMD Millipore		
PFD Reference	UF-04		
Operation	Batch		
Materials Handled		**Input (per batch)**	
	Thrombin Solution (L)	20.5	
	Thrombin (g)	24.3	
Characteristics	Model	Pellicon 2 Maxi Cassettes with Biomax Membrane	
	Material	Polypropylene	
		Polyethylene	
		Polyethersulfone	
		Stainless steel	
	MWCO:	10 kDa	
	Area of membrane per cassette:	2.5 m^2	
	Length:	8.3 in	
	Width:	7 in	
	Height:	3 in	
	Screen type:	A (tight)	
Operating Conditions	Temperature:	4°C	
	Recirculation Rate:	4 L/min	
	Pressure Drop:	1.4 bar	
Purchase Cost:	Cassettes:	$10,710	(3)
	Holder:	$15,840	(1)
	Total:	$47,970	

14.6. Columns

Fibrinogen Endotoxin Removal Column (CO-01)

Description and Function: To remove any possible endotoxins from the final fibrinogen solution. Resin must be replaced after 10 uses.

Vendor: GE Life Sciences (column), ThermoScientific (resin)

PFD Reference: CO-01

Operation: Batch

Materials Handed:

	Input (per Batch)
Fibrinogen Solution (L)	250
Elution Buffer (L)	250
Wash Buffer (L)	250
Endotoxin (g)	0.001
Fibrinogen (kg)	7.43

Characteristics:

Column Model:	AxiChrom 600/500 Column
Material:	316L Stainless Steel
Column Packer:	AxiChrom Master
Resin:	Detoxi-Gel Endotoxin Removal Gel
Column Diameter:	0.6 m
Column Height:	0.165 m
Column Volume:	140 L
Bed Volume:	45 L
Sterilization:	CIP (1% sodium deoxycholate)

Operating Conditions:

Temperature:	4 °C
Pressure Drop:	1.77 bar
Binding Capacity:	5,000 endotoxin units/mL of resin
Flow Rate:	1,250 L/hr
No. of Recirculations:	1

Purchase Cost:

Column:	$75,000
Resin:	$92,250 (annually)
Column Packer:	$45,000
Total:	$212,250

Snake Venom Packed Bed Reactor (CO-02)

Description and Function:	Packed bed immobilized enzyme column with snake venom enzyme. Snake venom activates the cleavage of prothrombin to thrombin. Resin must be replaced and enzyme must be immobilized again after every 10 uses.	
Vendor:	GE Life Sciences (column), ThermoScientific (resin)	
PFD Reference:	CO-02	
Operation:	Batch	
Materials Handed:		**Input (per Batch)**
	Prothrombin Solution (L)	20
	Prothrombin (g)	50.15
Characteristics:	Column Model:	BPG 100/500
	Material:	316L Stainless Steel
	Resin:	AminoLink Plus
	Column Diameter:	0.1 m
	Column Height:	50 cm
	Column Volume:	3.9 L
	Bed Volume:	1.42 L
	Sterilization:	CIP
Operating Conditions:	Temperature:	23 °C
	Pressure Drop:	1.6 bar
	Flow Rate:	40 L/hr
Purchase Cost:	Column:	$5,400
	Resin:	$8,300 (annually)
	Venom:	$42,800 (annually)
	Total:	$56,500

Heparin Column (CO-03)

Description and Function: Heparin binds to thrombin, to purify it and remove any residual blood proteins, such as fibrinogen and other small proteins. Resin must be replaced after 10 uses.

Vendor: GE Life Sciences (column and resin)

PFD Reference: CO-03

Operation: Batch

Materials Handed:

	Input (per Batch)
Thrombin Solution (L)	20
Thrombin (g)	25
Wash Buffer (L)	20
Elution Buffer (L)	20

Characteristics:

Column Model:	BPG 300/500
Material:	316L Stainless Steel
Resin:	Heparin Sepharose 6 Fast Flow
Column Diameter:	0.296 m
Column Height:	50 cm
Column Volume:	28.2 L
Bed Volume:	20.45 L
Sterilization:	CIP

Operating Conditions:

Temperature:	4 °C
Pressure Drop:	2.1 bar
Flow Rate:	2.87 L/min
No. of Recirculations:	8

Purchase Cost:

Column:	$19,950
Resin:	$185,000 (annually)
Total:	$204,050

Thrombin Endotoxin Removal Column (CO-04)

Description and Function:	Remove any possible endotoxins from the final thrombin solution. Resin must be replaced after 10 uses.	
Vendor:	GE Life Sciences (column), ThermoScientific (resin)	
PFD Reference:	CO-04	
Operation:	Batch	
Materials Handed:		**Input (per Batch)**
	Thrombin Solution (L)	20
	Endotoxin (g)	0.001
	Thrombin (g)	24.5
	Elution Buffer (L)	20
	Wash Buffer (L)	20
Characteristics:	Column Model:	AxiChrom 140/300
	Material:	316L Stainless Steel
	Resin:	Detoxi-Gel Endotoxin Removal Gel
	Column Diameter:	0.14 m
	Column Height:	30 cm
	Column Volume:	4.6 L
	Bed Volume:	4.1 L
	Sterilization:	CIP (1% sodium deoxycholate)
Operating Conditions:	Temperature:	4 °C
	Pressure Drop:	3.2 bar
	Binding Capacity:	5,000 endotoxin units/mL of resin
	Flow Rate:	81.8 L/hr
Purchase Cost:	Column:	$17,000
	Resin:	$7,500 (annually)
	Total:	$24,500

14.7. Finishing Equipment

Fibrinogen Sprayer System (F-01)

Description and Function:	Sprays purified fibrinogen solutions onto bandages	
Vendor:	Spraying Systems Co.	
PFD Reference:	F-01	
Operation:	Batch	
Characteristics:	Spray System:	63600 Hydraulic Sanitary Jacketed PulsaJet Manifold
	Control Systems:	AutoJet 2008+ Modular Spray System
	Spray Nozzle:	PulsaJet AA10000AUH-104210
	No. of Nozzles:	11
	Nozzle Spray Rate:	0.2 gpm per nozzle
	Material:	316L Stainless Steel
Purchase Cost:	$21,900	

Thrombin Sprayer System (F-03)

Description and Function:	Sprays purified thrombin solutions onto bandages	
Vendor:	Spraying Systems Co.	
PFD Reference:	F-03	
Operation:	Batch	
Characteristics:	Spray System:	63600 Hydraulic Sanitary Jacketed PulsaJet Manifold
	Control Systems:	AutoJet 2008+ Modular Spray System
	Spray Nozzle:	PulsaJet AA10000AUH-104210
	No. of Nozzles:	11
	Nozzle Spray Rate:	0.016 gpm per nozzle
	Material:	316L Stainless Steel
Purchase Cost:	$21,900	

Bandage Conveyor Belts (F-02, F-04)

Description and Function:	Move bandages along a conveyor belt as they are sprayed	
Vendor:	Bastian Solutions	
PFD Reference:	F-02, F-04	
Operation:	Batch	
Characteristics:	Model:	Custom (includes belt, motor and supports)
	Belth Width:	153 cm
	Belt Length:	30.5 m
	Belt Speed:	2.1 m/min
	Motor:	Center Drive, 460 V/3 Ph/60 Hz AC inverter duty 1 HP
Purchase Cost:	$25,600 each $51,200 total	

Conveyor Trays (accessory to F-02, F-04)

Description and Function:	Stainless steel trays that hold gauze pieces during spraying and lyophilization processing steps.	
Vendor:	Stainless Supply	
PFD Reference:	Accessory to F-02 and F-04	
Operation:	Batch	
Characteristics:	Model:	Custom Sized Stainless Steel Sheet
	Width:	121.7 cm
	Length:	152.2 cm
	Thickness:	0.3 cm
	Weight:	20.9 lb per sheet
	Material:	316L Stainless Steel
	No. of trays needed:	84
Purchase Cost:	$203.55 each $17,100 total	

Bandage Freeze Dryer (F-05)

Description and Function:	Freeze dries fibrinogen and thrombin onto gauze strips. Three units are needed for purchase.	
Vendor:	GEA-Niro	
PFD Reference:	F-05	
Operation:	Batch	
Characteristics:	Model:	GEA SmartLyo SL-400
	Floor Space Area:	16.8 m^2
	No. of Shelves:	36
	Total Shelf Area:	66.9 m^2
	Bandages per Shelf:	154
	Condenser Capacity:	400 kg/24 hr
	Power Supply:	105 kW
	Sterilization:	CIP/SIP system included
	CIP Water:	7 m^3
	Cooling Water:	30 m^3/h at peak
	Control System:	Included
	Condenser Temp.:	-75 °C
	Shelf Temp. Range:	-55 °C to 70 °C
Purchase Cost:	$100,000 each $300,000 total	

14.8. Pumps

All Pumps (PP-01—PP-38)

Description and Function:	Transfer solutions between tanks and batch operations	
Vendor:	Core=Palmer	
PFD Reference:	PP-01—PP-38	
Operation:	Batch	
Characteristics:	Model:	Masterflex B/T Variable Speed Pump
	Type:	Peristaltic
	Flow Range:	1.4—42 LPM
	Energy Usage:	6.5 Amps
	Max. Pressure:	25 bar
Purchase Cost:	$4,960 each $188,500 total	

14.9. Heat Exchangers

Prothrombin Solution Heating Heat Exchanger (HX-01)

Description and Function:	To heat the prothrombin solution from 4 °C to 23 °C for optimal kinetics for the prothrombin activation reaction.	
PFD Reference:	HX-01	
Operation:	Batch	
Materials Handed:		**Input (per Batch)**
	Prothrombin Solution (L)	20.45
	Hot Water (L)	20.45
Characteristics:	Type:	Double Pipe Heat Exchanger
	Flow:	Countercurrent
	Material:	316L Stainless Steel
	Length:	0.67 ft
	Inner Pipe:	Schedule 40, 1-in Pipe
	Outer Pipe:	Schedule 40, 2-in Pipe
	Sterilization:	CIP/SIP
Operating Conditions:	Prothrombin Inlet Temp.:	4 °C
	Prothrombin Outlet Temp.:	23 °C
	Prothrombin Pressure Drop:	10.6 psi
	Prothrombin Flow Rate:	0.5 ft/s
	Water Inlet Temp.:	93.3 °C
	Water Outlet Temp.:	77.5 °C
	Water Pressure Drop:	4.25 psi
	Water Flow Rate:	0.22 ft/s
Purchase Cost:	$4,700	

Thrombin Solution Cooling Heat Exchanger (HX-02)

Description and Function:	To cool the thrombin solution from 23 °C to 4 °C for subsequent processing and purification steps.	
PFD Reference:	HX-02	
Operation:	Batch	
Materials Handed:		**Input (per Batch)**
	Thrombin Solution (L)	20.45
	Chilled Brine (L)	102.25
Characteristics:	Type:	Double Pipe Heat Exchanger
	Flow:	Countercurrent
	Material:	316L Stainless Steel
	Length:	3.0 ft
	Inner Pipe:	Schedule 40, 1.25-in Pipe
	Outer Pipe:	Schedule 40, 4-in Pipe
	Sterilization:	CIP/SIP
Operating Conditions:	Thrombin Inlet Temp.:	23 °C
	Thrombin Outlet Temp.:	4 °C
	Thrombin Pressure Drop:	8.43 psi
	Thrombin Flow Rate:	0.25 ft/s
	Brine Inlet Temp.:	-17.78 °C
	Brine Outlet Temp.:	-13.76 °C
	Brine Pressure Drop:	4.76 psi
	Brine Flow Rate:	0.24 ft/s
Purchase Cost:	$6,200	

14.10. Miscellaneous

Plasma Storage Freezer (E-01)

Description and Function:	Low temperature cold room to store and freeze 7 days' worth of plasma after collection in centrifugation before protein processing	
Vendor:	Budzar Industries, Inc.	
PFD Reference:	E-01	
Operation:	Batch	
Characteristics:	Model:	ACM-5 Cold Storage Freezer
	Dimensions:	1.78 m × 2.95 m × 2.6 m
	Temperature:	-80 °C
	Insulation:	4-in urethane insulation
	Controls:	Automatic defrost circuit
	Refrigerant:	R404A non-ozone depleting refrigerant
	Power Requirement:	16.4 kW
	Energy Requirement:	2,755.2 kWh per batch
Purchase Cost:	$70,000	

Pellet Splitter (E-02)

Description and Function:	Weighing scale for operator to measure mass of prothrombin pellet and discard appropriate amount	
Vendor:	MeasureTek	
PFD Reference:	E-02	
Operation:	Batch	
Characteristics:	Model:	Shipping Scale, 12R979
	Capacity:	200 kg
	Weighing Surface:	12” × 12”
	Material:	Diamond Plated Steel
Purchase Cost:	$153	

15. Other Important Considerations

15.1. Strategic Partnership with Existing Bandage Company

DiamondStat will form a strategic partnership with a large existing bandage manufacturing company, such as Johnson & Johnson. This will allow DiamondStat to maintain its focus on its core area of expertise—pharmaceutical processing. Our strategic partner will provide the gauze, adhesive materials, and protective layer to cover the adhesive layer. It will also cover the management and costs associated with distribution and marketing the product. In exchange, our strategic partner will receive 10% of total revenue from the sale of DiamondStat bandages.

15.2. Strategic Partnership with Salmon Farming Company

DiamondStat will also form a business alliance with Marine Harvest, the largest producer of salmon in the world. Marine Harvest will provide the live salmon to DiamondStat. We will bleed the fish and then return the bled fish to Marine Harvest. Currently, Marine Harvest handles the bleeding of the fish and the disposal of associated biomaterials, such as blood. Because we will save them costs in both labor to bleed the fish and in disposing of biowaste, we have assumed for the purposes of economic analysis that we will receive the fish blood for free. Marine Harvest typically farms more than 11 million salmon annually, in Chile alone (*"Salmon Farming"*). As a result, we have also assumed that the availability of salmon for our process will not present any problems, and we are not at risk of facing a supply shortage.

15.3. Waste Disposal

The majority of waste produced in this process is classified as biological waste, and it must be disposed of in accordance with regulation, adding to operational costs. Blood cell waste (W-00) and prothrombin pellet waste (W-04), are classified as solid biowaste products and will cost $0.50 per kg and $0.22 per kg, respectively, to dispose of. All other waste is liquid, and will cost $0.033 per liter to dispose of. This amounts to a total waste disposal cost of $0.18 per bandage.

16. Economic Analysis

The DiamondStat processing plant will be profitable, with a net present value of over $489 million and an internal rate of return of 289.76%, based on the following analysis. For detailed profitability analysis values, refer to Appendix D.

16.1. Equipment Cost Summary

The total purchase costs and total bare module costs for each piece of equipment are shown in Table 16.1.1 below. The total bare module purchase cost for the equipment is $6.67 million. Additionally, the cassettes used for ultrafiltration will need to be replaced annually. A more detailed equipment cost table can be found in Appendix E. Purchase costs were determined through three methods: online price quote, manufacturer price quote or purchase cost equations. All purchase cost equations are described in *Product and Process Design Principles: Synthesis, Analysis and Evaluation*. Refer to Appendix F for further explanation on calculated equipment costs. Bare module costs were also found in *Product and Process Design Principles*.

Table 16.1.1. Equipment Cost Summary for DiamondStat Plant

Equipment Cost Summary			
Type	**Item Code**	**Total Purchase Cost**	**Total Bare Module Cost**
Holding Tanks	T	$211,200	$422,300
Waste Tanks	W	$72,600	$145,100
Mixing Tanks	M	$67,700	$135,400
Centrifuges	CE	$363,300	$737,400
Columns	CO	$162,400	$675,400
Finishing Equipment	F	$416,600	$934,300
Ultrafiltration	UF	$324,100	$562,700
Miscellaneous	E	$570,200	$1,237,100
Pumps	PP	$170,300	$562,000
Heat Exchangers	HX	$10,900	$19,620

16.2. Total Permanent Investment

The fixed capital investment of the plant encompasses all one-time fixed costs, such as the one-time sterilization verification fee, plant startup, and cost of land and construction. These values were estimated based on methods outlined in *Product and Process Design Principles.* Creation of the DiamondStat production plant has a total permanent investment of $3.22 million. In the first year of construction, 2016, 75% of this total permanent investment is incurred. The remaining 25% is incurred in 2017. Given $17.9 million in working capital when the plant is operating at 90% capacity, the total capital investment in the DiamondStat processing plant is $21.1 million. A more in-depth analysis of the total permanent investment can be found in Appendix D.

16.3. Variable Costs

In addition to the costs of constructing the DiamondStat plant in Chile, many costs are incurred during operations. As shown in Table 16.3.1, when the plant is operating at 100% capacity (300,000 bandages per year), total variable costs amount to nearly $50.1 million annually. The largest variable production cost is the 10% fee paid to our strategic bandage partner (explained in Section15.1). Raw materials, including resins, catalysts, salts and purchased liquid solutions, comprise the next largest production variable cost. Water is not included as a raw material, but rather as a utility. A utility breakdown by unit can be found in Appendix D.

Additional general expenses vary with production level and were estimated as a percentage of annual sales, based on guidelines presented in *Product and Process Design Principles.*

Table 16.3.1. Full Capacity Variable Costs for DiamondStat Plant

Full Capacity Variable Costs			
		Per Bandage Expense	**Annual Expenses**
Production Expenses	Raw Materials	$4.67	$1,401,300
	Packaging and Sterilization	$2.45	$735,000
	Bandage Partnership	$80.00	$24,000,000
	Waste Disposal	$0.18	$55,000
	Utilities	$3.36	$775,000
General Expenses	Selling/Transfer Expenses	$8.00	$2,400,000
	Direct Research	$38.40	$11,520,000
	Allocated Research	$4.00	$1,200,000
	Administrative Expenses	$16.00	$4,800,000
	Management Incentive Compensation	$10.00	$3,000,000
Total		$167.06	$49,886,300

16.4. Other Costs and Considerations

16.4.1. Labor Costs

The cost of labor in Chile is much cheaper than that in the United States. According to the Chilean Department of Labor, the minimum wage in Chile is equivalent to $2.33 U.S. dollars (Chilean Department of Labor). The ratio between Chilean and American minimum wages and the hourly wage recommendation by Seider et. al ($40 per hour in the United States), was used to calculate the hourly wage of plant operators, giving $10 per hour for plant operators in Chile. The majority (94%, on average) of operators are needed in the blood collection step of the process. Annually, direct wages, salaries and benefits cost the plant $3.7 million.

16.4.2. FDA Approval Process

The cost of the FDA approval process for the DiamondStat is not included in the economic analysis of the project. We have assumed that because our product will help save the lives of hundreds of thousands of American soldiers, the U.S. government will provide assistance to cover the cost of the approval process. However, even if our company was responsible for the costs of FDA approval, the costs of the approval process would not seriously affect our profitability. An average medical device approval process costs approximately $30 million. The net present value of this project is $489,514,100. Figuring the FDA approval process into the analysis only lowers the NPV 6.1%, to $459,514,100.

16.5. Profitability Analysis – Business Case

The DiamondStat processing plant will be a profitable endeavor. At 90% capacity, working capital is $17.9 million. Adding working capital to the total permanent investment of $3.22 million gives a total capital investment of $21.1 million for this project.

The economic analysis was performed using a 5-year MACRS depreciation schedule. An income tax rate of 37%, an inflation rate of 4%, and a 15% per annum discount rate were assumed.

At a selling price of $800 per bandage, DiamondStat achieves a net present value (NPV) in 2015 of $489,514,100. DiamondStat will experience 289.76% internal rate of return (IRR), far above the hurdle rate of 15% per annum. For investors, DiamondStat is able to give a return on investment (ROI) of 528.18% in its third year of production. DiamondStat becomes profitable in its first year of production, as shown in Figure 16.5.1. Negative cash flows are unsurprisingly experienced in 2016 and 2017, during plant construction before any sales have been made, as shown in Figure 16.5.2.

Figure 16.5.1. DiamondStat Net Earnings

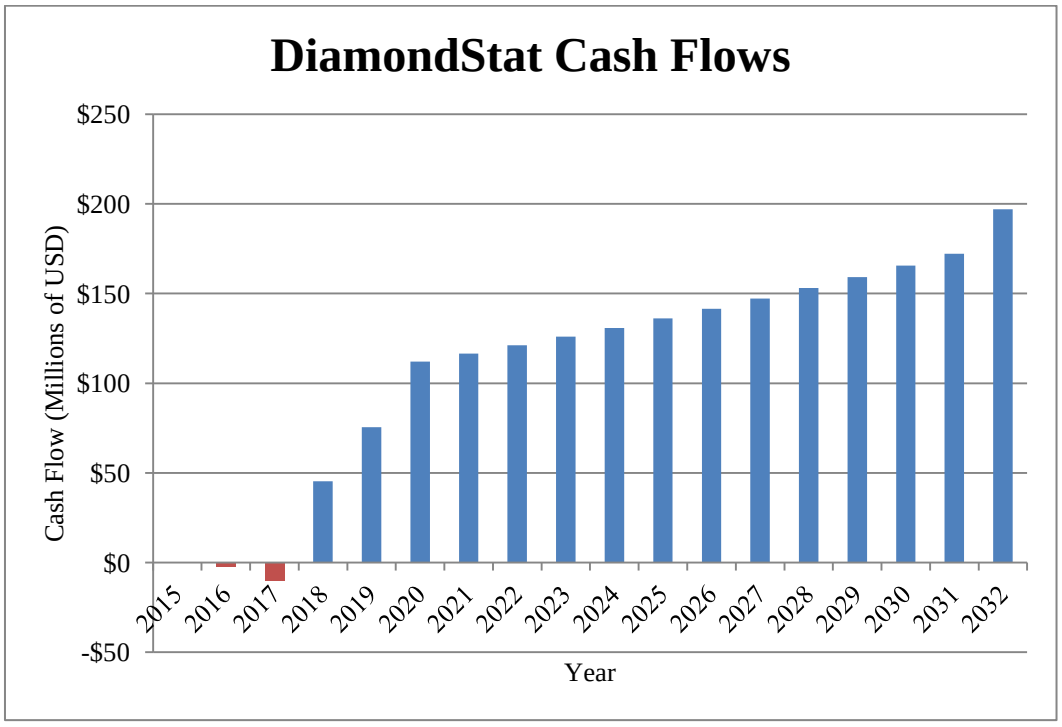


Figure 16.5.2. DiamondStat Cash Flows

Sensitivity analyses were performed on some of the major variables: product price, inflation, fixed costs, variable costs and total permanent investment. Their effect on IRR was calculated within the range of ± 50% of each variable. These analyses can be found in Appendix G. While there is a fairly wide range that the expected IRR can fall between, none of the sensitivity analyses yielded an IRR below our hurdle rate. In fact, the lowest IRR from the sensitivity analysis was 108%, which would be expected if the product price was halved to $400, and variable costs double to $75 million annually, which is unlikely.

An additional sensitivity analysis was performed on our two largest assumptions: the product price and the percent revenue share to our strategic bandage partner. These results can also be found in Appendix G. The most notable result is that at a price of $800 per bandage, the IRR is still positive as long as the percent revenue share is below 86%.

Given the high IRR, NPV and ROI of this project, and the high profitability indicated by the sensitivity analysis even with dramatic increases in expenses, this project is economically viable and offers a great profit for investors.

17. Conclusions and Recommendations

This report has proven the potential of the DiamondStat Bandage as an effective and profitable medical device to treat hemorrhage due to trauma. The bandages will be sold at $800 each to the U.S. military, yielding a net present value of over $489 million and an internal rate of return of 289.76%. This process depends on strategic partnerships with fisheries, bandage manufacturers, and packaging & sterilization companies. The major limitation for the expansion of this process is the bleeding of the fish. Unless a more efficient and less labor intensive method to bleed the fish is developed, it will be difficult to produce more than 300,000 bandages per year at a lower price. For future considerations, a robotic system using infrared or ultrasound guided detection of the veins within the fish could automate the bleeding process. This is a grandiose idea that is out of the scope of this project but would increase the feasibility of this process. Another recommendation would be to consider selling excess thrombin instead of disposing of 80% of the prothrombin that is extracted from the fish to further improve profit. The revenue from selling extra thrombin may exceed costs of larger equipment in the long term, which would make it a profitable decision. Ultimately, it is recommended that this process should be created as a new facility.

18. Acknowledgements

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20. Appendices

Appendix A: Calculations

A.1 Immobilized Enzyme Column Analysis and Calculations

Analysis of the column begins with the type of resin and the binding capacity of the resin: AminoLink Plus Resin from Thermo Scientific. Of course, binding capacity depends on the catalyst of interest (which would need to be determined from lab scale tests). But the website says that the typical range is 1-20 mg of catalyst bound per mL of resin. Using the lower end of the range, it was assumed that 1 mg of our snake venom binds per mL of resin.

$$r = \frac{v_{max} S}{K_m + S}$$

$$S = prothrombin\ concentration = \frac{N}{Q} = \frac{moler\ flow\ of\ prothrombin}{volumetric\ flow\ rate}$$

$$K_m = 166 \mu M$$

$$v_{max} = \frac{2.5\ \mu mol\ prothrombin}{min * mg\ of\ venom} = \frac{2.5\ \mu mol\ prothrombin}{min * mL\ of\ resin}$$

Let Q = 40L/hr. 20 L of prothrombin must be processed, so the operation should take 30 min.

The packed bed differential equation becomes:

$$\frac{dN}{dV} = (1-\varepsilon) r = (1-\varepsilon) \frac{v_{max} N/Q}{K_m + N/Q}$$

Where ε is the bed void volume. It was assumed to be 0.4 for now, since that is a typical value.

$$\int_{Ni}^{0.01Ni} \left(\frac{K_m Q}{v_{max} N} + \frac{1}{v_{max}} \right) dN = (1 - 0.4) \int_0^V dV$$

$$\frac{K_m Q}{v_{max}} = 166 \frac{\mu mol}{L} * \frac{2}{3} \frac{L}{min} * \frac{min * L\ resin}{2500\ \mu mol\ prothrom} = 0.044266\ L\ of\ resin$$

$$\frac{1}{v_{max}} = \frac{min * L\ resin}{2500\ \mu mol} = 0.0004\ \frac{min * L\ resin}{\mu mol}$$

The initial solution contains 694 micromole of prothrombin in 20 L. If Q =40 L/hr, then N_i = 23.133 micromole per min. The bounds on the integral are 23.133 micro-mole/min to 0.231 micromole/min.

$$\int_{23.133}^{0.231} \left(\frac{0.044266}{N} + 0.0004 \right) dN = 0.044266 \ln(N) + 0.0004N = 0.6V$$

Plugging in the bounds gives V = 355 mL. This corresponds to 355 mg of venom needed.

NB: The reactor volume is scaled up about 4 times to take into account reductions in the reaction rate. The column size is doubled to account for external mass transfer limitations, and then doubled again to account for any binding of fibrinogen to the resin, including a safety factor to ensure 99% conversion. So volume of the bed is 1.6 L, and 1.6 g of venom are needed.

A.2. Blood Collection Tank Calculations

To calculate the cost and energy usage of the vacuum system for the blood collection tank, it was first necessary to calculate the allowable pressure drop within the tubes of the tank. It is known that the fastest a salmon can be bled is 5 minutes. Anything faster will cause a large enough pressure drop to collapse the veins of the salmon.

Other known quantities for these calculations:

- Number of fish per tank, *N:* 5,000
- Time to fill tank, *t:* 6 hours
- Volume of citrated blood in tank, V_b: 260 L
- Volume of tank, V_t: 390 L

Number of Fish at One Time = $\frac{N}{t} \times 5\ min = 70$ fish must be bled at once

Because 70 fish are bled simultaneously, each vacuum tank will have 70 tubes connected to syringes. One tank will be filled in the first shift, and one tank will be filled in the second shift.

Pressure Drop in Each Tube

It is known that the average blood pressure in salmon blood vessels is 94.5 Torr and that removing blood at a rate faster than 5 minutes per fish requires too high of a pressure drop.

$$\text{Volumetric flow rate per tube, } Q = \frac{1}{70} \times \frac{V_b}{t} = 9.5 \times 10^{-6}\ m^3/s$$

Each tube is 0.5 m long (L) and has a 1 cm inner diameter (D).

$$\text{Tube cross sectional area, } A = \frac{\pi D^2}{4} = 7.85 \times 10^{-5}\ m^2/s$$

$$\text{Linear velocity in each tube, } u = \frac{Q}{A} = 0.121\ m/s$$

Blood has a dynamic viscosity (μ) of 0.0035 Pa·s and a density (ρ) of 1,060 kg/m^3.

$$\text{Kinematic viscosity, } v = \frac{\mu}{\rho} = 3.3 \times 10^{-6}\ m^2/s$$

Reynolds number, $Re = \frac{uD}{v} = 367.25$

This Reynolds number is less than 2,320, which places flow in the laminar regime.

For laminar flow through a circular pipe, the friction factor, $\lambda = 64/\mathrm{Re} = 0.17$

Using these values, a pressure drop in the pipe, ΔP, can be calculated, according to the following equation: $\Delta P = \frac{\lambda L}{D} \times \frac{\rho}{2} \times u^2 = 67.9\ Pa = 0.5\ Torr$

This means that the minimum allowable pressure in the vacuum tank, P, is 94 Torr.

Knowing the pressure in the vacuum tank allows a vacuum system to be designed appropriately.

Purchase Cost

First, the amount of air leakage is calculated according to equation 22.73 in *Product and Process Design Principles: Synthesis, Analysis and Evaluation*.

$$W = 5 + \{0.0298 + 0.03088[\ln P] - 0.0005733(\ln P)^2 \times V_t^{0.66} = 5.9\ lb/hr$$

Where P is in Torr and V_t is in ft^3.

The vacuum system will use a one-stage water sealed liquid-ring pump, with an efficiency, η, of 40%. It will be constructed of 316L stainless steel (for a material factor, F_M, of 2.5), and based on a CE factor of 567(giving CE adjustment, C_E, of 567/500).

The flow at suction of the vacuum system, S, is 10.4 ft^3/min (from W).

Using Table 22.32 in *Product and Process Design Principles: Synthesis, Analysis and Evaluation*, the purchase cost of this system will be:

$$C_p = C_r \times F_M \times 8250 \times S^{0.35} = \$53{,}000$$

Electricity Usage

Vacuum systems work by compressing the incoming air leakage gas and pumping it out.

Using Equation 6.1 in *Product and Process Design Principles: Synthesis, Analysis and Evaluation*, the theoretical horsepower, THp, of compressing a gas from P_1 (pressure in the vacuum tank, P) to P_2 (atmospheric pressure) with a temperature in the tank, T_1, is:

$$TH_p = SCFM\left(\frac{T_1}{8130a}\right)\left[\left(\frac{P_2}{P_1}\right)^a - 1\right]$$

Where $a = \frac{k-1}{k}$, $k = \frac{C_p}{C_v}$, and T_1 is in Rankine and both pressures are in the same absolute units. SCFM is the standard cubic feet of gas per minute at 60 °F and 1 atm. Assuming the vacuum system is handling pure air (molecular weight = 29.97) and that the air behaves ideally (k=1.4), the theoretical horsepower of the vacuum system is 0.22 Hp.

The actual power of the pump is equal to $\frac{TH_p}{\eta}$ = 0.55 Hp.

One unit of electrical horsepower is equal to 746 W. Assuming each vacuum system runs for 6 hours per day, 7 days per week:

Daily Electricity Usage per Vacuum: 2.44 kWh

Annual Total Electricity Usage: 1,610 kWh

A.3 Pressure Drops in Columns

To determine pressure drops in all packed bed columns in this process, the Ergun equation was used:

$$\Delta p = \frac{150\mu L}{D_p^2}\frac{(1-\varepsilon)^2}{\varepsilon^3}v_s + \frac{1.75L\rho}{D_p}\frac{(1-\varepsilon)}{\varepsilon^3}v_s^2$$

$\mu =$ Dynamic viscosity
$\rho =$ Density
$L =$ Height of the packed bed
$D_p =$ Diameter of bed resin
$\varepsilon =$ Void fraction of bed
$v_s =$ Superficial velocity of fluid

The following charts are these values for the four columns in this process. Plugging in numbers into the Ergun equation provides the pressure drop.

Density and dynamic viscosities were assumed to be the same as water. Void fraction cannot be known, and must be determined by lab scale experiments. However, beds composed of particles of similar size usually have void fractions of 0.2-0.3. All pressure drops were found to be reasonable.

Fibrinogen Endotoxin Removal Column		
Viscosity	0.0015	kg/(m*s)
Density	1000	kg/m^3
Particle Diameter	0.0001	m
Bed Height	0.177	m
Volumetric Flow Rate	0.000348	m^3/s
Superficial Velocity	0.00123	m/s
Void Fraction	0.25	
Pressure Drop	176576.1	Pa
Pressure Drop	1.765761	bar

Thrombin Endotoxin Removal Column		
Viscosity	0.0015	kg/(m*s)
Density	1000	kg/m^3
Particle Diameter	0.0001	m
Bed Height	0.266	m
Volumetric Flow Rate	0.000023	m^3/s
Superficial Velocity	0.00148	m/s
Void Fraction	0.25	
Pressure Drop	318650	Pa
Pressure Drop	3.186	bar

Heparin Column		
Viscosity	0.0015	kg/(m*s)
Density	1000	kg/m^3
Particle Diameter	0.00009	m
Bed Height	0.297	m
Volumetric Flow Rate	-	
Superficial Velocity	0.000694	m/s
Void Fraction	0.25	
Pressure Drop	2063830	Pa
Pressure Drop	2.064	bar

Snake Venom Column		
Viscosity	0.001002	kg/(m*s)
Density	1000	kg/m^3
Particle Diameter	0.0001	m
Bed Height	0.204	m
Volumetric Flow Rate	1.111E-05	m^3/s
Superficial Velocity	0.00141	m/s
Void Fraction	0.25	
Pressure Drop	156499	Pa
Pressure Drop	1.565	bar

A.4. Heat Exchanger Calculations

Heat Exchanger Fluid Properties				
	Prothrombin Solution	**Hot Water**	**Thrombin Solution**	**Chilled Brine**
T_{in} (°F)	39.20	200.00	73.40	0.00
T_{out} (°F)	73.40	171.41	39.20	7.24
ΔT (°F)	-34.20	28.59	34.20	-7.24
C_p (BTU/lb_m·°R)	0.84	1.00	0.84	0.79
m (lb_m)	45.08	45.08	45.08	225.42
ρ (lb_m/ft^3)	62.40	62.40	62.40	62.40
μ (lb_f·s/ft^2)	3.228×10^{-5}	3.228×10^{-5}	3.228×10^{-5}	3.228×10^{-5}
k (Btu/(hr·ft·°F))	0.280	0.335	0.280	0.265

To calculate the size of the heat exchangers, we first performed a preliminary energy balance based on suggested design overall heat transfer coefficients (U, BTU/hr·ft^2·°F), from *Product and Process Design Principles* and a temperature driving force (ΔT_{LM}).

$$\Delta T_{LM} = \frac{\Delta T_1 - \Delta T_2}{\ln\left(\frac{\Delta T_1}{\Delta T_2}\right)}$$

where
$\Delta T_1 = T_{h,out} - T_{c,in}$
$\Delta T_2 = T_{h,in} - T_{c,out}$

To determine the area needed for heat transfer, the heat transfer energy, Q, was calculated using:
$Q=mC_p\Delta T$
Where m equals the mass of either the thrombin or prothrombin stream, C_p is the specific heat and ΔT is the target change in temperature of the stream.

The heat transfer area, A, was calculated based on the suggested overall heat transfer coefficient in *Product and Process Design Principles.*

$$A = \frac{Q}{UF_T\Delta T_{LM}}$$

This initial area was used to calculate the preliminary heat exchanger geometry.

A countercurrent double-pipe heat exchanger was used because the heat transfer areas were much less than 200 ft^2.

The linear flow rate through the inner pipe (u_{in}) and the pipe types were arbitrarily chosen. Pipe dimensions came from Table 18.3 in *Product and Process Design Principles.* Pipe geometries are described by:
Outer diameter of the inner pipe: D_o
Inner diameter of the inner pipe: D_i
Wall thickness: $t_w = (D_o - D_i)/2$

Inner cross sectional area of the inner pipe: A_i
Outer cross sectional area of the inner pipe: A_o
Length: L
Inner diameter of the outer pipe: D_2
Hydraulic diameter of double pipe: $D_H = D_2 - D_o$

Using these dimensions and the mass of the material flowing through the inner (m_{in}) and annular (m_{out}) regions, the linear flow rate through the outer pipe, u_{out}, was calculated:

$$u_{out} = \frac{u_{in} D_i^2}{(D_2^2 - D_o^2)} \frac{m_{out}}{m_{in}}$$

The heat transfer area per linear foot of pipe was calculated using D_o ($\pi \cdot D_o$). This was used to determine the length of the pipe:

$$L = \frac{A}{\pi \cdot D_o}$$

These preliminary values were used to calculate dimensionless numbers and heat transfer coefficients, based on the methods of Gnielinski described in *Product and Process Design Principles*.

The following calculations were performed on the fluid traveling through the inner pipe (either prothrombin solution in HX-01 or thrombin solution in HX-02).

Reynolds Number:

$$Re = \frac{D_i G}{\mu}$$

where G is the mass flux and μ is the viscosity.

Prandtl Number:

$$Pr = \frac{C_P \mu}{k}$$

where C_p is the specific heat of the fluid and k is the thermal conductivity.

The Gnielinski correlations for determine heat transfer coefficients are valid for fluids with Re and Pr between 2,300 and 1,000,000, and 0.6 and 2,000, respectively.

The friction factor, f_D was calculated as:

$$f_D = [1.82 \log_{10} Re - 1.64]^{-2}$$

The Nusselt number was then determined to be:

$$Nu_{inner} = \frac{(f_D/8)(Re - 1000)Pr}{1 + 12.7\sqrt{f_D/8}\,(Pr^{2/3} - 1)} \times \left(1 + \left({}^{D_i}/_{L}\right)^{2/3}\right)$$

Knowing the Nusselt number allowed for the heat transfer coefficient for the inside surface of the inner pipe, h_i using the following relation:

$$Nu_{inner} = \frac{h_i D_i}{k}$$

The Nusselt number of the inner pipe was used to calculate the Nusselt number and heat transfer coefficient, h_o, in the outer pipe using the following formulas:

$$\frac{Nu_{outer}}{Nu_{inner}} = 0.86\left(\frac{D_o}{D_2}\right)^{-0.16}$$

$$Nu_{outer} = \frac{h_o D_H}{k}$$

With these numbers calculated, the overall heat transfer coefficient can be calculated, based on the outside area of the inner pipe.

$$\frac{1}{U_o} = R_{f,o} + \frac{1}{h_o} + \frac{t_w A_o}{k_w A_m} + \frac{A_o}{h_i A_m} + R_{fi}\frac{A_o}{A_i}$$

R_{fi} and R_{fo} are the resistances due to fouling at the inner and outer surfaces of the inner pipe, respectively. We assumed that there would be no fouling on the outer wall of the pipe in both cases, and calculated with an R_{fi} = 0.003 hr·ft^2·°F/Btu, as recommended in *Product and Process Design Principles.*

Other previously undefined variables in the above heat transfer coefficient equation are:
t_w = wall thickness
k_w = thermal conductivity of 316L stainless steel = 28.1 Btu/(hr·ft^2·°F)
D_m = mean of D_i and D_o
A_m= area based on D_m

An iterative calculation process then began. The calculated U was then used to redefine the initial guess U, until the two values varied by less than 1%.

After the heat exchanger geometries were finalized, the pressure drops for fluids in the inner tubes were calculated using the following formula:

$$-\Delta P = \frac{f_D G^2 L}{2 g_c \rho D_i}$$

The same formula was used to calculate pressure drops for the fluids flowing in the annular regions between the inner and outer pipes by replacing D_i with D_H.

Appendix B: Reagent Compositions

Reagents				
Reagent	**Storage Tank**	**Components (MW)**	**Mass (kg/batch)**	**Final Concentration in Process Stream**
Citrate Anticoagulant	T-01	Sodium Citrate Dihydrate (294.1)	21.41	20 mM
		WFI	140 L/batch	-
Benzamidine Hydrochloride	T-05	Benzamidine Hydrochloride (156.61)	3.84	10 mM
		WFI	24.5 L/batch	-
Barium Chloride	T-04	Barium Chloride (208.23)	76.67	150 mM
		WFI	368 L/batch	-
Tris Resuspension Buffer (pH 7.5)	T-11	Tris (121.14)	0.05	20 mM
		Sodium Chloride (58.44)	0.18	150 mM
		EGTA (380.35)	0.0078	1 mM
		WFI	20	-
Ammonium Sulfate Buffer (pH 7.3)	T-06	Ammonium Sulfate (132.14)	363.83	912 mM
		Ammonia (17.03)	0.59	11 mM
		Sodium Chloride (58.44)	6.03	34 mM
		WFI	688 L/batch	-
Citric Acid Buffer (pH 7.3)	T-07	Trisodium Citrate (214.11)	1.07	10 mM
		Citric Acid (192.12)	4.81 mg/batch	50 nM
		Sodium Chloride (58.44)	2.93	100 mM
		L-lysine (146.19)	0.073	1 mM
		WFI	501 L/batch	-
Endotoxin Wash/Elution Buffers	T-09, T-16	Sodium Deoxycholate (392.57)	5.41	1% w/v
		WFI	541 L/batch	-
Heparin Wash Buffer	T-13	Tris-HCl (157.6)	0.322	0.1 M
		Trisodium Citrate (294.1)	0.06	0.01 M
		NaCl (58.44)	0.329	0.275 M
		WFI	20.45 L/batch	-
Heparin Elution Buffer	T-14	Tris-HCl (157.6)	0.322	0.1 M
		Trisodium Citrate (294.1)	0.06	0.01 M
		NaCl (58.44)	2.39	2 M
		WFI	20.45 L/batch	

Snake Venom Reactor Wash Buffer	T-12.1	PBS Packets (Sigma)	38.4 packets/batch	pH 7.2
		WFI	19.2 L/batch	-
Snake Venom Reactor Sodium Azide Solution	T-12.2	Sodium Azide	0.0032	0.05% w/v
		WFI	6.4 L/batch	-

Snake Venom Immobilization Buffers			
Buffer	Components	Amount per Immobilization	Concentration
pH 7.2 Coupling Buffer and Wash (PBS)	PBS Packets	35.2 packets	pH 7.2
	WFI	17.6 L	
Sodium Azide in Wash Solution	Sodium Azide	2.4 g	0.05% w/v
	PBS Packets	9.6 packets	pH 7.2
	WFI	4.8 L	
Quenching Buffer	Tris-HCl	.504 kg	1 M
	WFI	3.2 L	
AminoLink Reductant Solution	Sodium Cyanoborohydride	20.1 g	5 M
	1 M NaOH	0.064 L	1 M

These buffers only need to be used approximately 5 times per year. The reactor resin is replaced after every 10 uses, at which point, more venom must be immobilized.

Appendix C: CIP and SIP Procedures

C.1. Standard Sterilization Procedure

The typical protocol for sterilization of tanks and the associated piping and pumps involves SIP spraying steam at 152°C at 3 lb per hr per square foot for approximately 30 minutes. This is followed by the subsequent CIP protocol:

1. WFI Pre-rinse: Half the volume of the vessel of WFI rinses the vessel for about 10 minutes.
2. Caustic Wash: The vessel is sprayed with half the volume of the vessel of 0.5 M NaOH for half an hour.
3. WFI Post-rinse: Step 1 is repeated to wash out the base.
4. Acid Wash: Half the volume of the vessel of 5% H_3PO_4 is sprayed in the vessel for half an hour.
5. WFI Post-rinse: Step 1 is repeated to wash out the acid.
6. Final WFI-Rinse: Step 1 is repeated to complete the process.

C.2. CIP for Heparin Column

After each batch, the heparin column should be cleaned according to the following sterilize and clean in place procedures.

Sterilize in Place: Rinse the column once with 20.45 L of each of the following solutions.

1) 0.1 M NaOH
2) 20% Ethanol
3) Heparin Column Wash Buffer

Clean in Place: Rinse the column once with 20.45 L of each of the following solutions.

1) 2 M NaCl
2) Heparin Column Wash Buffer

C.3. CIP for Snake Venom Reactor

After each batch, the snake venom reactor should be cleaned according to the following clean in place procedure.

Rinse the column once with 20.45 L of each of the following solutions.

1) 1 M NaCl
2) Snake Venom Reactor Wash Buffer (phosphate buffered saline)

C.4. CIP for Endotoxin Removal Columns

After each batch, the endotoxin removal columns should be cleaned according to the following clean in place procedure.

Rinse the column once with five resin bed volumes of each of the following solutions.

1) Endotoxin Removal Wash Buffer (1% sodium deoxycholate)
2) Water for Injection
3) 10% Ethanol
4) Endotoxin Removal Wash Buffer

C.5. CIP for Sprayers

After each batch, the sprayers should be cleaned according to the following clean in place procedure.

Run the following solutions through the spray systems. All solutions run through the fibrinogen sprayer should be equal in volume to five resin bed volumes of the fibrinogen endotoxin removal column. Likewise, five resin bed volumes of the thrombin endotoxin removal column should be run through the thrombin sprayer.

1) 2 M NaCl
2) Water for Injection
3) An additional round of Water for Injection

C.6. CIP for Ultrafiltration

After each batch, the ultrafiltration cassettes should be cleaned according to the following clean in place procedure.

Run the following solutions through the cassettes. All solutions run through the fibrinogen cassettes should be equal in volume to five resin bed volumes of the fibrinogen endotoxin removal column. Likewise, five resin bed volumes of the thrombin endotoxin removal column should be run through the thrombin cassettes.

1) 1% NaCl Solution
2) Ultrafiltration Caustic Cleaning Solution (1 M NaOH, 12.5% NaOCl)
3) Water for Injection

Appendix D: Profitability Analysis

General Information

Product:	DiamondStat
Plant Site Location:	Chile
Site Factor:	0.85
Operating Hours per Year:	7919
Operating Days Per Year:	330
Operating Factor:	0.9040

Assumptions

Production Capacity	90%	of Design Capacity
Start production at	50%	of Production Capacity
Years to achieve full capacity	2	
Number of Shifts	3	
Income Tax Rate	37%	
Cost of Capital	15%	
General Inflation Rate	4%	

Product Information

This Process will Yield	38	bandage of DiamondStat per hour
	909	bandage of DiamondStat per day
	300,000	bandage of DiamondStat per year
Price	$800.00	/bandage

Chronology

Year	Action	Distribution of Total Permanent Investment	Production Capacity	Depreciation (5 year MACRS)	Product Price
2015	Design		0.0%		-
2016	Construction	75%	0.0%		-
2017	Construction	25%	0.0%		-
2018	Production	0%	45.0%	20.00%	$800.00
2019	Production	0%	67.5%	32.00%	$832.00
2020	Production		90.0%	19.20%	$865.28
2021	Production		90.0%	11.52%	$899.89
2022	Production		90.0%	11.52%	$935.89
2023	Production		90.0%	5.76%	$973.32
2024	Production		90.0%		$1,012.26
2025	Production		90.0%		$1,052.75
2026	Production		90.0%		$1,094.86
2027	Production		90.0%		$1,138.65
2028	Production		90.0%		$1,184.20
2029	Production		90.0%		$1,231.56
2030	Production		90.0%		$1,280.83
2031	Production		90.0%		$1,332.06
2032	Production		90.0%		$1,385.34

Fixed Cost Summary

Operations	
Direct Wages and Benefits	$3,244,800
Direct Salaries and Benefits	$486,720
Operating Supplies and Services	$194,688
Technical Assistance to Manufacturing	$540,000
Control Laboratory	$585,000
Total Operations	**$5,051,208**
Maintenance	
Wages and Benefits	$152,338
Salaries and Benefits	$38,084
Materials and Services	$152,338
Maintenance Overhead	$7,617
Total Maintenance	**$350,376**
Operating Overhead	
General Plant Overhead:	$278,458
Mechanical Department Services:	$94,127
Employee Relations Department:	$231,395
Business Services:	$290,224
Total Operating Overhead	**$894,203**
Property Taxes and Insurance	
Property Taxes and Insurance:	**$67,706**
Other Annual Expenses	
Rental Fees (Office and Laboratory Space):	$0
Licensing Fees:	$0
Miscellaneous:	$364,400
Total Other Annual Expenses	**$364,400**
Total Fixed Costs	***$6,727,893***

Variable Cost Summary

Variable Costs at 100% Capacity:

General Expenses

Selling / Transfer Expenses:	$2,400,000
Direct Research:	$11,520,000
Allocated Research:	$1,200,000
Administrative Expense:	$4,800,000
Management Incentive Compensation:	$3,000,000
Total General Expenses	**$22,920,000**

Production Expenses

Raw Materials	$87.12	per bandage	$26,136,000
Byproducts	-$0.18	per bandage	$54,506
Utilities	$3.36	per bandage	$1,007,828
Total Production Expenses			$27,198,634

Total Variable Costs	***$50,118,634***

Investment Summary

Installed Equipment Costs:	
Total Direct Materials and Labor Costs	$100,500
Miscellaneous Installation Costs	$2,500,300
Material and Labor G&A Overhead and Contractor Fees	$0
Contractor Engineering Costs	$0
Indirect Costs	$0
Total Installed Equipment Costs	**$2,600,800**
Direct Permanent Investment	
Cost of Site Preparations:	$130,040
Cost of Service Facilities:	$130,040
Allocated Costs for Sterilization Verification:	$8,000
Direct Permanent Investment	**$2,860,880**
Total Depreciable Capital	
Cost of Contingencies & Contractor Fees	$516,398
Total Depreciable Capital	**$3,385,278**
Total Permanent Investment	
Cost of Land:	$67,706
Cost of Royalties:	$0
Cost of Plant Start-Up:	$338,528
Total Permanent Investment - Unadjusted	$3,791,512
Site Factor	0.85
Total Permanent Investment	**$3,222,785**

Profitability Measures

IRR	289.76%
Discount Rate	15%
Net Present Value	$ 489,514,100

ROI Analysis (Third Production Year)	
Annual Sales	$233,625,600
Annual Costs	($56,064,372)
Depreciation	($257,634)
Income Tax	($65,602,330)
Net Earnings	$111,701,264
Total Capital Investment	$21,148,245
ROI	528.18%

Raw Materials

Raw Material	Cost per Bandage
Resins	$0.977
Catalyst	$0.143
Salts for Buffers	$1.421
Liquid Solutions	$2.130
Packaging of Bandage	$1.450
Gamma Irradiation	$1.000
Bandage Partnership	$80.000
Total Weighted Average:	$87.121

Utilities

Utility	Unit:	Utilities per bandage	Utility Cost per Bandage
Electricity	kWh	0.8889	$0.090
150-psig Steam	lb	0.48	$0.0029
Pharma-Grade Process Water	L	16.78	$3.26
Chilled Water	m^3	0.000016	$0.0000007
Total Weighted Average:			$3.359

Byproducts

Byproduct:	Unit	Ratio to Product		Byproduct Selling Price	
Blood Cell Waste	kg	0.28	kg	-$0.500	per kg
Prothrombin Waste	kg	0.013	kg	-$0.220	per kg
Centrifuge Solution Waste	L	0.47	L	-$0.033	per L
Endotoxin Waste	L	0.085	L	-$0.033	per L
Heparin Waste	L	0.006	L	-$0.033	per L
Reactor Waste	L	0.00357	L	-$0.033	per L
Ultrafiltration Waste	L	0.612	L	-$0.033	per L
Total Weighted Average:				-$0.182	per bandage

Appendix E: Equipment Cost List

Holding Tanks						
	Item Number	No. of Units	Purchase Cost	Bare Module Factor	Total Bare Module Cost	Source of Prices*
Sodium Citrate Holding Tank	T-01	1	$1,150	2	$2,300	Purchase Cost Equations
Blood Collection Vacuum Tank System	T-02	2	$116,600	2	$233,200	Purchase Cost Equations
Plasma Storage Container	T-03	14	$18,350	2	$36,700	Purchase Cost Equations
Barium Chloride Holding Tank	T-04	1	$6,500	2	$13,000	Purchase Cost Equations
Benzamidine HCl Holding Tank HCl Stock	T-05	1	$1,300	2	$2,600	Purchase Cost Equations
Ammonium Sulfate Holding Tank	T-06	1	$9,500	2	$19,000	Purchase Cost Equations
Fibrinogen Resuspension Buffer Holding Tank	T-07	1	$7,850	2	$15,700	Purchase Cost Equations
Fibrinogen Ultrafiltration Dilutant Holding Tank	T-08	1	$25,200	2	$50,400	Purchase Cost Equations
Fibrinogen Endotoxin Removal Holding Tank (elution and wash buffer)	T-09	1	$7,850	2	$15,700	Purchase Cost Equations
Purified Fibrinogen Solution Holding Tank	T-10	1	$5,150	2	$10,300	Purchase Cost Equations
Prothrombin Resuspension Buffer Holding Tank	T-11	1	$1,150	2	$2,300	Purchase Cost Equations
Reactor Wash Buffer Holding Tank	T-12.1	1	$1,100	2	$2,200	Purchase Cost Equations
Reactor Sodium Azide Solution Holding Tank	T-12.2	1	$550	2	$1,100	Purchase Cost Equations
Heparin Wash Buffer Holding Tank	T-13	1	$1,150	2	$2,300	Purchase Cost Equations
Heparin Elution Buffer Holding Tank	T-14	1	$1,150	2	$2,300	Purchase Cost Equations
Thrombin Ultrafiltration Dilutant Holding Tank	T-15	1	$3,700	2	$7,400	Purchase Cost Equations
Thrombin Endotoxin Removal Holding Tank	T-16	1	$1,750	2	$3,500	Purchase Cost Equations

(elution and wash buffer)						
Purified Thrombin Solution Holding Tank	T-17	1	$1,150	2	$2,300	Purchase Cost Equations
Waste Tanks						
	Item Number	**No. of Units**	**Purchase Cost**	**Bare Module Factor**	**Total Bare Module Cost**	**Source of Prices***
Blood Waste Tank	W-00	1	$4,850	2	$9,700	Purchase Cost Equations
Centrifuge Waste Tank	W-01	1	$22,900	2	$45,800	Purchase Cost Equations
Fibrinogen Ultrafiltration Waste Tank	W-02	1	$26,250	2	$52,500	Purchase Cost Equations
Fibrinogen Endotoxin Waste Tank	W-03	1	$7,850	2	$15,700	Purchase Cost Equations
Excess Prothrombin Pellet Waste Tank	W-04	1	$2,200	2	$4,400	Purchase Cost Equations
Reactor Waste Tank	W-05	1	$1,300	2	$2,600	Purchase Cost Equations
Heparin Waste Tank	W-06	1	$1,750	2	$3,500	Purchase Cost Equations
Thrombin Ultrafiltration Waste Tank	W-07	1	$3,700	2	$7,400	Purchase Cost Equations
Thrombin Endotoxin Waste Tank	W-08	1	$1,750	2	$3,500	Purchase Cost Equations
Mixing Tanks						
	Item Number	**No. of Units**	**Purchase Cost**	**Bare Module Factor**	**Total Bare Module Cost**	**Source of Prices***
Barium Chloride Precipitation Tank	M-01	1	$75,200	3.9	$293,400	Purchase Cost Equations
Ammonium Sulfate Precipitation Tank	M-02	1	$81,150	3.9	$316,100	Purchase Cost Equations
Fibrinogen Resuspension Tank	M-03	1	$39,600	3.9	$154,500	Purchase Cost Equations
Prothombin Resuspension Tank	M-04	1	$19,400	3.9	$75,600	Purchase Cost Equations

Centrifuges						
	Item Number	No. of Units	Purchase Cost	Bare Module Factor	Total Bare Module Cost	Source of Prices*
Blood Centrifuge	CE-01	1	$178,600	2.03	$362,500	Purchase Cost Equations
Solution Centrifuge	CE-02	1	$184,700	2.03	$374,900	Purchase Cost Equations
Columns						
	Item Number	No. of Units	Purchase Cost	Bare Module Factor	Total Bare Module Cost	Source of Prices*
Fibrinogen Endotoxin Removal Column	CO-01	1	$120,000	4.16	$499,200	Manufacturer Quote
Snake Venom Reactor	CO-02	1	$5,400	4.16	$22,500	Manufacturer Quote
Heparin Column	CO-03	1	$20,000	4.16	$83,000	Manufacturer Quote
Thrombin Endotoxin Removal Column	CO-04	1	$17,000	4.16	$70,700	Manufacturer Quote
Finishing Equipment						
	Item Number	No. of Units	Purchase Cost	Bare Module Factor	Total Bare Module Cost	Source of Prices*
Fibrinogen Sprayer System	F-01	1	$13,600	3.3	$45,000	Manufacturer Quote
Fibrinogen Conveyor Belt	F-02	1	$25,600	3.3	$84,600	Manufacturer Quote
Thrombin Sprayer System	F-03	1	$21,800	3.3	$72,100	Manufacturer Quote
Thrombin Conveyor Belt	F-04	1	$25,600	3.3	$84,600	Manufacturer Quote
Freeze Dryer	F-05	3	$300,000	2.06	$618,000	Manufacturer Quote
Automated Packaging	F-06	1	--	--	$1.45 per bandage	Manufacturer Quote
Gamma Irradiation Sterilization	F-07	1	--	--	$30,000 (one-time fee), $1.00 per bandage	Manufacturer Quote
Trays for Spray/Conveyor System	--	84	$17,100	1	$17,100	Manufacturer Quote

Ultrafiltration						
	Item Number	**No. of Units**	**Purchase Cost**	**Bare Module Factor**	**Total Bare Module Cost**	**Source of Prices***
Fibrinogen Ultrafiltration Feed Tank	UF-01	1	$27,300	2	$54,600	Puchase Cost Equations
Fibrinogen Ultrafiltration Cassettes	UF-02	60	$124,900	2.32	$289,800	Manufacturer Quote
Thrombin Ultrafiltration Feed Tank	UF-03	1	$4,000	2	$8,000	Puchase Cost Equations
Thrombin Ultrafiltration Cassettes	UF-04	3	$32,100	2.32	$74,500	Manufacturer Quote
Fibrinogen Cassette Holders	--	6	$120,000	1	$120,000	Manufacturer Quote
Thrombin Cassette Holders	--	1	$15,800	1	$15,800	Manufacturer Quote
Miscellaneous						
	Item Number	**No. of Units**	**Purchase Cost**	**Bare Module Factor**	**Total Bare Module Cost**	**Source of Prices***
Freezer	E-01	1	$70,000	2.17	$151,900	Manufacturer Quote
Pellet Splitter	E-02	1	$200	1	$200	Online Price Quote
CIP System	--	1	$500,000	2.17	$1,085,000	Manufacturer Quote
Pumps						
	Item Number	**No. of Units**	**Purchase Cost**	**Bare Module Factor**	**Total Bare Module Cost**	**Source of Prices***
All Pumps	PP-1 – PP-38	38	$170,300	3.3	$562,000	Online Price Quote
Heat Exchangers						
	Item Number	**No. of Units**	**Purchase Cost**	**Bare Module Factor**	**Total Bare Module Cost**	**Source of Prices***
Prothrombin Heating Heat Exchanger	HX-01	1	$4,700	1.8	$8,460	Purchase Cost Equations
Thrombin Cooling Heat Exchanger	HX-02	1	$6,200	1.8	$11,160	Purchase Cost Equations

Appendix F: Purchase Cost Equations

All equations were taken from *Product and Process Design Principles: Synthesis, Analysis and Evaluation*. Purchase equations in this textbook are based on a CE index of 500, which gives 2006 prices. To adjust prices to 2015 prices, CE = 567, all purchase cost equations were multiplied by a factor of (567/500).

Vacuum System for Blood Collection Tank

One-stage water sealed liquid-ring pump made of 316L stainless steel. The purchase cost equation in *Product and Process Design Principles* considers vacuum systems constructed with stainless steel. To account for the more expensive electropolished stainless steel required in biopharmaceutical processing, the purchase cost equation was multiplied by a material factor equal to the ratio of the price of electropolished stainless steel to standard stainless steel (2.5/2.1).

$$C_p = 1{,}690S^{0.41} \times (567/500) \times (2.5/2.1) = \$53{,}050$$

Where S, the size factor, is the flow at suction in ft^3/min. S can be calculated from the inlet air leakage, W:

$$W = 5 + \{0.0298 + 0.03088[\ln(P)] - 0.0005733 \times [\ln(P)]^2\}V_t^{0.66}$$

Where P is the vacuum pressure in torr and V_t is the volume of the tank in ft^3.

The purchase cost was multiplied by a bare module factor of 3.30, taken from Table 22.11 in *Product and Process Design Principles.*

Conveyor Belts for the Fibrinogen and Thrombin Spray Systems

Both conveyor belts are to be custom-designed and purchased from Bastian Solutions.

The purchase cost of the conveyor belt, which does not include the motor or drive, was calculated as:

$$C_p = 21.5WL \times (567/500)$$

Where W is the width in inches and L is the length of the belt in feet. The purchase costs were multiplied by a bare module factor of 1.61, taken from Table 22.11 in *Product and Process Design Principles,* to find the total bare module costs of the two conveyor belts.

The motors for the conveyor belt systems are open, drip-proof enclosure 1800 rpm motors with capacities of 1 to 700 Hp. All metal components of the motors are 316L stainless steel. The purchase cost of the motor was calculated as:

$$C_p = 0.09 \times \exp\{5.8259 + 0.13141[\ln(P_c)] + 0.053255[\ln(P_c)]^2 + 0.028628[\ln(P_c)]^3 - 0.0035549[\ln(P_c)]^4\} \times (567/500) \times (2.5/2.1)$$

A bare module factor of 3.3 was used to calculate total bare module costs of the electric motors.

Centrifuges

There are two centrifuges used in the purification of salmon fibrinogen and thrombin for the DiamondStat bandage. Both centrifuges are constructed of 316L stainless steel. To adjust the purchase cost equations, which consider centrifuges of standard stainless steel, the same material factor used in the vacuum system, (2.5/2.1) was used.

The centrifuge for the crude blood (Carr Centritech, Viafuge Pilot Centrifuge), CE-01, is a continuous scroll solid bowl. The purchase cost of which is calculated as:

$$C_p = 60{,}000S^{0.50} \times (567/500) \times (2.5/2.1)$$

Where S is the tons of solid per hour.

The other centrifuge used in the process, CE-02, is a continuous reciprocating pusher centrifuge. The purchase cost of CE-02 is:

$$C_p = 150{,}000S^{0.30} \times (567/500) \times (2.5/2.1)$$

Where S is also the tons of solid per hour.

The purchase costs were multiplied by a bare module factor of 2.03, taken from Table 22.11 in *Product and Process Design Principles,* to find the total bare module costs of the two centrifuges.

Holding Tanks, Waste Tanks and Ultrafiltration Feed Tanks

The holding tanks, waste tanks and ultrafiltration tanks are all cone roof 316L stainless steel. The purchase cost equation found in *Product and Process Design Principles* considers holding tanks made out of carbon steel. To adjust for the proper construction material, the purchase cost equation was multiplied by a factor of (2.5/1). To adjust for proper construction date, the purchase cost equation was multiplied by a factor of (567/500). This gave a purchase cost equation of:

$$C_p = 265V^{0.51} \times (567/500) \times (2.5/2.1)$$

Where V is the size of the vessel in gallons. Because of the relatively small size of the holding tanks in the process compared to typical industry scale, the purchase cost equations in *Product Process Design Principles* for holding tanks were not applicable. The minimum size is 10,000 gallons.

To adjust for this discrepancy, the Sixth-Tenths Economy of Scale Equation was used:

$$Cost_1/Cost_2 = (Capacity_1/Capacity_2)^{0.6}$$

A base cost of a 316L stainless steel holding tank of volume 10,000 was calculated using the purchase cost equation in given in *Product and Process Design Principles.*

$$C_{p,base} = 265 \times (10{,}000)^{0.51} \times (567/500) \times (2.5/2.1) = \$82{,}375$$

The final purchase cost of the tanks (of vessel volume V, gal) used for this process was therefore:

$$C_p = C_{p,base} \times (10{,}000 \text{ gal}/V)^{-0.6}$$

The purchase costs were multiplied by a bare module factor of 2, taken from Table 22.11 in *Product and Process Design Principles,* to find the total bare module costs for all tanks.

Mixing Tanks

The purchase costs precipitation and resuspension tanks were calculated by finding the purchase costs for vertical pressure vessels and then the purchase costs for appropriately sized agitators.

Vertical pressure vessels were calculated using the Equipment Cost Microsoft Excel Workbook provided. These prices were then adjusted by the CE factor of (567/500) and material factor of (2.5/2.1).

The two precipitation tanks have agitators that supply power at a rate of 5 Hp/1,000 gal. The agitators of the two resuspension tanks provide power at a rate of 10 Hp/1,000 gal. Total horsepowers of the four agitators range from 1 Hp 5.98 Hp.

All agitators are classified as closed vessel propeller agitators with a purchase cost of:

$$C_p = 3{,}300S^{0.17} \times (567/500) \times (2.5/2.1)$$

The bare module factor used for agitators was 2.15. The bare module factor used for the vertical pressure vessels was 4.16.

Heat Exchangers

To account for a CE index of 576, double-pipe heat exchanger purchase cost equations were multiplied by a factor of (567/500). To account for the 316L stainless steel construction, the equations, which are based on construction with carbon steel, were multiplied by 4. A design pressure limit was set at 700 psig for each heat exchanger. The purchase cost equation for heat exchangers is:

$$C_p = (567/500) \times 4 \times F_P \times C_B$$

where F_p is the pressure factor (based on design pressure, P) and C_B is the base cost, defined as:

$$F_P = 0.8510 + 0.1292(P/600) + 0.0198(P/600)^2$$

$$C_B = \exp\{7.1460 + 0.16[\ln(A)]\}$$

The purchase costs were multiplied by a bare module factor of 1.8, taken from Table 22.11 in *Product and Process Design Principles*, to find the total bare module costs for the heat exchangers.

Bare Module Factors for Prices Based on Vendor/Online Quotes

All price quotes were taken as the unit purchase quote, and thus bare module factors were needed to calculate bare module costs for equipment. The following table summarizes the bare module factors used were:

Unit	Bare Module Factor
Columns (CO-01, CO-02, CO-03, CO-04)	4.16
Sprayer Systems (F-01, F-03)	2.06
Freeze Dryer (F-05)	2.06
Ultrafiltration Cassettes (UF-02, UF-04)	2.32
Freezer (E-01) and CIP System	2.17
Pumps (PP)	3.3

Appendix G: Sensitivity Analysis

		Product Price										
		$400	$480	$560	$640	$720	**$800**	$880	$960	$1,040	$1,120	$1,200
Inflation	2.00%	161.61%	195.35%	223.88%	248.68%	270.67%	290.45%	308.42%	324.90%	340.12%	354.26%	367.45%
	2.40%	161.22%	195.06%	223.65%	248.50%	270.52%	290.31%	308.30%	324.79%	340.02%	354.17%	367.37%
	2.80%	160.84%	194.78%	223.43%	248.32%	270.36%	290.17%	308.18%	324.68%	339.92%	354.07%	367.28%
	3.20%	160.44%	194.50%	223.21%	248.13%	270.20%	290.04%	308.06%	324.58%	339.82%	353.98%	367.20%
	3.60%	160.05%	194.21%	222.98%	247.95%	270.05%	289.90%	307.94%	324.47%	339.72%	353.89%	367.11%
	4.00%	159.65%	193.92%	222.76%	247.76%	269.89%	**289.76%**	307.81%	324.35%	339.62%	353.80%	367.03%
	4.40%	159.24%	193.63%	222.53%	247.57%	269.73%	289.62%	307.69%	324.24%	339.52%	353.71%	366.94%
	4.80%	158.83%	193.33%	222.30%	247.38%	269.57%	289.48%	307.57%	324.13%	339.42%	353.61%	366.86%
	5.20%	158.41%	193.04%	222.07%	247.19%	269.41%	289.34%	307.44%	324.02%	339.32%	353.52%	366.77%
	5.60%	157.99%	192.74%	221.83%	247.00%	269.24%	289.20%	307.32%	323.91%	339.22%	353.43%	366.68%
	6.00%	157.57%	192.43%	221.60%	246.81%	269.08%	289.06%	307.19%	323.80%	339.12%	353.33%	366.60%

		Variable Costs										
		$25,059,317	$30,071,181	$35,083,044	$40,094,907	$45,106,771	**$50,118,634**	$55,130,498	$60,142,361	$65,154,224	$70,166,088	$75,177,951
Fixed Costs	$3,363,946	324.53%	319.14%	313.69%	308.19%	302.64%	297.02%	291.34%	285.60%	279.79%	273.91%	267.96%
	$4,036,736	323.14%	317.74%	312.28%	306.77%	301.20%	295.57%	289.88%	284.12%	278.30%	272.41%	266.45%
	$4,709,525	321.75%	316.34%	310.87%	305.34%	299.76%	294.12%	288.42%	282.65%	276.82%	270.91%	264.94%
	$5,382,314	320.35%	314.93%	309.45%	303.92%	298.32%	292.67%	286.95%	281.17%	275.33%	269.41%	263.42%
	$6,055,103	318.96%	313.52%	308.03%	302.49%	296.88%	291.22%	285.49%	279.69%	273.83%	267.90%	261.90%
	$6,727,893	317.56%	312.12%	306.61%	301.06%	295.44%	**289.76%**	284.02%	278.21%	272.34%	266.40%	260.38%
	$7,400,682	316.16%	310.70%	305.19%	299.62%	293.99%	288.30%	282.55%	276.73%	270.84%	264.89%	258.86%
	$8,073,471	314.76%	309.29%	303.77%	298.19%	292.55%	286.84%	281.08%	275.24%	269.35%	263.38%	257.33%
	$8,746,260	313.35%	307.88%	302.34%	296.75%	291.10%	285.38%	279.60%	273.76%	267.84%	261.86%	255.80%
	$9,419,050	311.95%	306.46%	300.91%	295.31%	289.64%	283.92%	278.12%	272.27%	266.34%	260.34%	254.27%
	$10,091,839	310.54%	305.04%	299.48%	293.87%	288.19%	282.45%	276.65%	270.78%	264.84%	258.83%	252.74%

Total Permanent Investment	Product Price										
	$400	$480	$560	$640	$720	**$800**	$880	$960	$1,040	$1,120	$1,200
$1,611,393	237.38%	289.40%	331.93%	367.75%	398.58%	425.53%	449.38%	470.72%	489.95%	507.42%	523.38%
$1,933,671	218.28%	265.73%	304.82%	338.01%	366.80%	392.16%	414.77%	435.13%	453.62%	470.51%	486.03%
$2,255,950	201.02%	244.47%	280.49%	311.29%	338.17%	362.00%	383.38%	402.74%	420.41%	436.64%	451.63%
$2,578,228	185.59%	225.55%	258.88%	287.52%	312.66%	335.06%	355.25%	373.63%	390.47%	406.01%	420.42%
$2,900,507	171.86%	208.79%	239.73%	266.45%	290.01%	311.09%	330.17%	347.60%	363.64%	378.49%	392.30%
$3,222,785	159.65%	193.92%	222.76%	247.76%	269.89%	**289.76%**	307.81%	324.35%	339.62%	353.80%	367.03%
$3,545,064	148.76%	180.70%	207.67%	231.14%	251.98%	270.75%	287.85%	303.56%	318.11%	331.64%	344.30%
$3,867,342	139.02%	168.91%	194.23%	216.32%	235.99%	253.75%	269.98%	284.92%	298.78%	311.71%	323.83%
$4,189,621	130.29%	158.35%	182.18%	203.04%	221.65%	238.50%	253.92%	268.15%	281.38%	293.74%	305.35%
$4,511,899	122.43%	148.86%	171.36%	191.09%	208.75%	224.76%	239.44%	253.02%	265.66%	277.49%	288.61%
$4,834,178	115.32%	140.28%	161.59%	180.31%	197.09%	212.33%	226.34%	239.30%	251.39%	262.73%	273.40%

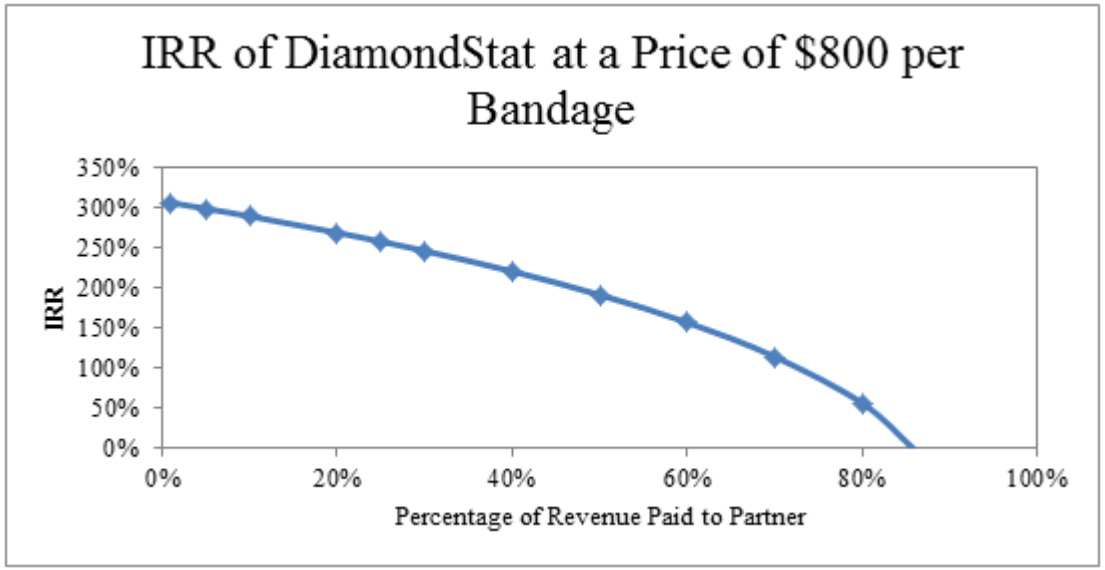
Variable Costs	Product Price										
	$400	$480	$560	$640	$720	**$800**	$880	$960	$1,040	$1,120	$1,200
$25,059,317	203.97%	232.80%	257.76%	279.82%	299.60%	317.56%	334.00%	349.17%	363.25%	376.37%	388.67%
$30,071,181	195.55%	225.33%	250.99%	273.58%	293.80%	312.12%	328.86%	344.29%	358.59%	371.92%	384.40%
$35,083,044	186.93%	217.72%	244.10%	267.26%	287.93%	306.61%	323.67%	339.37%	353.90%	367.44%	380.10%
$40,094,907	178.08%	209.95%	237.11%	260.85%	281.99%	301.06%	318.44%	334.41%	349.18%	362.92%	375.77%
$45,106,771	168.99%	202.02%	229.99%	254.35%	275.97%	295.44%	313.15%	329.40%	344.42%	358.38%	371.41%
$50,118,634	159.65%	193.92%	222.76%	247.76%	269.89%	**289.76%**	307.81%	324.35%	339.62%	353.80%	367.03%
$55,130,498	150.01%	185.63%	215.39%	241.07%	263.72%	284.02%	302.42%	319.26%	334.79%	349.19%	362.61%
$60,142,361	140.07%	177.15%	207.88%	234.27%	257.48%	278.21%	296.98%	314.13%	329.91%	344.54%	358.17%
$65,154,224	129.78%	168.45%	200.23%	227.37%	251.14%	272.34%	291.48%	308.94%	325.00%	339.86%	353.70%
$70,166,088	119.12%	159.53%	192.42%	220.35%	244.73%	266.40%	285.93%	303.71%	320.05%	335.15%	349.20%
$75,177,951	108.03%	150.36%	184.44%	213.22%	238.22%	260.38%	280.31%	298.43%	315.05%	330.40%	344.66%

Fixed Costs	Total Permanent Investment										
	$1,611,393	$1,933,671	$2,255,950	$2,578,228	$2,900,507	**$3,222,785**	$3,545,064	$3,867,342	$4,189,621	$4,511,899	$4,834,178
$3,363,946	438.01%	403.19%	371.82%	343.87%	319.06%	297.02%	277.40%	259.88%	244.18%	230.04%	217.27%
$4,036,736	435.51%	400.99%	369.86%	342.11%	317.47%	295.57%	276.08%	258.66%	243.05%	228.99%	216.29%
$4,709,525	433.02%	398.78%	367.90%	340.35%	315.88%	294.12%	274.75%	257.44%	241.91%	227.93%	215.30%
$5,382,314	430.52%	396.58%	365.94%	338.59%	314.28%	292.67%	273.42%	256.21%	240.78%	226.88%	214.31%
$6,055,103	428.03%	394.37%	363.97%	336.83%	312.69%	291.22%	272.08%	254.98%	239.64%	225.82%	213.32%
$6,727,893	425.53%	392.16%	362.00%	335.06%	311.09%	**289.76%**	270.75%	253.75%	238.50%	224.76%	212.33%
$7,400,682	423.02%	389.94%	360.03%	333.29%	309.49%	288.30%	269.41%	252.52%	237.36%	223.70%	211.34%
$8,073,471	420.52%	387.73%	358.06%	331.52%	307.88%	286.84%	268.08%	251.29%	236.22%	222.63%	210.35%
$8,746,260	418.01%	385.51%	356.08%	329.74%	306.28%	285.38%	266.74%	250.05%	235.07%	221.57%	209.35%
$9,419,050	415.51%	383.29%	354.10%	327.97%	304.67%	283.92%	265.39%	248.81%	233.92%	220.50%	208.35%
$10,091,839	412.99%	381.07%	352.12%	326.19%	303.06%	282.45%	264.05%	247.58%	232.78%	219.43%	207.35%

Total Permanent Investment	Variable Costs										
	$25,059,317	$30,071,181	$35,083,044	$40,094,907	$45,106,771	**$50,118,634**	$55,130,498	$60,142,361	$65,154,224	$70,166,088	$75,177,951
$1,611,393	473.16%	463.78%	454.33%	444.80%	435.20%	425.53%	415.78%	405.95%	396.04%	386.05%	375.98%
$1,933,671	434.24%	425.96%	417.62%	409.21%	400.72%	392.16%	383.52%	374.80%	366.00%	357.12%	348.16%
$2,255,950	399.48%	392.12%	384.70%	377.20%	369.64%	362.00%	354.29%	346.50%	338.64%	330.69%	322.66%
$2,578,228	368.72%	362.12%	355.45%	348.72%	341.93%	335.06%	328.12%	321.11%	314.03%	306.86%	299.62%
$2,900,507	341.57%	335.59%	329.56%	323.47%	317.31%	311.09%	304.80%	298.44%	292.01%	285.51%	278.93%
$3,222,785	317.56%	312.12%	306.61%	301.06%	295.44%	**289.76%**	284.02%	278.21%	272.34%	266.40%	260.38%
$3,545,064	296.27%	291.27%	286.23%	281.12%	275.97%	270.75%	265.48%	260.14%	254.74%	249.28%	243.75%
$3,867,342	277.32%	272.70%	268.04%	263.33%	258.57%	253.75%	248.88%	243.95%	238.96%	233.91%	228.79%
$4,189,621	260.37%	256.09%	251.76%	247.39%	242.97%	238.50%	233.98%	229.40%	224.76%	220.07%	215.32%
$4,511,899	245.15%	241.16%	237.13%	233.05%	228.93%	224.76%	220.54%	216.27%	211.95%	207.57%	203.13%
$4,834,178	231.42%	227.69%	223.91%	220.10%	216.24%	212.33%	208.38%	204.38%	200.33%	196.23%	192.08%

The most important sensitivity analysis was performed on the product price and the percentage of revenue we will have to give to our strategic bandage partner. The product price and the percent revenue share were the two biggest assumptions in our economic analysis. From our sensitivity analysis, we saw that as long as the percentage of revenue share is below 86%, we will see a positive IRR at a price of $800.

		Revenue Percentage for Strategic Bandage Partner										
		1%	5%	**10%**	20%	25%	30%	40%	50%	60%	70%	80%
Product Price	$400	191.35%	177.92%	159.65%	116.30%	89.55%	57.07%	Negative IRR	Negative IRR	Negative IRR	Negative IRR	Negative IRR
	$480	220.66%	209.22%	193.92%	159.04%	138.74%	115.77%	56.72%	Negative IRR	Negative IRR	Negative IRR	Negative IRR
	$560	246.00%	236.00%	222.76%	193.28%	176.67%	158.44%	115.24%	56.38%	Negative IRR	Negative IRR	Negative IRR
	$640	268.39%	259.47%	247.76%	222.10%	207.92%	192.64%	157.84%	114.72%	56.04%	Negative IRR	Negative IRR
	$720	288.47%	280.41%	269.89%	247.09%	234.67%	221.44%	192.01%	157.24%	114.20%	55.70%	Negative IRR
	$800	306.69%	299.33%	289.76%	269.21%	258.13%	246.43%	220.79%	191.38%	156.65%	113.68%	55.37%
	$880	323.37%	316.59%	307.81%	289.09%	279.07%	268.54%	245.76%	220.14%	190.75%	156.06%	113.17%
	$960	338.75%	332.47%	324.35%	307.14%	297.98%	288.42%	267.88%	245.10%	219.49%	190.13%	155.48%
	$1,040	353.03%	347.17%	339.62%	323.68%	315.25%	306.47%	287.75%	267.21%	244.45%	218.85%	189.50%
	$1,120	366.34%	360.86%	353.80%	338.95%	331.13%	323.01%	305.80%	287.08%	266.55%	243.79%	218.21%
	$1,200	378.81%	373.65%	367.03%	353.13%	345.84%	338.29%	322.35%	305.13%	286.41%	265.89%	243.14%



Appendix H: Material Safety Data Sheets and Vendor Equipment Data Sheets

The MSDS sheets for the materials used in all the reagents are attached to this report. MSDS for human fibrinogen and thrombin are attached as a close analog to salmon proteins to evaluate safety of these materials. Following MSDS is the Vendor Equipment Specification sheets for all the equipment used in the DiamondStat production plant.

GE Healthcare

Material Safety Data Sheet

United States
English

Section 1. Chemical product and company identification

Product name **Heparin Sepharose™ 6 Fast Flow, 50 ml**

Catalogue Number 17-0998-01

Material uses Industrial applications: Analytical chemistry. Research. Liquid chromatography.
Product type Liquid.
Validation date 29 November 2013
Print date 29 November 2013

Supplier GE Healthcare UK Ltd
Amersham Place
Little Chalfont
Buckinghamshire HP7 9NA
England
+44 0870 606 1921

In case of emergency			
	US	ChemTrec (US)	1-800-424-9300
	Canada	ChemTrec (US)	1-703-527-3887

2. Hazards identification

Physical state Liquid. [and Suspension.]

Color Solution : Colorless. / Suspension. : White. White to yellowish.

Odor Sweetish. Alcohol-like. [Slight]

Signal word WARNING!

Hazard statements FLAMMABLE LIQUID AND VAPOR. COMBUSTIBLE. CAUSES EYE IRRITATION. MAY CAUSE RESPIRATORY TRACT AND SKIN IRRITATION. CONTAINS MATERIAL THAT CAN CAUSE TARGET ORGAN DAMAGE. CANCER HAZARD - CONTAINS MATERIAL WHICH CAN CAUSE CANCER.

Precautionary measures Do not handle until all safety precautions have been read and understood. Obtain special instructions before use. Do not breathe vapor or mist. Use only with adequate ventilation. Do not eat, drink or smoke when using this product. Avoid contact with eyes, skin and clothing. Keep away from heat, sparks and flame. Keep container tightly closed. Use personal protective equipment as required. Wash thoroughly after handling.

OSHA/HCS status This material is considered hazardous by the OSHA Hazard Communication Standard (29 CFR 1910.1200).

Routes of entry Dermal contact. Eye contact. Inhalation. Ingestion.

Potential acute health effects

Eyes Irritating to eyes.
Skin Moderately irritating to the skin.
Inhalation Moderately irritating to the respiratory system.
Ingestion No known significant effects or critical hazards.

Potential chronic health effects

Chronic effects Contains material that can cause target organ damage.
Carcinogenicity Contains material which can cause cancer. Risk of cancer depends on duration and level of exposure.
Mutagenicity No known significant effects or critical hazards.
Teratogenicity No known significant effects or critical hazards.
Developmental effects No known significant effects or critical hazards.
Fertility effects No known significant effects or critical hazards.
Target organs Contains material which causes damage to the following organs: kidneys.
Contains material which may cause damage to the following organs: blood, the reproductive system, liver, upper respiratory tract, skin, eyes, central nervous system (CNS).

Inhalation Adverse symptoms may include the following:
respiratory tract irritation
coughing

Ingestion	No specific data.
Skin	Adverse symptoms may include the following: irritation redness
Eyes	Adverse symptoms may include the following: pain or irritation watering redness
Medical conditions aggravated by over-exposure	Pre-existing disorders involving any target organs mentioned in this MSDS as being at risk may be aggravated by over-exposure to this product.

See toxicological information (Section 11)

3. Composition/information on ingredients

Name	CAS number	% by weight
ethanol	64-17-5	14 - 19

There are no additional ingredients present which, within the current knowledge of the supplier and in the concentrations applicable, are classified as hazardous to health or the environment and hence require reporting in this section.

Section 4. First aid measures

Eye contact	Check for and remove any contact lenses. Immediately flush eyes with plenty of water for at least 15 minutes, occasionally lifting the upper and lower eyelids. Get medical attention immediately.
Skin contact	In case of contact, immediately flush skin with plenty of water for at least 15 minutes while removing contaminated clothing and shoes. Wash clothing before reuse. Clean shoes thoroughly before reuse. Get medical attention immediately.
Inhalation	Move exposed person to fresh air. If not breathing, if breathing is irregular or if respiratory arrest occurs, provide artificial respiration or oxygen by trained personnel. Loosen tight clothing such as a collar, tie, belt or waistband. Get medical attention immediately.
Ingestion	Wash out mouth with water. Do not induce vomiting unless directed to do so by medical personnel. Never give anything by mouth to an unconscious person. Get medical attention immediately.
Protection of first-aiders	No action shall be taken involving any personal risk or without suitable training. If it is suspected that fumes are still present, the rescuer should wear an appropriate mask or self-contained breathing apparatus. It may be dangerous to the person providing aid to give mouth-to-mouth resuscitation. Wash contaminated clothing thoroughly with water before removing it, or wear gloves.

Section 5. Fire-fighting measures

Flammability of the product	Flammable liquid. In a fire or if heated, a pressure increase will occur and the container may burst, with the risk of a subsequent explosion. Runoff to sewer may create fire or explosion hazard.
Extinguishing media	
Suitable	Use dry chemical, CO_2, water spray (fog) or foam.
Not suitable	Do not use water jet.
Special exposure hazards	Promptly isolate the scene by removing all persons from the vicinity of the incident if there is a fire. No action shall be taken involving any personal risk or without suitable training. Move containers from fire area if this can be done without risk. Use water spray to keep fire-exposed containers cool.
Hazardous combustion products	Decomposition products may include the following materials: carbon dioxide carbon monoxide
Special protective equipment for fire-fighters	Fire-fighters should wear appropriate protective equipment and self-contained breathing apparatus (SCBA) with a full face-piece operated in positive pressure mode.

Section 6. Accidental release measures

Personal precautions	No action shall be taken involving any personal risk or without suitable training. Evacuate surrounding areas. Keep unnecessary and unprotected personnel from entering. Do not touch or walk through spilled material. Shut off all ignition sources. No flares, smoking or flames in hazard area. Avoid breathing vapor or mist. Provide adequate ventilation. Wear appropriate respirator when ventilation is inadequate. Put on appropriate personal protective equipment (see Section 8).
Environmental precautions	Avoid dispersal of spilled material and runoff and contact with soil, waterways, drains and sewers. Inform the relevant authorities if the product has caused environmental pollution (sewers, waterways, soil or air).
Methods for cleaning up	Stop leak if without risk. Move containers from spill area. Use spark-proof tools and explosion-proof equipment. Approach release from upwind. Prevent entry into sewers, water courses, basements or confined areas. Wash spillages into an effluent treatment plant or proceed as follows. Contain and collect spillage with non-combustible, absorbent material e.g. sand, earth, vermiculite or diatomaceous earth and place in container for disposal according to local regulations (see Section 13). Dispose of via a licensed waste disposal contractor. Contaminated absorbent material may pose the same hazard as the spilled product. Note: see Section 1 for emergency contact information and Section 13 for waste disposal.
Small spill	Stop leak if without risk. Move containers from spill area. Use spark-proof tools and explosion-proof equipment. Dilute with water and mop up if water-soluble. Alternatively, or if water-insoluble, absorb with an inert dry material and place in an appropriate waste disposal container. Dispose of via a licensed waste disposal contractor.

Section 7. Handling and storage

Handling

Put on appropriate personal protective equipment (see Section 8). Eating, drinking and smoking should be prohibited in areas where this material is handled, stored and processed. Workers should wash hands and face before eating, drinking and smoking. Remove contaminated clothing and protective equipment before entering eating areas. Avoid exposure - obtain special instructions before use. Do not get in eyes or on skin or clothing. Do not ingest. Avoid breathing vapor or mist. Use only with adequate ventilation. Wear appropriate respirator when ventilation is inadequate. Do not enter storage areas and confined spaces unless adequately ventilated. Keep in the original container or an approved alternative made from a compatible material, kept tightly closed when not in use. Store and use away from heat, sparks, open flame or any other ignition source. Use explosion-proof electrical (ventilating, lighting and material handling) equipment. Use non-sparking tools. Take precautionary measures against electrostatic discharges. To avoid fire or explosion, dissipate static electricity during transfer by grounding and bonding containers and equipment before transferring material. Empty containers retain product residue and can be hazardous. Do not reuse container.

Storage

Store between the following temperatures: 4 to 30°C (39.2 to 86°F). Store in accordance with local regulations. Store in a segregated and approved area. Store in original container protected from direct sunlight in a dry, cool and well-ventilated area, away from incompatible materials (see Section 10) and food and drink. Eliminate all ignition sources. Separate from oxidizing materials. Keep container tightly closed and sealed until ready for use. Containers that have been opened must be carefully resealed and kept upright to prevent leakage. Do not store in unlabeled containers. Use appropriate containment to avoid environmental contamination.

Section 8. Exposure controls/personal protection

Ingredient	Exposure limits
ethanol	**ACGIH TLV (United States, 3/2012). Notes: 1996 Adoption Refers to Appendix A -- Carcinogens.** STEL: 1000 ppm 15 minutes. **NIOSH REL (United States, 6/2009). Notes:** TWA: 1900 mg/m³ 10 hours. **NIOSH REL (United States, 6/2009).** TWA: 1000 ppm 10 hours. **OSHA PEL (United States, 6/2010).** TWA: 1900 mg/m³ 8 hours. TWA: 1000 ppm 8 hours. **OSHA PEL 1989 (United States, 3/1989).** TWA: 1900 mg/m³ 8 hours. TWA: 1000 ppm 8 hours.

Recommended monitoring procedures

If this product contains ingredients with exposure limits, personal, workplace atmosphere or biological monitoring may be required to determine the effectiveness of the ventilation or other control measures and/or the necessity to use respiratory protective equipment. Reference should be made to appropriate monitoring standards. Reference to national guidance documents for methods for the determination of hazardous substances will also be required.

Engineering measures

Use only with adequate ventilation. Use process enclosures, local exhaust ventilation or other engineering controls to keep worker exposure to airborne contaminants below any recommended or statutory limits. The engineering controls also need to keep gas, vapor or dust concentrations below any lower explosive limits. Use explosion-proof ventilation equipment.

Hygiene measures

Wash hands, forearms and face thoroughly after handling chemical products, before eating, smoking and using the lavatory and at the end of the working period. Appropriate techniques should be used to remove potentially contaminated clothing. Wash contaminated clothing before reusing. Ensure that eyewash stations and safety showers are close to the workstation location.

Personal protection

Respiratory

Use a properly fitted, air-purifying or air-fed respirator complying with an approved standard if a risk assessment indicates this is necessary. Respirator selection must be based on known or anticipated exposure levels, the hazards of the product and the safe working limits of the selected respirator. Recommended: A respirator is not needed under normal and intended conditions of product use.

Hands

Chemical-resistant, impervious gloves complying with an approved standard should be worn at all times when handling chemical products if a risk assessment indicates this is necessary. Considering the parameters specified by the glove manufacturer, check during use that the gloves are still retaining their protective properties. It should be noted that the time to breakthrough for any glove material may be different for different glove manufacturers. In the case of mixtures, consisting of several substances, the protection time of the gloves cannot be accurately estimated. 1 - 4 hours (breakthrough time): butyl rubber, neoprene

Eyes

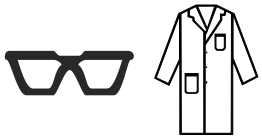
Safety eyewear complying with an approved standard should be used when a risk assessment indicates this is necessary to avoid exposure to liquid splashes, mists or dusts. If contact is possible, the following protection should be worn, unless the assessment indicates a higher degree of protection: chemical splash goggles. Recommended: safety glasses with side-shields

Skin

Personal protective equipment for the body should be selected based on the task being performed and the risks involved and should be approved by a specialist before handling this product.
When there is a risk of ignition from static electricity, wear anti-static protective clothing.
For the greatest protection from static discharges, clothing should include anti-static overalls, boots and gloves.
Recommended: lab coat

Environmental exposure controls Emissions from ventilation or work process equipment should be checked to ensure they comply with the requirements of environmental protection legislation. In some cases, fume scrubbers, filters or engineering modifications to the process equipment will be necessary to reduce emissions to acceptable levels.

Personal protective equipment (Pictograms)



Section 9. Physical and chemical properties

Physical state Liquid. [and Suspension.]

Flash point Closed cup: 38 to 43°C (100.4 to 109.4°F)

Color Solution : Colorless. / Suspension. : White. White to yellowish.

Odor Sweetish. Alcohol-like. [Slight]

Taste Alcohol-like.

Volatility 14 to 19% (w/w)

Odor threshold 180 ppm

Ionicity (in water) Non-ionic.

Solubility Easily soluble in the following materials: cold water and hot water.

Section 10. Stability and reactivity

Chemical stability The product is stable.

Conditions to avoid Avoid all possible sources of ignition (spark or flame). Do not pressurize, cut, weld, braze, solder, drill, grind or expose containers to heat or sources of ignition.

Incompatible materials Reactive or incompatible with the following materials:
oxidizing materials

Possibility of hazardous reactions Under normal conditions of storage and use, hazardous reactions will not occur.

Section 11. Toxicological information

Acute toxicity

Product/ingredient name	Result	Species	Dose	Exposure
ethanol	LC50 Inhalation Vapor	Rat	124700 mg/m³	4 hours

Conclusion/Summary Not available.

Chronic toxicity

Conclusion/Summary Not available.

Irritation/Corrosion

Conclusion/Summary

Skin Repeated exposure may cause skin dryness or cracking.

Sensitizer

Conclusion/Summary Not available.

Carcinogenicity

Conclusion/Summary Not available.

Classification

Product/ingredient name	OSHA	IARC	NTP	ACGIH	EPA	NIOSH
ethanol	-	1	-	A3	-	-

Mutagenicity

Conclusion/Summary Not available.

Teratogenicity

Conclusion/Summary Not available.

Reproductive toxicity

Conclusion/Summary Not available.

Section 12. Ecological information

Environmental effects No known significant effects or critical hazards.

Aquatic ecotoxicity

Product/ingredient name	Result	Species	Exposure
ethanol	Acute EC50 17.921 mg/l Marine water	Algae - Ulva pertusa	96 hours
	Acute EC50 2000 µg/l Fresh water	Daphnia - Daphnia magna	48 hours
	Acute LC50 25500 µg/l Marine water	Crustaceans - Artemia franchiscana - Larvae	48 hours
	Acute LC50 42000 µg/l Fresh water	Fish - Oncorhynchus mykiss	4 days
	Chronic NOEC 4.995 mg/l Marine water	Algae - Ulva pertusa	96 hours

Conclusion/Summary Not available.

Persistence/degradability

Product/ingredient name	Test	Result	Dose	Inoculum
ethanol	-	100 % - Readily - 20 days	-	-

Conclusion/Summary Not available.

Toxicity of the products of biodegradation The product itself and its products of degradation are not toxic.

Other adverse effects No known significant effects or critical hazards.

Section 13. Disposal considerations

Waste disposal The generation of waste should be avoided or minimized wherever possible. Disposal of this product, solutions and any by-products should at all times comply with the requirements of environmental protection and waste disposal legislation and any regional local authority requirements. Dispose of surplus and non-recyclable products via a licensed waste disposal contractor. Waste should not be disposed of untreated to the sewer unless fully compliant with the requirements of all authorities with jurisdiction. Waste packaging should be recycled. Incineration or landfill should only be considered when recycling is not feasible. This material and its container must be disposed of in a safe way. Care should be taken when handling emptied containers that have not been cleaned or rinsed out. Empty containers or liners may retain some product residues. Vapor from product residues may create a highly flammable or explosive atmosphere inside the container. Do not cut, weld or grind used containers unless they have been cleaned thoroughly internally. Avoid dispersal of spilled material and runoff and contact with soil, waterways, drains and sewers.

Waste stream Code: D001
Classification: Ignitability

Disposal should be in accordance with applicable regional, national and local laws and regulations.

Refer to Section 7: HANDLING AND STORAGE and Section 8: EXPOSURE CONTROLS/PERSONAL PROTECTION for additional handling information and protection of employees.

Section 14. Transport information

IATA-DGR Class	Classes	PG*

PG* : Packing group

Section 15. Regulatory information

HCS Classification Combustible liquid
Irritating material
Carcinogen
Target organ effects

U.S. Federal regulations **TSCA 8(a) CDR Exempt/Partial exemption**: Not determined

United States inventory (TSCA 8b): All components are listed or exempted.

Clean Air Act Section 112(b) Hazardous Air Pollutants (HAPs) Not listed

Clean Air Act Section 602 Class I Substances Not listed

Clean Air Act Section 602 Class II Substances Not listed

DEA List I Chemicals (Precursor Chemicals) Not listed

DEA List II Chemicals (Essential Chemicals) Not listed

SARA 302/304

Composition/information on ingredients

No products were found.

SARA 304 RQ Not applicable.

SARA 311/312

Classification Fire hazard
Immediate (acute) health hazard
Delayed (chronic) health hazard

Composition/information on ingredients

Name	%	Fire hazard	Sudden release of pressure	Reactive	Immediate (acute) health hazard	Delayed (chronic) health hazard
ethanol	14 - 19	Yes.	No.	No.	Yes.	Yes.

State regulations

Massachusetts The following components are listed: ETHYL ALCOHOL

New York None of the components are listed.

New Jersey The following components are listed: ETHYL ALCOHOL; ALCOHOL

Pennsylvania The following components are listed: DENATURED ALCOHOL

California Prop. 65

WARNING: This product contains a chemical known to the State of California to cause cancer.

Ingredient name	Cancer	Reproductive	No significant risk level	Maximum acceptable dosage level
ethanol	Yes.	No.	No.	No.

United States inventory (TSCA 8b) All components are listed or exempted.

International regulations

International lists **Australia inventory (AICS)**: All components are listed or exempted.
China inventory (IECSC): All components are listed or exempted.
Japan inventory: Not determined.
Korea inventory: All components are listed or exempted.
Malaysia Inventory (EHS Register): Not determined.
New Zealand Inventory of Chemicals (NZIoC): All components are listed or exempted.
Philippines inventory (PICCS): All components are listed or exempted.
Taiwan inventory (CSNN): Not determined.

Chemical Weapons Convention List Schedule I Chemicals Not listed

Chemical Weapons Convention List Schedule II Chemicals Not listed

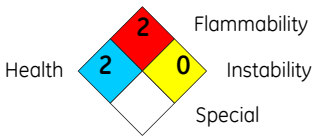
Chemical Weapons Convention List Schedule III Chemicals Not listed

Section 16. Other information

Label requirements FLAMMABLE LIQUID AND VAPOR. COMBUSTIBLE. CAUSES EYE IRRITATION. MAY CAUSE RESPIRATORY TRACT AND SKIN IRRITATION. CONTAINS MATERIAL THAT CAN CAUSE TARGET ORGAN DAMAGE. CANCER HAZARD - CONTAINS MATERIAL WHICH CAN CAUSE CANCER.

The customer is responsible for determining the PPE code for this material.

National Fire Protection Association (U.S.A.)



Indicates information that has changed from previously issued version.

History

Date of printing	29 November 2013	**Date of previous issue**	12 March 2012
Date of issue	29 November 2013	**Version**	6.1

Notice to reader

To the best of our knowledge, the information contained herein is accurate. However, neither the above-named supplier, nor any of its subsidiaries, assumes any liability whatsoever for the accuracy or completeness of the information contained herein.
Final determination of suitability of any material is the sole responsibility of the user. All materials may present unknown hazards and should be used with caution. Although certain hazards are described herein, we cannot guarantee that these are the only hazards that exist.

SAFETY DATA SHEET

AminoLink Coupling Resin

Section 1. Identification

GHS product identifier : AminoLink Coupling Resin

Other means of identification : Not available.

Product type : Liquid.

Product code : 0020381 0020382 0020382B 1851920

SDS # : 1025

Chemical formula : Not applicable.

CAS # : Not applicable.

Relevant identified uses of the substance or mixture and uses advised against

Not applicable.

Supplier's details : Thermo Fisher Scientific
Pierce Biotechnology
P.O. Box 117
Rockford, IL 61105
United States
815.968.0747 or
800.874.3723
7 AM - 5 PM Central Time (GMT -06:00)

Emergency telephone number (with hours of operation) : CHEMTREC: 800.424.9300
Outside US: 703.527.3887

Section 2. Hazards identification

OSHA/HCS status : While this material is not considered hazardous by the OSHA Hazard Communication Standard (29 CFR 1910.1200), this SDS contains valuable information critical to the safe handling and proper use of the product. This SDS should be retained and available for employees and other users of this product.

Classification of the substance or mixture : Not classified.

GHS label elements

Signal word : No signal word.

Hazard statements : No known significant effects or critical hazards.

Precautionary statements

Prevention : Not applicable.

Response : Not applicable.

Storage : Not applicable.

Disposal : Not applicable.

Hazards not otherwise classified : None known.

Section 3. Composition/information on ingredients

Substance/mixture : Mixture

Other means of identification : Not available.

CAS number/other identifiers

CAS number : Not applicable.

Section 3. Composition/information on ingredients

Any concentration shown as a range is to protect confidentiality or is due to batch variation.

There are no ingredients present which, within the current knowledge of the supplier and in the concentrations applicable, are classified as hazardous to health or the environment and hence require reporting in this section.

Occupational exposure limits, if available, are listed in Section 8.

Section 4. First aid measures

Description of necessary first aid measures

Eye contact : Immediately flush eyes with plenty of water, occasionally lifting the upper and lower eyelids. Check for and remove any contact lenses. Get medical attention if irritation occurs.

Inhalation : Remove victim to fresh air and keep at rest in a position comfortable for breathing. Get medical attention if symptoms occur.

Skin contact : Flush contaminated skin with plenty of water. Remove contaminated clothing and shoes. Get medical attention if symptoms occur.

Ingestion : Wash out mouth with water. Remove victim to fresh air and keep at rest in a position comfortable for breathing. If material has been swallowed and the exposed person is conscious, give small quantities of water to drink. Do not induce vomiting unless directed to do so by medical personnel. Get medical attention if symptoms occur.

Most important symptoms/effects, acute and delayed

Potential acute health effects

Eye contact : No known significant effects or critical hazards.

Inhalation : No known significant effects or critical hazards.

Skin contact : No known significant effects or critical hazards.

Ingestion : No known significant effects or critical hazards.

Over-exposure signs/symptoms

Eye contact : No specific data.

Inhalation : No specific data.

Skin contact : No specific data.

Ingestion : No specific data.

Indication of immediate medical attention and special treatment needed, if necessary

Notes to physician : Treat symptomatically. Contact poison treatment specialist immediately if large quantities have been ingested or inhaled.

Specific treatments : No specific treatment.

Protection of first-aiders : No action shall be taken involving any personal risk or without suitable training.

See toxicological information (Section 11)

Section 5. Fire-fighting measures

Extinguishing media

Suitable extinguishing media : Use an extinguishing agent suitable for the surrounding fire.

Unsuitable extinguishing media : None known.

Specific hazards arising from the chemical : In a fire or if heated, a pressure increase will occur and the container may burst.

Hazardous thermal decomposition products : Decomposition products may include the following materials:
carbon dioxide
carbon monoxide

Section 5. Fire-fighting measures

Special protective actions for fire-fighters : Promptly isolate the scene by removing all persons from the vicinity of the incident if there is a fire. No action shall be taken involving any personal risk or without suitable training.

Special protective equipment for fire-fighters : Fire-fighters should wear appropriate protective equipment and self-contained breathing apparatus (SCBA) with a full face-piece operated in positive pressure mode.

Section 6. Accidental release measures

Personal precautions, protective equipment and emergency procedures

For non-emergency personnel : No action shall be taken involving any personal risk or without suitable training. Evacuate surrounding areas. Keep unnecessary and unprotected personnel from entering. Do not touch or walk through spilled material. Put on appropriate personal protective equipment.

For emergency responders : If specialised clothing is required to deal with the spillage, take note of any information in Section 8 on suitable and unsuitable materials. See also the information in "For non-emergency personnel".

Environmental precautions : Avoid dispersal of spilled material and runoff and contact with soil, waterways, drains and sewers. Inform the relevant authorities if the product has caused environmental pollution (sewers, waterways, soil or air).

Methods and materials for containment and cleaning up

Small spill : Stop leak if without risk. Move containers from spill area. Dilute with water and mop up if water-soluble. Alternatively, or if water-insoluble, absorb with an inert dry material and place in an appropriate waste disposal container. Dispose of via a licensed waste disposal contractor.

Large spill : Stop leak if without risk. Move containers from spill area. Prevent entry into sewers, water courses, basements or confined areas. Wash spillages into an effluent treatment plant or proceed as follows. Contain and collect spillage with non-combustible, absorbent material e.g. sand, earth, vermiculite or diatomaceous earth and place in container for disposal according to local regulations (see Section 13). Dispose of via a licensed waste disposal contractor. Note: see Section 1 for emergency contact information and Section 13 for waste disposal.

Section 7. Handling and storage

Precautions for safe handling

Protective measures : Put on appropriate personal protective equipment (see Section 8).

Advice on general occupational hygiene : Eating, drinking and smoking should be prohibited in areas where this material is handled, stored and processed. Workers should wash hands and face before eating, drinking and smoking. Remove contaminated clothing and protective equipment before entering eating areas. See also Section 8 for additional information on hygiene measures.

Conditions for safe storage, including any incompatibilities : Store between the following temperatures: 2 to 8°C (35.6 to 46.4°F). Store in accordance with local regulations. Store in original container protected from direct sunlight in a dry, cool and well-ventilated area, away from incompatible materials (see Section 10) and food and drink. Keep container tightly closed and sealed until ready for use. Containers that have been opened must be carefully resealed and kept upright to prevent leakage. Do not store in unlabeled containers. Use appropriate containment to avoid environmental contamination.

Section 8. Exposure controls/personal protection

Control parameters

Occupational exposure limits

None.

Appropriate engineering controls : Good general ventilation should be sufficient to control worker exposure to airborne contaminants.

Section 8. Exposure controls/personal protection

Environmental exposure controls : Emissions from ventilation or work process equipment should be checked to ensure they comply with the requirements of environmental protection legislation. In some cases, fume scrubbers, filters or engineering modifications to the process equipment will be necessary to reduce emissions to acceptable levels.

Individual protection measures

Hygiene measures : Wash hands, forearms and face thoroughly after handling chemical products, before eating, smoking and using the lavatory and at the end of the working period. Appropriate techniques should be used to remove potentially contaminated clothing. Wash contaminated clothing before reusing. Ensure that eyewash stations and safety showers are close to the workstation location.

Eye/face protection : Safety eyewear complying with an approved standard should be used when a risk assessment indicates this is necessary to avoid exposure to liquid splashes, mists, gases or dusts. If contact is possible, the following protection should be worn, unless the assessment indicates a higher degree of protection: safety glasses with side-shields.

Skin protection

Hand protection : Chemical-resistant, impervious gloves complying with an approved standard should be worn at all times when handling chemical products if a risk assessment indicates this is necessary.

Body protection : Personal protective equipment for the body should be selected based on the task being performed and the risks involved and should be approved by a specialist before handling this product.

Other skin protection : Appropriate footwear and any additional skin protection measures should be selected based on the task being performed and the risks involved and should be approved by a specialist before handling this product.

Respiratory protection : Use a properly fitted, air-purifying or air-fed respirator complying with an approved standard if a risk assessment indicates this is necessary. Respirator selection must be based on known or anticipated exposure levels, the hazards of the product and the safe working limits of the selected respirator.

Section 9. Physical and chemical properties

Appearance

Physical state : Liquid. [Suspension.]

Color : White.

Odor : Not available.

Odor threshold : Not available.

pH : Not available.

Melting point : Not available.

Boiling point : Not available.

Flash point : Not available.

Burning time : Not applicable.

Burning rate : Not applicable.

Evaporation rate : Not available.

Flammability (solid, gas) : Not available.

Lower and upper explosive (flammable) limits : Not available.

Vapor pressure : Not available.

Vapor density : Not available.

Relative density : Not available.

Solubility : Partially soluble in the following materials: cold water and hot water.

Solubility in water : Not available.

Partition coefficient: n-octanol/water : Not available.

Auto-ignition temperature : Not available.

Decomposition temperature : Not available.

Section 9. Physical and chemical properties

SADT : Not available.

Viscosity : Not available.

Section 10. Stability and reactivity

Reactivity : No specific test data related to reactivity available for this product or its ingredients.

Chemical stability : The product is stable.

Possibility of hazardous reactions : Under normal conditions of storage and use, hazardous reactions will not occur.

Conditions to avoid : No specific data.

Incompatible materials : No specific data.

Hazardous decomposition products : Under normal conditions of storage and use, hazardous decomposition products should not be produced.

Section 11. Toxicological information

Information on toxicological effects

Acute toxicity

Not available.

Conclusion/Summary : To the best of our knowledge, the toxicological properties of this product have not been thoroughly investigated.

Irritation/Corrosion

Not available.

Sensitization

Not available.

Mutagenicity

Not available.

Carcinogenicity

Not available.

Reproductive toxicity

Not available.

Teratogenicity

Not available.

Specific target organ toxicity (single exposure)

Not available.

Specific target organ toxicity (repeated exposure)

Not available.

Aspiration hazard

Not available.

Information on the likely routes of exposure : Routes of entry anticipated: Oral, Dermal, Inhalation.

Potential acute health effects

Eye contact : No known significant effects or critical hazards.

Inhalation : No known significant effects or critical hazards.

Section 11. Toxicological information

Skin contact : No known significant effects or critical hazards.

Ingestion : No known significant effects or critical hazards.

Symptoms related to the physical, chemical and toxicological characteristics

Eye contact : No specific data.

Inhalation : No specific data.

Skin contact : No specific data.

Ingestion : No specific data.

Delayed and immediate effects and also chronic effects from short and long term exposure

Short term exposure

Potential immediate effects : Not available.

Potential delayed effects : Not available.

Long term exposure

Potential immediate effects : Not available.

Potential delayed effects : Not available.

Potential chronic health effects

Not available.

General : No known significant effects or critical hazards.

Carcinogenicity : No known significant effects or critical hazards.

Mutagenicity : No known significant effects or critical hazards.

Teratogenicity : No known significant effects or critical hazards.

Developmental effects : No known significant effects or critical hazards.

Fertility effects : No known significant effects or critical hazards.

Numerical measures of toxicity

Acute toxicity estimates

Not available.

Section 12. Ecological information

Toxicity

Not available.

Persistence and degradability

Not available.

Bioaccumulative potential

Not available.

Mobility in soil

Soil/water partition coefficient (K_{OC}) : Not available.

Other adverse effects : No known significant effects or critical hazards.

Section 13. Disposal considerations

Disposal methods : The generation of waste should be avoided or minimized wherever possible. Disposal of this product, solutions and any by-products should at all times comply with the requirements of environmental protection and waste disposal legislation and any regional local authority requirements. Dispose of surplus and non-recyclable products via a licensed waste disposal contractor. Waste should not be disposed of untreated to the sewer unless fully compliant with the requirements of all authorities with jurisdiction. Waste packaging should be recycled. Incineration or landfill should only be considered when recycling is not feasible. This material and its container must be disposed of in a safe way. Empty containers or liners may retain some product residues. Avoid dispersal of spilled material and runoff and contact with soil, waterways, drains and sewers.

Section 14. Transport information

	DOT Classification	IATA
UN number	Not regulated.	Not regulated.
UN proper shipping name	-	-
Transport hazard class(es)	-	-
Packing group	-	-
Environmental hazards	No.	No.
Additional information	-	-

Special precautions for user : **Transport within user's premises:** always transport in closed containers that are upright and secure. Ensure that persons transporting the product know what to do in the event of an accident or spillage.

Transport in bulk according to Annex II of MARPOL 73/78 and the IBC Code : Not available.

Section 15. Regulatory information

U.S. Federal regulations : **TSCA 8(a) CDR Exempt/Partial exemption**: Not determined

United States inventory (TSCA 8b): All components are listed or exempted.

Clean Air Act Section 112 (b) Hazardous Air Pollutants (HAPs) : Not listed

Clean Air Act Section 602 Class I Substances : Not listed

Clean Air Act Section 602 Class II Substances : Not listed

DEA List I Chemicals (Precursor Chemicals) : Not listed

DEA List II Chemicals (Essential Chemicals) : Not listed

SARA 302/304

Composition/information on ingredients

Section 15. Regulatory information

Name	%	EHS	SARA 302 TPQ (lbs)	SARA 302 TPQ (gallons)	SARA 304 RQ (lbs)	SARA 304 RQ (gallons)
sodium azide	0 - 0.1	Yes.	500	-	1000	-

SARA 304 RQ : 5000000 lbs / 2270000 kg

SARA 311/312

Classification : Not applicable.

Composition/information on ingredients

No products were found.

State regulations

Massachusetts : None of the components are listed.

New York : None of the components are listed.

New Jersey : The following components are listed: Agarose

Pennsylvania : The following components are listed: Agarose

Canada inventory : All components are listed or exempted.

International regulations

International lists : **Australia inventory (AICS)**: All components are listed or exempted.
China inventory (IECSC): All components are listed or exempted.
Japan inventory: Not determined.
Korea inventory: All components are listed or exempted.
Malaysia Inventory (EHS Register): Not determined.
New Zealand Inventory of Chemicals (NZIoC): All components are listed or exempted.
Philippines inventory (PICCS): All components are listed or exempted.
Taiwan inventory (CSNN): Not determined.

Chemical Weapons Convention List Schedule I Chemicals : Not listed

Chemical Weapons Convention List Schedule II Chemicals : Not listed

Chemical Weapons Convention List Schedule III Chemicals : Not listed

Section 16. Other information

Hazardous Material Information System (U.S.A.)

Health	0
Chronic Health Hazard	
Flammability	0
Physical hazards	0

National Fire Protection Association (U.S.A.)

Health	0
Flammability	0
Instability/Reactivity	0
Special	

The customer is responsible for determining the PPE code for this material.

Caution: HMIS® ratings are based on a 0-4 rating scale, with 0 representing minimal hazards or risks, and 4 representing significant hazards or risks Although HMIS® ratings are not required on SDSs under 29 CFR 1910. 1200, the preparer may choose to provide them. HMIS® ratings are to be used with a fully implemented HMIS® program. HMIS® is a registered mark of the National Paint & Coatings Association (NPCA). HMIS® materials may be purchased exclusively from J. J. Keller (800) 327-6868.

Section 16. Other information

Reprinted with permission from NFPA 704-2001, Identification of the Hazards of Materials for Emergency Response Copyright ©1997, National Fire Protection Association, Quincy, MA 02269. This reprinted material is not the complete and official position of the National Fire Protection Association, on the referenced subject which is represented only by the standard in its entirety.

History

Date of printing : 8/21/2014.

Date of issue/Date of revision : 8/21/2014.

Date of previous issue : No previous validation.

Version : 1

Prepared by : MSDS (Regulatory Specialist)

Key to abbreviations : ATE = Acute Toxicity Estimate
BCF = Bioconcentration Factor
GHS = Globally Harmonized System of Classification and Labelling of Chemicals
IATA = International Air Transport Association
IBC = Intermediate Bulk Container
IMDG = International Maritime Dangerous Goods
LogPow = logarithm of the octanol/water partition coefficient
MARPOL 73/78 = International Convention for the Prevention of Pollution From Ships, 1973 as modified by the Protocol of 1978. ("Marpol" = marine pollution)
UN = United Nations

References : Not available.

Indicates information that has changed from previously issued version.

Notice to reader

To the best of our knowledge, the information contained herein is accurate. However, neither the above-named supplier, nor any of its subsidiaries, assumes any liability whatsoever for the accuracy or completeness of the information contained herein.
Final determination of suitability of any material is the sole responsibility of the user. All materials may present unknown hazards and should be used with caution. Although certain hazards are described herein, we cannot guarantee that these are the only hazards that exist.

SAFETY DATA SHEET

Detoxi-Gel Endotoxin Removing Gel

Section 1. Identification

GHS product identifier : Detoxi-Gel Endotoxin Removing Gel

Other means of identification : DetoxiGel™ Endotoxin Removing Columns

Product type : Liquid.

Product code : 0020339 0020340 0020344 1880200

SDS # : 0099

Chemical formula : Not applicable.

CAS # : Not applicable.

Relevant identified uses of the substance or mixture and uses advised against

Not applicable.

Supplier's details : Thermo Fisher Scientific
Pierce Biotechnology
P.O. Box 117
Rockford, IL 61105
United States
815.968.0747 or
800.874.3723
7 AM - 5 PM Central Time (GMT -06:00)

Emergency telephone number (with hours of operation) : CHEMTREC: 800.424.9300
Outside US: 703.527.3887

Section 2. Hazards identification

OSHA/HCS status : This material is considered hazardous by the OSHA Hazard Communication Standard (29 CFR 1910.1200).

Classification of the substance or mixture : SKIN CORROSION/IRRITATION - Category 2
SERIOUS EYE DAMAGE/ EYE IRRITATION - Category 2A
CARCINOGENICITY - Category 2
TOXIC TO REPRODUCTION (Fertility) - Category 1A
TOXIC TO REPRODUCTION (Unborn child) - Category 1B

GHS label elements

Hazard pictograms :

Signal word : Danger

Hazard statements : Causes serious eye irritation.
Causes skin irritation.
May damage fertility or the unborn child.
Suspected of causing cancer.

Precautionary statements

Prevention : Obtain special instructions before use. Do not handle until all safety precautions have been read and understood. Use personal protective equipment as required. Wear protective gloves. Wear eye or face protection. Wash hands thoroughly after handling.

Response : IF exposed or concerned: Get medical attention. IF ON SKIN: Wash with plenty of soap and water. Take off contaminated clothing. Wash contaminated clothing before reuse. If skin irritation occurs: Get medical attention. IF IN EYES: Rinse cautiously with water for several minutes. Remove contact lenses, if present and easy to do. Continue rinsing. If eye irritation persists: Get medical attention.

Storage : Store locked up.

Section 2. Hazards identification

Disposal : Dispose of contents and container in accordance with all local, regional, national and international regulations.

Hazards not otherwise classified : None known.

Section 3. Composition/information on ingredients

Substance/mixture : Mixture

Other means of identification : DetoxiGel™ Endotoxin Removing Columns

CAS number/other identifiers

CAS number : Not applicable.

Ingredient name	%	CAS number
ethanol	25 - 45	64-17-5

Any concentration shown as a range is to protect confidentiality or is due to batch variation.

There are no additional ingredients present which, within the current knowledge of the supplier and in the concentrations applicable, are classified as hazardous to health or the environment and hence require reporting in this section.

Occupational exposure limits, if available, are listed in Section 8.

Section 4. First aid measures

Description of necessary first aid measures

Eye contact : Immediately flush eyes with plenty of water, occasionally lifting the upper and lower eyelids. Check for and remove any contact lenses. Continue to rinse for at least 10 minutes. Get medical attention.

Inhalation : Remove victim to fresh air and keep at rest in a position comfortable for breathing. If not breathing, if breathing is irregular or if respiratory arrest occurs, provide artificial respiration or oxygen by trained personnel. It may be dangerous to the person providing aid to give mouth-to-mouth resuscitation. Get medical attention. If unconscious, place in recovery position and get medical attention immediately. Maintain an open airway. Loosen tight clothing such as a collar, tie, belt or waistband.

Skin contact : Flush contaminated skin with plenty of water. Remove contaminated clothing and shoes. Wash contaminated clothing thoroughly with water before removing it, or wear gloves. Continue to rinse for at least 10 minutes. Get medical attention. Wash clothing before reuse. Clean shoes thoroughly before reuse.

Ingestion : Wash out mouth with water. Remove dentures if any. Remove victim to fresh air and keep at rest in a position comfortable for breathing. If material has been swallowed and the exposed person is conscious, give small quantities of water to drink. Stop if the exposed person feels sick as vomiting may be dangerous. Do not induce vomiting unless directed to do so by medical personnel. If vomiting occurs, the head should be kept low so that vomit does not enter the lungs. Get medical attention. Never give anything by mouth to an unconscious person. If unconscious, place in recovery position and get medical attention immediately. Maintain an open airway. Loosen tight clothing such as a collar, tie, belt or waistband.

Most important symptoms/effects, acute and delayed

Potential acute health effects

Eye contact : Causes serious eye irritation.

Inhalation : No known significant effects or critical hazards.

Skin contact : Causes skin irritation.

Ingestion : Irritating to mouth, throat and stomach.

Over-exposure signs/symptoms

Section 4. First aid measures

Eye contact : Adverse symptoms may include the following:
pain or irritation
watering
redness

Inhalation : Adverse symptoms may include the following:
reduced fetal weight
increase in fetal deaths
skeletal malformations

Skin contact : Adverse symptoms may include the following:
irritation
redness
reduced fetal weight
increase in fetal deaths
skeletal malformations

Ingestion : Adverse symptoms may include the following:
reduced fetal weight
increase in fetal deaths
skeletal malformations

Indication of immediate medical attention and special treatment needed, if necessary

Notes to physician : Treat symptomatically. Contact poison treatment specialist immediately if large quantities have been ingested or inhaled.

Specific treatments : No specific treatment.

Protection of first-aiders : No action shall be taken involving any personal risk or without suitable training. If it is suspected that fumes are still present, the rescuer should wear an appropriate mask or self-contained breathing apparatus. It may be dangerous to the person providing aid to give mouth-to-mouth resuscitation. Wash contaminated clothing thoroughly with water before removing it, or wear gloves.

See toxicological information (Section 11)

Section 5. Fire-fighting measures

Extinguishing media

Suitable extinguishing media : Use an extinguishing agent suitable for the surrounding fire.

Unsuitable extinguishing media : None known.

Specific hazards arising from the chemical : In a fire or if heated, a pressure increase will occur and the container may burst.

Hazardous thermal decomposition products : Decomposition products may include the following materials:
carbon dioxide
carbon monoxide

Special protective actions for fire-fighters : Promptly isolate the scene by removing all persons from the vicinity of the incident if there is a fire. No action shall be taken involving any personal risk or without suitable training.

Special protective equipment for fire-fighters : Fire-fighters should wear appropriate protective equipment and self-contained breathing apparatus (SCBA) with a full face-piece operated in positive pressure mode.

Section 6. Accidental release measures

Personal precautions, protective equipment and emergency procedures

For non-emergency personnel : No action shall be taken involving any personal risk or without suitable training. Evacuate surrounding areas. Keep unnecessary and unprotected personnel from entering. Do not touch or walk through spilled material. Avoid breathing vapor or mist. Provide adequate ventilation. Wear appropriate respirator when ventilation is inadequate. Put on appropriate personal protective equipment.

Section 6. Accidental release measures

For emergency responders : If specialised clothing is required to deal with the spillage, take note of any information in Section 8 on suitable and unsuitable materials. See also the information in "For non-emergency personnel".

Environmental precautions : Avoid dispersal of spilled material and runoff and contact with soil, waterways, drains and sewers. Inform the relevant authorities if the product has caused environmental pollution (sewers, waterways, soil or air).

Methods and materials for containment and cleaning up

Small spill : Stop leak if without risk. Move containers from spill area. Dilute with water and mop up if water-soluble. Alternatively, or if water-insoluble, absorb with an inert dry material and place in an appropriate waste disposal container. Dispose of via a licensed waste disposal contractor.

Large spill : Stop leak if without risk. Move containers from spill area. Approach release from upwind. Prevent entry into sewers, water courses, basements or confined areas. Wash spillages into an effluent treatment plant or proceed as follows. Contain and collect spillage with non-combustible, absorbent material e.g. sand, earth, vermiculite or diatomaceous earth and place in container for disposal according to local regulations (see Section 13). Dispose of via a licensed waste disposal contractor. Contaminated absorbent material may pose the same hazard as the spilled product. Note: see Section 1 for emergency contact information and Section 13 for waste disposal.

Section 7. Handling and storage

Precautions for safe handling

Protective measures : Put on appropriate personal protective equipment (see Section 8). Avoid exposure - obtain special instructions before use. Avoid exposure during pregnancy. Do not handle until all safety precautions have been read and understood. Do not get in eyes or on skin or clothing. Do not ingest. Avoid breathing vapor or mist. If during normal use the material presents a respiratory hazard, use only with adequate ventilation or wear appropriate respirator. Keep in the original container or an approved alternative made from a compatible material, kept tightly closed when not in use. Empty containers retain product residue and can be hazardous. Do not reuse container.

Advice on general occupational hygiene : Eating, drinking and smoking should be prohibited in areas where this material is handled, stored and processed. Workers should wash hands and face before eating, drinking and smoking. Remove contaminated clothing and protective equipment before entering eating areas. See also Section 8 for additional information on hygiene measures.

Conditions for safe storage, including any incompatibilities : Store between the following temperatures: 2 to 8°C (35.6 to 46.4°F). Store in accordance with local regulations. Store in original container protected from direct sunlight in a dry, cool and well-ventilated area, away from incompatible materials (see Section 10) and food and drink. Store locked up. Keep container tightly closed and sealed until ready for use. Containers that have been opened must be carefully resealed and kept upright to prevent leakage. Do not store in unlabeled containers. Use appropriate containment to avoid environmental contamination.

Section 8. Exposure controls/personal protection

Control parameters

Occupational exposure limits

Ingredient name	Exposure limits
ethanol	**ACGIH TLV (United States, 2000).** TWA: 1880 mg/m³ 8 hours. **OSHA (United States, 0/1989).** CEIL: 7600 ppm TWA: 1000 ppm TWA: 1900 mg/m³ **MSHA (United States).** TWA: 1900 mg/m³ **NIOSH (United States, 0/1994).** TWA: 1000 ppm

Section 8. Exposure controls/personal protection

	TWA: 1900 mg/m³ **ACGIH (United States, 0/1996).** TWA: 1880 mg/m³ **ACGIH (United States).** TWA: 1000 ppm **ACGIH TLV (United States, 4/2014).** STEL: 1000 ppm 15 minutes. **NIOSH REL (United States, 10/2013).** TWA: 1900 mg/m³ 10 hours. TWA: 1000 ppm 10 hours. **OSHA PEL (United States, 2/2013).** TWA: 1900 mg/m³ 8 hours. TWA: 1000 ppm 8 hours. **OSHA PEL 1989 (United States, 3/1989).** TWA: 1900 mg/m³ 8 hours. TWA: 1000 ppm 8 hours.

Appropriate engineering controls : If user operations generate dust, fumes, gas, vapor or mist, use process enclosures, local exhaust ventilation or other engineering controls to keep worker exposure to airborne contaminants below any recommended or statutory limits.

Environmental exposure controls : Emissions from ventilation or work process equipment should be checked to ensure they comply with the requirements of environmental protection legislation. In some cases, fume scrubbers, filters or engineering modifications to the process equipment will be necessary to reduce emissions to acceptable levels.

Individual protection measures

Hygiene measures : Wash hands, forearms and face thoroughly after handling chemical products, before eating, smoking and using the lavatory and at the end of the working period. Appropriate techniques should be used to remove potentially contaminated clothing. Wash contaminated clothing before reusing. Ensure that eyewash stations and safety showers are close to the workstation location.

Eye/face protection : Safety eyewear complying with an approved standard should be used when a risk assessment indicates this is necessary to avoid exposure to liquid splashes, mists, gases or dusts. If contact is possible, the following protection should be worn, unless the assessment indicates a higher degree of protection: chemical splash goggles.

Skin protection

Hand protection : Chemical-resistant, impervious gloves complying with an approved standard should be worn at all times when handling chemical products if a risk assessment indicates this is necessary. Considering the parameters specified by the glove manufacturer, check during use that the gloves are still retaining their protective properties. It should be noted that the time to breakthrough for any glove material may be different for different glove manufacturers. In the case of mixtures, consisting of several substances, the protection time of the gloves cannot be accurately estimated.

Body protection : Personal protective equipment for the body should be selected based on the task being performed and the risks involved and should be approved by a specialist before handling this product.

Other skin protection : Appropriate footwear and any additional skin protection measures should be selected based on the task being performed and the risks involved and should be approved by a specialist before handling this product.

Respiratory protection : Use a properly fitted, air-purifying or air-fed respirator complying with an approved standard if a risk assessment indicates this is necessary. Respirator selection must be based on known or anticipated exposure levels, the hazards of the product and the safe working limits of the selected respirator.

Section 9. Physical and chemical properties

Appearance

Physical state : Liquid. [Suspension.]

Color : White to off-white. Opaque.

Odor : Not available.

Odor threshold : Not available.

pH : Not available.

Melting point : Not available.

Boiling point : Not available.

Flash point : Closed cup: >100°C (>212°F) [Pensky-Martens.]

Burning time : Not applicable.

Burning rate : Not applicable.

Evaporation rate : Not available.

Flammability (solid, gas) : Not available.

Lower and upper explosive (flammable) limits : Not available.

Vapor pressure : Not available.

Vapor density : Not available.

Relative density : Not available.

Solubility : Insoluble in the following materials: cold water and hot water.

Solubility in water : Not available.

Partition coefficient: n-octanol/water : Not available.

Auto-ignition temperature : Not available.

Decomposition temperature : Not available.

SADT : Not available.

Viscosity : Not available.

Section 10. Stability and reactivity

Reactivity : No specific test data related to reactivity available for this product or its ingredients.

Chemical stability : The product is stable.

Possibility of hazardous reactions : Under normal conditions of storage and use, hazardous reactions will not occur.

Conditions to avoid : No specific data.

Incompatible materials : No specific data.

Hazardous decomposition products : Under normal conditions of storage and use, hazardous decomposition products should not be produced.

Section 11. Toxicological information

Information on toxicological effects

Acute toxicity

Product/ingredient name	Result	Species	Dose	Exposure
ethanol	LC50 Inhalation Vapor LD50 Oral	Rat Rat	124700 mg/m³ 7 g/kg	4 hours -

Conclusion/Summary : To the best of our knowledge, the toxicological properties of this product have not been thoroughly investigated.

Irritation/Corrosion

Section 11. Toxicological information

Product/ingredient name	Result	Species	Score	Exposure	Observation
ethanol	Eyes - Mild irritant	Rabbit	-	24 hours 500 milligrams	-
	Eyes - Moderate irritant	Rabbit	-	0.066666667 minutes 100 milligrams	-
	Eyes - Moderate irritant	Rabbit	-	100 microliters	-
	Eyes - Severe irritant	Rabbit	-	500 milligrams	-
	Skin - Mild irritant	Rabbit	-	400 milligrams	-
	Skin - Moderate irritant	Rabbit	-	24 hours 20 milligrams	-

Sensitization

Not available.

Mutagenicity

Product/ingredient name	Test	Experiment	Result
ethanol	DNA Damage	Subject: Bacteria	Positive
	DNA Damage	Subject: Bacteria	Positive
	Mutation in Microorganisms	Subject: Bacteria	Positive
	Mutation in Microorganisms	Subject: Bacteria	Positive
	Gene Conversion and Mitotic Recombination	Subject: Bacteria	Positive
	Sex chromosome loss and nondisjunction.	Subject: Insect	Positive
	Cytogenetic Analysis	Subject: Mammalian-Animal	Positive
	Cytogenetic Analysis	Subject: Mammalian-Animal	Positive
	Cytogenetic Analysis	Subject: Mammalian-Animal	Positive
	Cytogenetic Analysis	Subject: Mammalian-Animal	Positive
	DNA Adduct	Subject: Mammalian-Animal	Positive
	DNA Adduct	Subject: Mammalian-Animal	Positive
	DNA Damage	Subject: Mammalian-Animal	Positive
	Micronucleus Test	Subject: Mammalian-Animal	Positive
	-	Subject: Mammalian-Animal	Positive
	Other Mutation Test Systems	Subject: Mammalian-Animal	Positive
	Other Mutation Test Systems	Subject: Mammalian-Animal	Positive
	Sister Chromatid Exchange	Subject: Mammalian-Animal	Positive
	Specific Locus Test	Subject: Mammalian-Animal	Positive
	Sperm Morphology	Subject: Mammalian-Animal	Positive
	Cytogenetic Analysis	Subject: Mammalian-Human	Positive
	Cytogenetic Analysis	Subject: Mammalian-Human Cell: Germ	Positive
	Micronucleus Test	Subject: Mammalian-Human Cell: Somatic	Positive
	Micronucleus Test	Subject: Mammalian-Human	Positive
	DNA Inhibition	Subject: Mammalian-Human	Positive
	Cytogenetic Analysis	Subject: Mammalian-Human	Positive
	Cytogenetic Analysis	Subject: Mammalian-Human	Positive
	Cytogenetic Analysis	Subject: Mammalian-Human	Positive
	Sister Chromatid Exchange	Subject: Mammalian-Human	Positive

Carcinogenicity

Section 11. Toxicological information

Product/ingredient name	Result	Species	Dose	Exposure
ethanol	Equivocal - Oral - TD	Mouse	400 g/kg	57 weeks Intermittent
	Equivocal - Unreported - TDLo	Mouse	120 g/kg	18 weeks Intermittent
	Equivocal - Oral - TDLo	Mouse	320 mg/kg	50 weeks Intermittent

Classification

Product/ingredient name	OSHA	IARC	NTP
ethanol	+	1	-

Reproductive toxicity

Product/ingredient name	Maternal toxicity	Fertility	Development toxin	Species	Dose	Exposure
ethanol	-	-	-	Mouse	Intraperitoneal: 2.9 g/kg	8 days
	-	-	-	Mouse	Intraperitoneal: 2900 mg/kg	8 days
	-	-	-	Dog - Male	Unreported: 100 mg/kg	1 days
	-	Positive	-	Rat	Intraperitoneal: 600 mg/kg	15 days
	Positive	-	-	Mammal - species unspecified	Oral: 206 g/kg	-
	-	Positive	-	Rat - Male	Unreported: 400 mg/kg	1 days
	-	-	Positive	Mouse	Intraperitoneal: 15 g/kg	8 days
	-	Positive	-	Rat - Female	Unreported: 2400 mg/kg	10 days
	-	Positive	-	Woman - Female	Unreported: 200 mg/kg	5 days
	-	Positive	-	Dog	Oral: 221 g/kg	-
	-	Positive	-	Mammal - species unspecified	Oral: 78 g/kg	-
	-	-	Positive	Mouse	Intraperitoneal: 22.8 g/kg	8 days
	-	-	Positive	Mouse	Intraperitoneal: 5.8 g/kg	5 days
	-	-	Positive	Rat	Intraperitoneal: 600 mg/kg	15 days
	-	Positive	Positive	Mouse	Intraperitoneal: 2900 mg/kg	8 days
	-	-	Positive	Mammal - species unspecified	Intravenous	-
	-	-	-	Mouse - Male	Oral: 1680 g/kg	70 days

Teratogenicity

Product/ingredient name	Result	Species	Dose	Exposure
ethanol	Positive - Oral	Woman - Female	41 g/kg	-

Specific target organ toxicity (single exposure)

Not available.

Specific target organ toxicity (repeated exposure)

Not available.

Section 11. Toxicological information

Aspiration hazard

Not available.

Information on the likely routes of exposure : Routes of entry anticipated: Oral, Dermal, Inhalation.

Potential acute health effects

Eye contact : Causes serious eye irritation.

Inhalation : No known significant effects or critical hazards.

Skin contact : Causes skin irritation.

Ingestion : Irritating to mouth, throat and stomach.

Symptoms related to the physical, chemical and toxicological characteristics

Eye contact : Adverse symptoms may include the following:
pain or irritation
watering
redness

Inhalation : Adverse symptoms may include the following:
reduced fetal weight
increase in fetal deaths
skeletal malformations

Skin contact : Adverse symptoms may include the following:
irritation
redness
reduced fetal weight
increase in fetal deaths
skeletal malformations

Ingestion : Adverse symptoms may include the following:
reduced fetal weight
increase in fetal deaths
skeletal malformations

Delayed and immediate effects and also chronic effects from short and long term exposure

Short term exposure

Potential immediate effects : Not available.

Potential delayed effects : Not available.

Long term exposure

Potential immediate effects : Not available.

Potential delayed effects : Not available.

Potential chronic health effects

Not available.

General : No known significant effects or critical hazards.

Carcinogenicity : Suspected of causing cancer. Risk of cancer depends on duration and level of exposure.

Mutagenicity : No known significant effects or critical hazards.

Teratogenicity : May damage the unborn child.

Developmental effects : No known significant effects or critical hazards.

Fertility effects : May damage fertility.

Numerical measures of toxicity

Acute toxicity estimates

Not available.

Section 11. Toxicological information

Section 12. Ecological information

Toxicity

Product/ingredient name	Result	Species	Exposure
ethanol	Acute EC50 17.921 mg/l Marine water Acute EC50 2000 µg/l Fresh water Acute LC50 25500 µg/l Marine water Acute LC50 42000 µg/l Fresh water Chronic NOEC 4.995 mg/l Marine water Chronic NOEC 0.375 ul/L Fresh water	Algae - Ulva pertusa Daphnia - Daphnia magna Crustaceans - Artemia franciscana - Larvae Fish - Oncorhynchus mykiss Algae - Ulva pertusa Fish - Gambusia holbrooki - Larvae	96 hours 48 hours 48 hours 4 days 96 hours 12 weeks

Persistence and degradability

Product/ingredient name	Aquatic half-life	Photolysis	Biodegradability
ethanol	-	-	Readily

Bioaccumulative potential

Product/ingredient name	$LogP_{ow}$	BCF	Potential
ethanol	-0.35	0.66	low

Mobility in soil

Soil/water partition coefficient (K_{OC}) : Not available.

Other adverse effects : No known significant effects or critical hazards.

Section 13. Disposal considerations

Disposal methods : The generation of waste should be avoided or minimized wherever possible. Disposal of this product, solutions and any by-products should at all times comply with the requirements of environmental protection and waste disposal legislation and any regional local authority requirements. Dispose of surplus and non-recyclable products via a licensed waste disposal contractor. Waste should not be disposed of untreated to the sewer unless fully compliant with the requirements of all authorities with jurisdiction. Waste packaging should be recycled. Incineration or landfill should only be considered when recycling is not feasible. This material and its container must be disposed of in a safe way. Care should be taken when handling emptied containers that have not been cleaned or rinsed out. Empty containers or liners may retain some product residues. Avoid dispersal of spilled material and runoff and contact with soil, waterways, drains and sewers.

Section 14. Transport information

	DOT Classification	IATA
UN number	Not regulated.	Not regulated.
UN proper shipping name	-	-
Transport hazard class(es)	-	-
Packing group	-	-

Section 14. Transport information

Environmental hazards	No.	No.
Additional information	**Packaging instruction** **Passenger aircraft** Quantity limitation: 60 L **Cargo aircraft** Quantity limitation: 220 L **Special provisions** 24, B1, IB3, T2, TP1	-

Special precautions for user : **Transport within user's premises:** always transport in closed containers that are upright and secure. Ensure that persons transporting the product know what to do in the event of an accident or spillage.

Transport in bulk according to Annex II of MARPOL 73/78 and the IBC Code : Not available.

Section 15. Regulatory information

U.S. Federal regulations : **TSCA 8(a) CDR Exempt/Partial exemption**: Not determined

United States inventory (TSCA 8b): Not determined.

Clean Air Act Section 112 (b) Hazardous Air Pollutants (HAPs) : Not listed

Clean Air Act Section 602 Class I Substances : Not listed

Clean Air Act Section 602 Class II Substances : Not listed

DEA List I Chemicals (Precursor Chemicals) : Not listed

DEA List II Chemicals (Essential Chemicals) : Not listed

SARA 302/304

Composition/information on ingredients

No products were found.

SARA 304 RQ : Not applicable.

SARA 311/312

Classification : Immediate (acute) health hazard
Delayed (chronic) health hazard

Composition/information on ingredients

Name	%	Fire hazard	Sudden release of pressure	Reactive	Immediate (acute) health hazard	Delayed (chronic) health hazard
ethanol	25 - 45	Yes.	No.	No.	Yes.	Yes.

State regulations

Massachusetts : The following components are listed: ETHYL ALCOHOL

New York : None of the components are listed.

New Jersey : The following components are listed: Agarose; ETHYL ALCOHOL; ALCOHOL

Section 15. Regulatory information

Pennsylvania : The following components are listed: Agarose; DENATURED ALCOHOL

California Prop. 65

WARNING: This product contains a chemical known to the State of California to cause birth defects or other reproductive harm.

Ingredient name	Cancer	Reproductive	No significant risk level	Maximum acceptable dosage level
ethanol	No.	Yes.	No.	No.

Canada inventory : All components are listed or exempted.

International regulations

International lists : **Australia inventory (AICS)**: All components are listed or exempted.
China inventory (IECSC): All components are listed or exempted.
Japan inventory: Not determined.
Korea inventory: All components are listed or exempted.
Malaysia Inventory (EHS Register): Not determined.
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Philippines inventory (PICCS): All components are listed or exempted.
Taiwan inventory (CSNN): Not determined.

Chemical Weapons Convention List Schedule I Chemicals : Not listed

Chemical Weapons Convention List Schedule II Chemicals : Not listed

Chemical Weapons Convention List Schedule III Chemicals : Not listed

Section 16. Other information

Hazardous Material Information System (U.S.A.)

Health	1
Chronic Health Hazard	
Flammability	0
Physical hazards	0

National Fire Protection Association (U.S.A.)

Health	1
Flammability	0
Instability/Reactivity	0
Special	

The customer is responsible for determining the PPE code for this material.

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Section 16. Other information

History

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Version : 1

Prepared by : SDS Specialist

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IMDG = International Maritime Dangerous Goods
LogPow = logarithm of the octanol/water partition coefficient
MARPOL 73/78 = International Convention for the Prevention of Pollution From Ships, 1973 as modified by the Protocol of 1978. ("Marpol" = marine pollution)
UN = United Nations

References : Not available.

Indicates information that has changed from previously issued version.

Notice to reader

To the best of our knowledge, the information contained herein is accurate. However, neither the above-named supplier, nor any of its subsidiaries, assumes any liability whatsoever for the accuracy or completeness of the information contained herein.
Final determination of suitability of any material is the sole responsibility of the user. All materials may present unknown hazards and should be used with caution. Although certain hazards are described herein, we cannot guarantee that these are the only hazards that exist.

SAFETY DATA SHEET

Version 5.1
Revision Date 06/30/2014
Print Date 04/06/2015

1. PRODUCT AND COMPANY IDENTIFICATION

1.1 Product identifiers

Product name : Snake venom from *Oxyuranus scutellatus*

Product Number : V3129
Brand : Sigma

1.2 Relevant identified uses of the substance or mixture and uses advised against

Identified uses : Laboratory chemicals, Manufacture of substances

1.3 Details of the supplier of the safety data sheet

Company : Sigma-Aldrich
3050 Spruce Street
SAINT LOUIS MO 63103
USA

Telephone : +1 800-325-5832
Fax : +1 800-325-5052

1.4 Emergency telephone number

Emergency Phone # : (314) 776-6555

2. HAZARDS IDENTIFICATION

2.1 Classification of the substance or mixture

Not a hazardous substance or mixture.

2.2 GHS Label elements, including precautionary statements

Not a hazardous substance or mixture.

2.3 Hazards not otherwise classified (HNOC) or not covered by GHS - none

3. COMPOSITION/INFORMATION ON INGREDIENTS

3.1 Substances

Hazardous components

Component	Classification	Concentration
Snake venom from Oxyuranus scutellatus		
		-

4. FIRST AID MEASURES

4.1 Description of first aid measures

General advice
Move out of dangerous area.

If inhaled
If breathed in, move person into fresh air. If not breathing, give artificial respiration.

In case of skin contact
Wash off with soap and plenty of water.

In case of eye contact
Flush eyes with water as a precaution.

If swallowed
Never give anything by mouth to an unconscious person. Rinse mouth with water.

4.2 Most important symptoms and effects, both acute and delayed
The most important known symptoms and effects are described in the labelling (see section 2.2) and/or in section 11

4.3 Indication of any immediate medical attention and special treatment needed
no data available

5. FIREFIGHTING MEASURES

5.1 Extinguishing media

Suitable extinguishing media
Use water spray, alcohol-resistant foam, dry chemical or carbon dioxide.

5.2 Special hazards arising from the substance or mixture
Nature of decomposition products not known.

5.3 Advice for firefighters
Wear self contained breathing apparatus for fire fighting if necessary.

5.4 Further information
no data available

6. ACCIDENTAL RELEASE MEASURES

6.1 Personal precautions, protective equipment and emergency procedures
Avoid dust formation. Avoid breathing vapours, mist or gas.
For personal protection see section 8.

6.2 Environmental precautions
Do not let product enter drains.

6.3 Methods and materials for containment and cleaning up
Sweep up and shovel. Keep in suitable, closed containers for disposal.

6.4 Reference to other sections
For disposal see section 13.

7. HANDLING AND STORAGE

7.1 Precautions for safe handling
Provide appropriate exhaust ventilation at places where dust is formed.Normal measures for preventive fire protection.
For precautions see section 2.2.

7.2 Conditions for safe storage, including any incompatibilities
Keep container tightly closed in a dry and well-ventilated place.

Recommended storage temperature: -20 °C

7.3 Specific end use(s)
Apart from the uses mentioned in section 1.2 no other specific uses are stipulated

8. EXPOSURE CONTROLS/PERSONAL PROTECTION

8.1 Control parameters

Components with workplace control parameters
Contains no substances with occupational exposure limit values.

8.2 Exposure controls

Appropriate engineering controls
General industrial hygiene practice.

Personal protective equipment

Eye/face protection
Use equipment for eye protection tested and approved under appropriate government standards such as NIOSH (US) or EN 166(EU).

Skin protection
Handle with gloves. Gloves must be inspected prior to use. Use proper glove removal technique (without touching glove's outer surface) to avoid skin contact with this product. Dispose of contaminated gloves after use in accordance with applicable laws and good laboratory practices. Wash and dry hands.

Body Protection
Choose body protection in relation to its type, to the concentration and amount of dangerous substances, and to the specific work-place., The type of protective equipment must be selected according to the concentration and amount of the dangerous substance at the specific workplace.

Respiratory protection
Respiratory protection is not required. Where protection from nuisance levels of dusts are desired, use type N95 (US) or type P1 (EN 143) dust masks. Use respirators and components tested and approved under appropriate government standards such as NIOSH (US) or CEN (EU).

Control of environmental exposure
Do not let product enter drains.

9. PHYSICAL AND CHEMICAL PROPERTIES

9.1 Information on basic physical and chemical properties

a)	Appearance	Form: solid
b)	Odour	no data available
c)	Odour Threshold	no data available
d)	pH	no data available
e)	Melting point/freezing point	no data available
f)	Initial boiling point and boiling range	no data available
g)	Flash point	no data available
h)	Evapouration rate	no data available
i)	Flammability (solid, gas)	no data available
j)	Upper/lower flammability or explosive limits	no data available
k)	Vapour pressure	no data available
l)	Vapour density	no data available
m)	Relative density	no data available
n)	Water solubility	no data available
o)	Partition coefficient: n-octanol/water	no data available
p)	Auto-ignition temperature	no data available
q)	Decomposition temperature	no data available
r)	Viscosity	no data available
s)	Explosive properties	no data available
t)	Oxidizing properties	no data available

9.2 Other safety information
no data available

10. STABILITY AND REACTIVITY

10.1 Reactivity
no data available

10.2 Chemical stability
Stable under recommended storage conditions.

10.3 Possibility of hazardous reactions
no data available

10.4 Conditions to avoid
no data available

10.5 Incompatible materials
Strong oxidizing agents

10.6 Hazardous decomposition products
Other decomposition products - no data available
In the event of fire: see section 5

11. TOXICOLOGICAL INFORMATION

11.1 Information on toxicological effects

Acute toxicity
Inhalation: no data available

Dermal: no data available

LD50 Intraperitoneal - mouse - 0.009 mg/kg

LD50 Subcutaneous - mouse - 0.064 mg/kg

Skin corrosion/irritation
no data available

Serious eye damage/eye irritation
no data available

Respiratory or skin sensitisation
Prolonged or repeated exposure may cause allergic reactions in certain sensitive individuals.

Germ cell mutagenicity
no data available

Carcinogenicity

IARC: No component of this product present at levels greater than or equal to 0.1% is identified as probable, possible or confirmed human carcinogen by IARC.

ACGIH: No component of this product present at levels greater than or equal to 0.1% is identified as a carcinogen or potential carcinogen by ACGIH.

NTP: No component of this product present at levels greater than or equal to 0.1% is identified as a known or anticipated carcinogen by NTP.

OSHA: No component of this product present at levels greater than or equal to 0.1% is identified as a carcinogen or potential carcinogen by OSHA.

Reproductive toxicity
no data available

no data available

Specific target organ toxicity - single exposure
no data available

Specific target organ toxicity - repeated exposure
no data available

Aspiration hazard
no data available

Additional Information
RTECS: YX3994000

To the best of our knowledge, the chemical, physical, and toxicological properties have not been thoroughly investigated.

Stomach - Irregularities - Based on Human Evidence
Stomach - Irregularities - Based on Human Evidence

12. ECOLOGICAL INFORMATION

12.1 Toxicity
no data available

12.2 Persistence and degradability
no data available

12.3 Bioaccumulative potential
no data available

12.4 Mobility in soil
no data available

12.5 Results of PBT and vPvB assessment
PBT/vPvB assessment not available as chemical safety assessment not required/not conducted

12.6 Other adverse effects

no data available

13. DISPOSAL CONSIDERATIONS

13.1 Waste treatment methods

Product
Offer surplus and non-recyclable solutions to a licensed disposal company.

Contaminated packaging
Dispose of as unused product.

14. TRANSPORT INFORMATION

DOT (US)
Not dangerous goods

IMDG
Not dangerous goods

IATA
Not dangerous goods

15. REGULATORY INFORMATION

SARA 302 Components
SARA 302: No chemicals in this material are subject to the reporting requirements of SARA Title III, Section 302.

SARA 313 Components
SARA 313: This material does not contain any chemical components with known CAS numbers that exceed the threshold (De Minimis) reporting levels established by SARA Title III, Section 313.

SARA 311/312 Hazards
Chronic Health Hazard

Massachusetts Right To Know Components

No components are subject to the Massachusetts Right to Know Act.

Pennsylvania Right To Know Components

	CAS-No.	Revision Date
Snake venom from Oxyuranus scutellatus	-	

New Jersey Right To Know Components

	CAS-No.	Revision Date
Snake venom from Oxyuranus scutellatus	-	

California Prop. 65 Components

This product does not contain any chemicals known to State of California to cause cancer, birth defects, or any other reproductive harm.

16. OTHER INFORMATION

HMIS Rating

Health hazard:	0
Chronic Health Hazard:	*
Flammability:	0
Physical Hazard	0

NFPA Rating

Health hazard:	0
Fire Hazard:	0
Reactivity Hazard:	0

Further information

The above information is believed to be correct but does not purport to be all inclusive and shall be used only as a guide. The information in this document is based on the present state of our knowledge and is applicable to the product with regard to appropriate safety precautions. It does not represent any guarantee of the properties of the product. Sigma-Aldrich Corporation and its Affiliates shall not be held liable for any damage resulting from handling or from contact with the above product. See www.sigma-aldrich.com and/or the reverse side of invoice or packing slip for additional terms and conditions of sale.

Preparation Information

Sigma-Aldrich Corporation
Product Safety – Americas Region
1-800-521-8956

Version: 5.1 Revision Date: 06/30/2014 Print Date: 04/06/2015

SAFETY DATA SHEET

Version 5.3
Revision Date 03/07/2015
Print Date 04/06/2015

1. PRODUCT AND COMPANY IDENTIFICATION

1.1 Product identifiers

Product name : Ammonia

Product Number : QC1593
Brand : Fluka

1.2 Relevant identified uses of the substance or mixture and uses advised against

Identified uses : Laboratory chemicals, Manufacture of substances

1.3 Details of the supplier of the safety data sheet

Company : Sigma-Aldrich
3050 Spruce Street
SAINT LOUIS MO 63103
USA

Telephone : +1 800-325-5832
Fax : +1 800-325-5052

1.4 Emergency telephone number

Emergency Phone # : (314) 776-6555

2. HAZARDS IDENTIFICATION

2.1 Classification of the substance or mixture

Not a hazardous substance or mixture.

2.2 GHS Label elements, including precautionary statements

Not a hazardous substance or mixture.

2.3 Hazards not otherwise classified (HNOC) or not covered by GHS - none

3. COMPOSITION/INFORMATION ON INGREDIENTS

3.2 Mixtures

No components need to be disclosed according to the applicable regulations.

4. FIRST AID MEASURES

4.1 Description of first aid measures

If inhaled
If breathed in, move person into fresh air. If not breathing, give artificial respiration.

In case of skin contact
Wash off with soap and plenty of water.

In case of eye contact
Flush eyes with water as a precaution.

If swallowed
Never give anything by mouth to an unconscious person. Rinse mouth with water.

4.2 Most important symptoms and effects, both acute and delayed

The most important known symptoms and effects are described in the labelling (see section 2.2) and/or in section 11

4.3 Indication of any immediate medical attention and special treatment needed
No data available

5. FIREFIGHTING MEASURES

5.1 Extinguishing media

Suitable extinguishing media
Use water spray, alcohol-resistant foam, dry chemical or carbon dioxide.

5.2 Special hazards arising from the substance or mixture
No data available

5.3 Advice for firefighters
Wear self-contained breathing apparatus for firefighting if necessary.

5.4 Further information
No data available

6. ACCIDENTAL RELEASE MEASURES

6.1 Personal precautions, protective equipment and emergency procedures
Avoid breathing vapours, mist or gas.
For personal protection see section 8.

6.2 Environmental precautions
No special environmental precautions required.

6.3 Methods and materials for containment and cleaning up
Keep in suitable, closed containers for disposal.

6.4 Reference to other sections
For disposal see section 13.

7. HANDLING AND STORAGE

7.1 Precautions for safe handling
For precautions see section 2.2.

7.2 Conditions for safe storage, including any incompatibilities
Keep container tightly closed in a dry and well-ventilated place.

Store at Room Temperature.
Storage class (TRGS 510): Non Combustible Liquids

7.3 Specific end use(s)
Apart from the uses mentioned in section 1.2 no other specific uses are stipulated

8. EXPOSURE CONTROLS/PERSONAL PROTECTION

8.1 Control parameters

Components with workplace control parameters
Contains no substances with occupational exposure limit values.

8.2 Exposure controls

Appropriate engineering controls
General industrial hygiene practice.

Personal protective equipment

Eye/face protection
Use equipment for eye protection tested and approved under appropriate government standards such as NIOSH (US) or EN 166(EU).

Skin protection
Handle with gloves. Gloves must be inspected prior to use. Use proper glove removal technique (without touching glove's outer surface) to avoid skin contact with this product. Dispose of contaminated gloves after use in accordance with applicable laws and good laboratory practices. Wash and dry hands.

Body Protection
impervious clothing, The type of protective equipment must be selected according to the concentration and amount of the dangerous substance at the specific workplace.

Respiratory protection
Respiratory protection not required. For nuisance exposures use type OV/AG (US) or type ABEK (EU EN 14387) respirator cartridges. Use respirators and components tested and approved under appropriate government standards such as NIOSH (US) or CEN (EU).

Control of environmental exposure
No special environmental precautions required.

9. PHYSICAL AND CHEMICAL PROPERTIES

9.1 Information on basic physical and chemical properties

a)	Appearance	Form: liquid
b)	Odour	No data available
c)	Odour Threshold	No data available
d)	pH	No data available
e)	Melting point/freezing point	No data available
f)	Initial boiling point and boiling range	No data available
g)	Flash point	No data available
h)	Evaporation rate	No data available
i)	Flammability (solid, gas)	No data available
j)	Upper/lower flammability or explosive limits	No data available
k)	Vapour pressure	No data available
l)	Vapour density	No data available
m)	Relative density	No data available
n)	Water solubility	No data available
o)	Partition coefficient: n-octanol/water	No data available
p)	Auto-ignition temperature	No data available
q)	Decomposition temperature	No data available
r)	Viscosity	No data available
s)	Explosive properties	No data available
t)	Oxidizing properties	No data available

9.2 Other safety information
No data available

10. STABILITY AND REACTIVITY

10.1 Reactivity
No data available

10.2 Chemical stability
Stable under recommended storage conditions.

10.3 Possibility of hazardous reactions
No data available

10.4 Conditions to avoid
No data available

10.5 Incompatible materials
Strong oxidizing agents

10.6 Hazardous decomposition products
Other decomposition products - No data available
In the event of fire: see section 5

11. TOXICOLOGICAL INFORMATION

11.1 Information on toxicological effects

Acute toxicity
No data available

Inhalation: No data available

Dermal: No data available

No data available

Skin corrosion/irritation
No data available

Serious eye damage/eye irritation
No data available

Respiratory or skin sensitisation
No data available

Germ cell mutagenicity
No data available

Carcinogenicity

IARC: No component of this product present at levels greater than or equal to 0.1% is identified as probable, possible or confirmed human carcinogen by IARC.

ACGIH: No component of this product present at levels greater than or equal to 0.1% is identified as a carcinogen or potential carcinogen by ACGIH.

NTP: No component of this product present at levels greater than or equal to 0.1% is identified as a known or anticipated carcinogen by NTP.

OSHA: No component of this product present at levels greater than or equal to 0.1% is identified as a carcinogen or potential carcinogen by OSHA.

Reproductive toxicity
No data available
No data available

Specific target organ toxicity - single exposure
No data available

Specific target organ toxicity - repeated exposure
No data available

Aspiration hazard
No data available

Additional Information
RTECS: Not available

To the best of our knowledge, the chemical, physical, and toxicological properties have not been thoroughly investigated.

12. ECOLOGICAL INFORMATION

12.1 Toxicity
No data available

12.2 Persistence and degradability
No data available

12.3 Bioaccumulative potential
No data available

12.4 Mobility in soil
No data available

12.5 Results of PBT and vPvB assessment
PBT/vPvB assessment not available as chemical safety assessment not required/not conducted

12.6 Other adverse effects
No data available

13. DISPOSAL CONSIDERATIONS

13.1 Waste treatment methods

Product
Offer surplus and non-recyclable solutions to a licensed disposal company.

Contaminated packaging
Dispose of as unused product.

14. TRANSPORT INFORMATION

DOT (US)
Not dangerous goods

IMDG
Not dangerous goods

IATA
Not dangerous goods

15. REGULATORY INFORMATION

SARA 302 Components
No chemicals in this material are subject to the reporting requirements of SARA Title III, Section 302.

SARA 313 Components
This material does not contain any chemical components with known CAS numbers that exceed the threshold (De Minimis) reporting levels established by SARA Title III, Section 313.

SARA 311/312 Hazards
No SARA Hazards

Massachusetts Right To Know Components
No components are subject to the Massachusetts Right to Know Act.

Pennsylvania Right To Know Components

	CAS-No.	Revision Date
Water	7732-18-5	
Ammonium chloride	12125-02-9	1994-04-01

New Jersey Right To Know Components

	CAS-No.	Revision Date
Water	7732-18-5	

California Prop. 65 Components
This product does not contain any chemicals known to State of California to cause cancer, birth defects, or any other reproductive harm.

16. OTHER INFORMATION

HMIS Rating

Health hazard:	0
Chronic Health Hazard:	
Flammability:	0
Physical Hazard	0

NFPA Rating

Health hazard:	0
Fire Hazard:	0
Reactivity Hazard:	0

Further information

The above information is believed to be correct but does not purport to be all inclusive and shall be used only as a guide. The information in this document is based on the present state of our knowledge and is applicable to the product with regard to appropriate safety precautions. It does not represent any guarantee of the properties of the product. Sigma-Aldrich Corporation and its Affiliates shall not be held liable for any damage resulting from handling or from contact with the above product. See www.sigma-aldrich.com and/or the reverse side of invoice or packing slip for additional terms and conditions of sale.

Preparation Information

Sigma-Aldrich Corporation
Product Safety – Americas Region
1-800-521-8956

Version: 5.3 Revision Date: 03/07/2015 Print Date: 04/06/2015

SAFETY DATA SHEET

Version 4.11
Revision Date 08/12/2014
Print Date 04/06/2015

1. PRODUCT AND COMPANY IDENTIFICATION

1.1 Product identifiers

Product name : Ethyl alcohol, pure

Product Number : E7023
Brand : Sigma-Aldrich
Index-No. : 603-002-00-5

CAS-No. : 64-17-5

1.2 Relevant identified uses of the substance or mixture and uses advised against

Identified uses : Laboratory chemicals, Manufacture of substances

1.3 Details of the supplier of the safety data sheet

Company : Sigma-Aldrich
3050 Spruce Street
SAINT LOUIS MO 63103
USA

Telephone : +1 800-325-5832
Fax : +1 800-325-5052

1.4 Emergency telephone number

Emergency Phone # : (314) 776-6555

2. HAZARDS IDENTIFICATION

2.1 Classification of the substance or mixture

GHS Classification in accordance with 29 CFR 1910 (OSHA HCS)
Flammable liquids (Category 2), H225

For the full text of the H-Statements mentioned in this Section, see Section 16.

2.2 GHS Label elements, including precautionary statements

Pictogram

Signal word Danger

Hazard statement(s)
H225 Highly flammable liquid and vapour.

Precautionary statement(s)
P210 Keep away from heat/sparks/open flames/hot surfaces. - No smoking.
P233 Keep container tightly closed.
P240 Ground/bond container and receiving equipment.
P241 Use explosion-proof electrical/ ventilating/ lighting/ equipment.
P242 Use only non-sparking tools.
P243 Take precautionary measures against static discharge.
P280 Wear protective gloves/ protective clothing/ eye protection/ face protection.
P303 + P361 + P353 IF ON SKIN (or hair): Remove/ Take off immediately all contaminated clothing. Rinse skin with water/ shower.
P370 + P378 In case of fire: Use dry sand, dry chemical or alcohol-resistant foam for

extinction.

P403 + P235	Store in a well-ventilated place. Keep cool.
P501	Dispose of contents/ container to an approved waste disposal plant.

2.3 Hazards not otherwise classified (HNOC) or not covered by GHS - none

3. COMPOSITION/INFORMATION ON INGREDIENTS

3.1 Substances

Synonyms	:	Absolute alcohol
Formula	:	C_2H_6O
Molecular weight	:	46.07 g/mol
CAS-No.	:	64-17-5
EC-No.	:	200-578-6
Index-No.	:	603-002-00-5

Hazardous components

Component	Classification	Concentration
Ethanol		
	Flam. Liq. 2; H225	90 - 100 %

For the full text of the H-Statements mentioned in this Section, see Section 16.

4. FIRST AID MEASURES

4.1 Description of first aid measures

General advice
Move out of dangerous area.Consult a physician. Show this safety data sheet to the doctor in attendance.

If inhaled
If breathed in, move person into fresh air. If not breathing, give artificial respiration. Consult a physician.

In case of skin contact
Wash off with soap and plenty of water. Consult a physician.

In case of eye contact
Rinse thoroughly with plenty of water for at least 15 minutes and consult a physician.

If swallowed
Do NOT induce vomiting. Never give anything by mouth to an unconscious person. Rinse mouth with water. Consult a physician.

4.2 Most important symptoms and effects, both acute and delayed
The most important known symptoms and effects are described in the labelling (see section 2.2) and/or in section 11

4.3 Indication of any immediate medical attention and special treatment needed
No data available

5. FIREFIGHTING MEASURES

5.1 Extinguishing media

Suitable extinguishing media
Use water spray, alcohol-resistant foam, dry chemical or carbon dioxide.

5.2 Special hazards arising from the substance or mixture
No data available

5.3 Advice for firefighters
Wear self-contained breathing apparatus for firefighting if necessary.

5.4 Further information
Use water spray to cool unopened containers.

6. ACCIDENTAL RELEASE MEASURES

6.1 Personal precautions, protective equipment and emergency procedures

Use personal protective equipment. Avoid breathing vapours, mist or gas. Ensure adequate ventilation. Remove all sources of ignition. Evacuate personnel to safe areas. Beware of vapours accumulating to form explosive concentrations. Vapours can accumulate in low areas.
For personal protection see section 8.

6.2 Environmental precautions

Prevent further leakage or spillage if safe to do so. Do not let product enter drains.

6.3 Methods and materials for containment and cleaning up

Contain spillage, and then collect with an electrically protected vacuum cleaner or by wet-brushing and place in container for disposal according to local regulations (see section 13).

6.4 Reference to other sections

For disposal see section 13.

7. HANDLING AND STORAGE

7.1 Precautions for safe handling

Avoid contact with skin and eyes. Avoid inhalation of vapour or mist.
Use explosion-proof equipment.Keep away from sources of ignition - No smoking.Take measures to prevent the build up of electrostatic charge.
For precautions see section 2.2.

7.2 Conditions for safe storage, including any incompatibilities

Keep container tightly closed in a dry and well-ventilated place. Containers which are opened must be carefully resealed and kept upright to prevent leakage.

Hygroscopic.

7.3 Specific end use(s)

Apart from the uses mentioned in section 1.2 no other specific uses are stipulated

8. EXPOSURE CONTROLS/PERSONAL PROTECTION

8.1 Control parameters

Components with workplace control parameters

Component	CAS-No.	Value	Control parameters	Basis
Ethanol	64-17-5	TWA	1,000 ppm	USA. ACGIH Threshold Limit Values (TLV)
	Remarks	Upper Respiratory Tract irritation Confirmed animal carcinogen with unknown relevance to humans		
		TWA	1,000 ppm 1,900 mg/m3	USA. Occupational Exposure Limits (OSHA) - Table Z-1 Limits for Air Contaminants
		The value in mg/m3 is approximate.		
		TWA	1,000 ppm 1,900 mg/m3	USA. NIOSH Recommended Exposure Limits

8.2 Exposure controls

Appropriate engineering controls

Handle in accordance with good industrial hygiene and safety practice. Wash hands before breaks and at the end of workday.

Personal protective equipment

Eye/face protection

Face shield and safety glasses Use equipment for eye protection tested and approved under appropriate government standards such as NIOSH (US) or EN 166(EU).

Skin protection
Handle with gloves. Gloves must be inspected prior to use. Use proper glove removal technique (without touching glove's outer surface) to avoid skin contact with this product. Dispose of contaminated gloves after use in accordance with applicable laws and good laboratory practices. Wash and dry hands.

Full contact
Material: butyl-rubber
Minimum layer thickness: 0.3 mm
Break through time: 480 min
Material tested:Butoject® (KCL 897 / Aldrich Z677647, Size M)

Splash contact
Material: Nitrile rubber
Minimum layer thickness: 0.2 mm
Break through time: 38 min
Material tested:Dermatril® P (KCL 743 / Aldrich Z677388, Size M)

data source: KCL GmbH, D-36124 Eichenzell, phone +49 (0)6659 87300, e-mail sales@kcl.de, test method: EN374
If used in solution, or mixed with other substances, and under conditions which differ from EN 374, contact the supplier of the CE approved gloves. This recommendation is advisory only and must be evaluated by an industrial hygienist and safety officer familiar with the specific situation of anticipated use by our customers. It should not be construed as offering an approval for any specific use scenario.

Body Protection
impervious clothing, Flame retardant antistatic protective clothing., The type of protective equipment must be selected according to the concentration and amount of the dangerous substance at the specific workplace.

Respiratory protection
Where risk assessment shows air-purifying respirators are appropriate use a full-face respirator with multi-purpose combination (US) or type ABEK (EN 14387) respirator cartridges as a backup to engineering controls. If the respirator is the sole means of protection, use a full-face supplied air respirator. Use respirators and components tested and approved under appropriate government standards such as NIOSH (US) or CEN (EU).

Control of environmental exposure
Prevent further leakage or spillage if safe to do so. Do not let product enter drains.

9. PHYSICAL AND CHEMICAL PROPERTIES

9.1 Information on basic physical and chemical properties

a)	Appearance	Form: liquid, clear Colour: colourless
b)	Odour	No data available
c)	Odour Threshold	No data available
d)	pH	No data available
e)	Melting point/freezing point	-144.0 °C (-227.2 °F)
f)	Initial boiling point and boiling range	78.0 - 80.0 °C (172.4 - 176.0 °F)
g)	Flash point	14.0 °C (57.2 °F) - closed cup
h)	Evaporation rate	No data available
i)	Flammability (solid, gas)	No data available
j)	Upper/lower flammability or explosive limits	Upper explosion limit: 19 %(V) Lower explosion limit: 3.3 %(V)
k)	Vapour pressure	59.5 hPa (44.6 mmHg) at 20.0 °C (68.0 °F)
l)	Vapour density	No data available
m)	Relative density	0.7974 g/cm3

n)	Water solubility	completely soluble
o)	Partition coefficient: n-octanol/water	No data available
p)	Auto-ignition temperature	363.0 °C (685.4 °F)
q)	Decomposition temperature	No data available
r)	Viscosity	No data available
s)	Explosive properties	No data available
t)	Oxidizing properties	No data available

9.2 Other safety information
No data available

10. STABILITY AND REACTIVITY

10.1 Reactivity
No data available

10.2 Chemical stability
Stable under recommended storage conditions.

10.3 Possibility of hazardous reactions
Vapours may form explosive mixture with air.

10.4 Conditions to avoid
Heat, flames and sparks. Extremes of temperature and direct sunlight.

10.5 Incompatible materials
Alkali metals, Ammonia, Oxidizing agents, Peroxides

10.6 Hazardous decomposition products
Other decomposition products - No data available
In the event of fire: see section 5

11. TOXICOLOGICAL INFORMATION

11.1 Information on toxicological effects

Acute toxicity
LD50 Oral - Rat - 7,060 mg/kg
Remarks: Lungs, Thorax, or Respiration:Other changes.

LC50 Inhalation - Rat - 10 h - 20000 ppm

Dermal: No data available

No data available

Skin corrosion/irritation
Skin - Rabbit
Result: No skin irritation - 24 h
(OECD Test Guideline 404)

Serious eye damage/eye irritation
Eyes - Rabbit
Result: Mild eye irritation - 24 h
(OECD Test Guideline 405)

Respiratory or skin sensitisation
No data available

Germ cell mutagenicity
No data available

Carcinogenicity

Carcinogenicity - Mouse - Oral
Tumorigenic:Equivocal tumorigenic agent by RTECS criteria. Liver:Tumors. Blood:Lymphomas including Hodgkin's disease.

IARC: No component of this product present at levels greater than or equal to 0.1% is identified as probable, possible or confirmed human carcinogen by IARC.

NTP: No component of this product present at levels greater than or equal to 0.1% is identified as a known or anticipated carcinogen by NTP.

OSHA: No component of this product present at levels greater than or equal to 0.1% is identified as a carcinogen or potential carcinogen by OSHA.

Reproductive toxicity
No data available

Reproductive toxicity - Human - female - Oral
Effects on Newborn: Apgar score (human only). Effects on Newborn: Other neonatal measures or effects. Effects on Newborn: Drug dependence.

Specific target organ toxicity - single exposure
No data available

Specific target organ toxicity - repeated exposure
No data available

Aspiration hazard
No data available

Additional Information
RTECS: KQ6300000

Central nervous system depression, narcosis, Damage to the heart., To the best of our knowledge, the chemical, physical, and toxicological properties have not been thoroughly investigated.

Stomach - Irregularities - Based on Human Evidence
Stomach - Irregularities - Based on Human Evidence

12. ECOLOGICAL INFORMATION

12.1 Toxicity
No data available

12.2 Persistence and degradability
No data available

12.3 Bioaccumulative potential
No data available

12.4 Mobility in soil
No data available

12.5 Results of PBT and vPvB assessment
PBT/vPvB assessment not available as chemical safety assessment not required/not conducted

12.6 Other adverse effects

No data available

13. DISPOSAL CONSIDERATIONS

13.1 Waste treatment methods

Product
Contact a licensed professional waste disposal service to dispose of this material. Burn in a chemical incinerator equipped with an afterburner and scrubber but exert extra care in igniting as this material is highly flammable. Offer surplus and non-recyclable solutions to a licensed disposal company.

Contaminated packaging
Dispose of as unused product.

14. TRANSPORT INFORMATION

DOT (US)
UN number: 1170 Class: 3 Packing group: II
Proper shipping name: Ethanol
Reportable Quantity (RQ):
Marine pollutant: No
Poison Inhalation Hazard: No

IMDG
UN number: 1170 Class: 3 Packing group: II EMS-No: F-E, S-D
Proper shipping name: ETHANOL
Marine pollutant: No

IATA
UN number: 1170 Class: 3 Packing group: II
Proper shipping name: Ethanol

15. REGULATORY INFORMATION

SARA 302 Components
No chemicals in this material are subject to the reporting requirements of SARA Title III, Section 302.

SARA 313 Components
This material does not contain any chemical components with known CAS numbers that exceed the threshold (De Minimis) reporting levels established by SARA Title III, Section 313.

SARA 311/312 Hazards
Fire Hazard, Acute Health Hazard, Chronic Health Hazard

Massachusetts Right To Know Components

	CAS-No.	Revision Date
Ethanol	64-17-5	2007-03-01

Pennsylvania Right To Know Components

	CAS-No.	Revision Date
Ethanol	64-17-5	2007-03-01

New Jersey Right To Know Components

	CAS-No.	Revision Date
Ethanol	64-17-5	2007-03-01

California Prop. 65 Components
This product does not contain any chemicals known to State of California to cause cancer, birth defects, or any other reproductive harm.

16. OTHER INFORMATION

Full text of H-Statements referred to under sections 2 and 3.

Flam. Liq.	Flammable liquids
H225	Highly flammable liquid and vapour.

HMIS Rating

Health hazard:	2
Chronic Health Hazard:	*
Flammability:	3
Physical Hazard	0

NFPA Rating
Health hazard: 2

Fire Hazard:	3
Reactivity Hazard:	0

Further information

The above information is believed to be correct but does not purport to be all inclusive and shall be used only as a guide. The information in this document is based on the present state of our knowledge and is applicable to the product with regard to appropriate safety precautions. It does not represent any guarantee of the properties of the product. Sigma-Aldrich Corporation and its Affiliates shall not be held liable for any damage resulting from handling or from contact with the above product. See www.sigma-aldrich.com and/or the reverse side of invoice or packing slip for additional terms and conditions of sale.

Preparation Information

Sigma-Aldrich Corporation
Product Safety – Americas Region
1-800-521-8956

Version: 4.11 Revision Date: 08/12/2014 Print Date: 04/06/2015

SAFETY DATA SHEET

Version 5.7
Revision Date 12/10/2014
Print Date 04/06/2015

1. PRODUCT AND COMPANY IDENTIFICATION

1.1 Product identifiers

Product name : Sodium hypochlorite solution

Product Number : 425044
Brand : Sigma-Aldrich

1.2 Relevant identified uses of the substance or mixture and uses advised against

Identified uses : Laboratory chemicals, Manufacture of substances

1.3 Details of the supplier of the safety data sheet

Company : Sigma-Aldrich
3050 Spruce Street
SAINT LOUIS MO 63103
USA

Telephone : +1 800-325-5832
Fax : +1 800-325-5052

1.4 Emergency telephone number

Emergency Phone # : (314) 776-6555

2. HAZARDS IDENTIFICATION

2.1 Classification of the substance or mixture

GHS Classification in accordance with 29 CFR 1910 (OSHA HCS)
Skin corrosion (Category 1B), H314
Serious eye damage (Category 1), H318
Acute aquatic toxicity (Category 1), H400
Chronic aquatic toxicity (Category 1), H410

For the full text of the H-Statements mentioned in this Section, see Section 16.

2.2 GHS Label elements, including precautionary statements

Pictogram

Signal word Danger

Hazard statement(s)
H314 Causes severe skin burns and eye damage.
H318 Causes serious eye damage.
H410 Very toxic to aquatic life with long lasting effects.

Precautionary statement(s)
P264 Wash skin thoroughly after handling.
P273 Avoid release to the environment.
P280 Wear protective gloves/ protective clothing/ eye protection/ face protection.
P301 + P330 + P331 IF SWALLOWED: Rinse mouth. Do NOT induce vomiting.
P303 + P361 + P353 IF ON SKIN (or hair): Remove/ Take off immediately all contaminated clothing. Rinse skin with water/ shower.
P304 + P340 + P310 IF INHALED: Remove victim to fresh air and keep at rest in a position

	comfortable for breathing. Immediately call a POISON CENTER or doctor/ physician.
P305 + P351 + P338 + P310	IF IN EYES: Rinse cautiously with water for several minutes. Remove contact lenses, if present and easy to do. Continue rinsing. Immediately call a POISON CENTER or doctor/ physician.
P363	Wash contaminated clothing before reuse.
P391	Collect spillage.
P405	Store locked up.
P501	Dispose of contents/ container to an approved waste disposal plant.

2.3 Hazards not otherwise classified (HNOC) or not covered by GHS

Contact with acids liberates toxic gas.

3. COMPOSITION/INFORMATION ON INGREDIENTS

3.2 Mixtures

Formula : ClNaO
Molecular weight : 74.44 g/mol

Hazardous components

Component		Classification	Concentration
Sodium hypochlorite			
CAS-No. EC-No. Index-No.	7681-52-9 231-668-3 017-011-00-1	Skin Corr. 1B; Eye Irrit. 2A; Aquatic Acute 1; Aquatic Chronic 1; H314, H319, H410	>= 10 - < 20 %

For the full text of the H-Statements mentioned in this Section, see Section 16.

4. FIRST AID MEASURES

4.1 Description of first aid measures

General advice
Consult a physician. Show this safety data sheet to the doctor in attendance.Move out of dangerous area.

If inhaled
If breathed in, move person into fresh air. If not breathing, give artificial respiration. Consult a physician.

In case of skin contact
Take off contaminated clothing and shoes immediately. Wash off with soap and plenty of water. Consult a physician.

In case of eye contact
Continue rinsing eyes during transport to hospital.Rinse thoroughly with plenty of water for at least 15 minutes and consult a physician.

If swallowed
Do NOT induce vomiting. Never give anything by mouth to an unconscious person. Rinse mouth with water. Consult a physician.

4.2 Most important symptoms and effects, both acute and delayed

The most important known symptoms and effects are described in the labelling (see section 2.2) and/or in section 11

4.3 Indication of any immediate medical attention and special treatment needed

No data available

5. FIREFIGHTING MEASURES

5.1 Extinguishing media

Suitable extinguishing media
Dry powder

5.2 Special hazards arising from the substance or mixture

Hydrogen chloride gas, Sodium oxides

5.3 Advice for firefighters

Wear self-contained breathing apparatus for firefighting if necessary.

5.4 Further information
No data available

6. ACCIDENTAL RELEASE MEASURES

6.1 Personal precautions, protective equipment and emergency procedures
Wear respiratory protection. Avoid breathing vapours, mist or gas. Ensure adequate ventilation. Evacuate personnel to safe areas.
For personal protection see section 8.

6.2 Environmental precautions
Prevent further leakage or spillage if safe to do so. Do not let product enter drains. Discharge into the environment must be avoided.

6.3 Methods and materials for containment and cleaning up
Soak up with inert absorbent material and dispose of as hazardous waste. Do not flush with water. Keep in suitable, closed containers for disposal.

6.4 Reference to other sections
For disposal see section 13.

7. HANDLING AND STORAGE

7.1 Precautions for safe handling
Avoid inhalation of vapour or mist.
For precautions see section 2.2.

7.2 Conditions for safe storage, including any incompatibilities
Keep container tightly closed in a dry and well-ventilated place. Containers which are opened must be carefully resealed and kept upright to prevent leakage.
Never allow product to get in contact with water during storage. Do not store near acids.

Recommended storage temperature 2 - 8 °C
Storage class (TRGS 510): Non-combustible, corrosive hazardous materials

7.3 Specific end use(s)
Apart from the uses mentioned in section 1.2 no other specific uses are stipulated

8. EXPOSURE CONTROLS/PERSONAL PROTECTION

8.1 Control parameters

Components with workplace control parameters

Component	CAS-No.	Value	Control parameters	Basis
Sodium hypochlorite	7681-52-9	STEL	2.000000 mg/m3	USA. Workplace Environmental Exposure Levels (WEEL)

8.2 Exposure controls

Appropriate engineering controls
Handle in accordance with good industrial hygiene and safety practice. Wash hands before breaks and at the end of workday.

Personal protective equipment

Eye/face protection
Tightly fitting safety goggles. Faceshield (8-inch minimum). Use equipment for eye protection tested and approved under appropriate government standards such as NIOSH (US) or EN 166(EU).

Skin protection
Handle with gloves. Gloves must be inspected prior to use. Use proper glove removal technique (without touching glove's outer surface) to avoid skin contact with this product. Dispose of contaminated gloves after use in accordance with applicable laws and good laboratory practices. Wash and dry hands.

Full contact
Material: Nitrile rubber
Minimum layer thickness: 0.11 mm

Break through time: 480 min
Material tested:Dermatril® (KCL 740 / Aldrich Z677272, Size M)

Splash contact
Material: Nitrile rubber
Minimum layer thickness: 0.11 mm
Break through time: 480 min
Material tested:Dermatril® (KCL 740 / Aldrich Z677272, Size M)

data source: KCL GmbH, D-36124 Eichenzell, phone +49 (0)6659 87300, e-mail sales@kcl.de, test method: EN374
If used in solution, or mixed with other substances, and under conditions which differ from EN 374, contact the supplier of the CE approved gloves. This recommendation is advisory only and must be evaluated by an industrial hygienist and safety officer familiar with the specific situation of anticipated use by our customers. It should not be construed as offering an approval for any specific use scenario.

Body Protection
Complete suit protecting against chemicals, The type of protective equipment must be selected according to the concentration and amount of the dangerous substance at the specific workplace.

Respiratory protection
Where risk assessment shows air-purifying respirators are appropriate use a full-face respirator with multi-purpose combination (US) or type ABEK (EN 14387) respirator cartridges as a backup to engineering controls. If the respirator is the sole means of protection, use a full-face supplied air respirator. Use respirators and components tested and approved under appropriate government standards such as NIOSH (US) or CEN (EU).

Control of environmental exposure
Prevent further leakage or spillage if safe to do so. Do not let product enter drains. Discharge into the environment must be avoided.

9. PHYSICAL AND CHEMICAL PROPERTIES

9.1 Information on basic physical and chemical properties

a)	Appearance	Form: liquid
b)	Odour	No data available
c)	Odour Threshold	No data available
d)	pH	No data available
e)	Melting point/freezing point	-30 - -20 °C (-22 - -4 °F)
f)	Initial boiling point and boiling range	111 °C (232 °F)
g)	Flash point	Not applicable
h)	Evaporation rate	No data available
i)	Flammability (solid, gas)	No data available
j)	Upper/lower flammability or explosive limits	No data available
k)	Vapour pressure	23.3 hPa (17.5 mmHg) at 20 °C (68 °F)
l)	Vapour density	No data available
m)	Relative density	1.206 g/mL at 25 °C (77 °F)
n)	Water solubility	completely miscible
o)	Partition coefficient: n-octanol/water	No data available
p)	Auto-ignition temperature	No data available
q)	Decomposition	No data available

temperature

r) Viscosity No data available

s) Explosive properties No data available

t) Oxidizing properties No data available

9.2 Other safety information
No data available

10. STABILITY AND REACTIVITY

10.1 Reactivity
No data available

10.2 Chemical stability
Stable under recommended storage conditions.

10.3 Possibility of hazardous reactions
No data available

10.4 Conditions to avoid
No data available

10.5 Incompatible materials
Strong acids, Organic materials, Powdered metals, Forms shock-sensitive mixtures with certain other materials., Amines, Reacts violently with ammonium salts, aziridine, methanol, and phenylacetonitrile, sometimes resulting in explosions. Reacts with primary aliphatic or aromatic amines to form explosively unstable n-chloroamines. Reaction with formic acid becomes explosive at 55°C.

10.6 Hazardous decomposition products
Other decomposition products - No data available
In the event of fire: see section 5

11. TOXICOLOGICAL INFORMATION

11.1 Information on toxicological effects

Acute toxicity
No data available

Inhalation: No data available

Dermal: No data available

No data available

Skin corrosion/irritation
No data available

Serious eye damage/eye irritation
No data available

Respiratory or skin sensitisation
No data available

Germ cell mutagenicity

No data available

Carcinogenicity

IARC: A4 - Not classifiable as a human carcinogen (Sodium hypochlorite)

3 - Group 3: Not classifiable as to its carcinogenicity to humans (Sodium hypochlorite)

ACGIH: No component of this product present at levels greater than or equal to 0.1% is identified as a carcinogen or potential carcinogen by ACGIH.

NTP: No component of this product present at levels greater than or equal to 0.1% is identified as a

known or anticipated carcinogen by NTP.

OSHA: No component of this product present at levels greater than or equal to 0.1% is identified as a carcinogen or potential carcinogen by OSHA.

Reproductive toxicity
No data available
No data available

Specific target organ toxicity - single exposure
No data available

Specific target organ toxicity - repeated exposure
No data available

Aspiration hazard
No data available

Additional Information
RTECS: Not available

burning sensation, Cough, wheezing, laryngitis, Shortness of breath, spasm, inflammation and edema of the larynx, spasm, inflammation and edema of the bronchi, pneumonitis, pulmonary edema, Material is extremely destructive to tissue of the mucous membranes and upper respiratory tract, eyes, and skin.

12. ECOLOGICAL INFORMATION

12.1 Toxicity
No data available

12.2 Persistence and degradability
No data available

12.3 Bioaccumulative potential
No data available

12.4 Mobility in soil
No data available

12.5 Results of PBT and vPvB assessment
PBT/vPvB assessment not available as chemical safety assessment not required/not conducted

12.6 Other adverse effects
An environmental hazard cannot be excluded in the event of unprofessional handling or disposal.
Very toxic to aquatic life with long lasting effects.

13. DISPOSAL CONSIDERATIONS

13.1 Waste treatment methods

Product
Offer surplus and non-recyclable solutions to a licensed disposal company. Contact a licensed professional waste disposal service to dispose of this material. Dissolve or mix the material with a combustible solvent and burn in a chemical incinerator equipped with an afterburner and scrubber.

Contaminated packaging
Dispose of as unused product.

14. TRANSPORT INFORMATION

DOT (US)
UN number: 1791 Class: 8 Packing group: III
Proper shipping name: Hypochlorite solutions
Reportable Quantity (RQ): 667 lbs

Poison Inhalation Hazard: No

IMDG

UN number: 1791 Class: 8 Packing group: III EMS-No: F-A, S-B
Proper shipping name: HYPOCHLORITE SOLUTION
Marine pollutant:yes

IATA

UN number: 1791 Class: 8 Packing group: III
Proper shipping name: Hypochlorite solution

15. REGULATORY INFORMATION

SARA 302 Components

No chemicals in this material are subject to the reporting requirements of SARA Title III, Section 302.

SARA 313 Components

This material does not contain any chemical components with known CAS numbers that exceed the threshold (De Minimis) reporting levels established by SARA Title III, Section 313.

SARA 311/312 Hazards

Acute Health Hazard

Massachusetts Right To Know Components

	CAS-No.	Revision Date
Sodium hypochlorite	7681-52-9	2007-03-01

Pennsylvania Right To Know Components

	CAS-No.	Revision Date
Water	7732-18-5	
Sodium hypochlorite	7681-52-9	2007-03-01

New Jersey Right To Know Components

	CAS-No.	Revision Date
Water	7732-18-5	
Sodium hypochlorite	7681-52-9	2007-03-01

California Prop. 65 Components

This product does not contain any chemicals known to State of California to cause cancer, birth defects, or any other reproductive harm.

16. OTHER INFORMATION

Full text of H-Statements referred to under sections 2 and 3.

Aquatic Acute	Acute aquatic toxicity
Aquatic Chronic	Chronic aquatic toxicity
Eye Irrit.	Eye irritation
H314	Causes severe skin burns and eye damage.
H318	Causes serious eye damage.
H319	Causes serious eye irritation.
H400	Very toxic to aquatic life.
H410	Very toxic to aquatic life with long lasting effects.
Skin Corr.	Skin corrosion

HMIS Rating

Health hazard:	3
Chronic Health Hazard:	
Flammability:	0
Physical Hazard	0

NFPA Rating

Health hazard:	3
Fire Hazard:	0
Reactivity Hazard:	0

Further information

The above information is believed to be correct but does not purport to be all inclusive and shall be used only as a guide. The information in this document is based on the present state of our knowledge and is applicable to the product with regard to appropriate safety precautions. It does not represent any guarantee of the properties of the product. Sigma-Aldrich Corporation and its Affiliates shall not be held liable for any damage resulting from handling or from contact with the above product. See www.sigma-aldrich.com and/or the reverse side of invoice or packing slip for additional terms and conditions of sale.

Preparation Information

Sigma-Aldrich Corporation
Product Safety – Americas Region
1-800-521-8956

Version: 5.7 Revision Date: 12/10/2014 Print Date: 04/06/2015

SAFETY DATA SHEET

Version 3.12
Revision Date 03/06/2015
Print Date 04/06/2015

1. PRODUCT AND COMPANY IDENTIFICATION

1.1 Product identifiers

Product name : Phosphoric acid solution

Product Number : W290017
Brand : Aldrich

1.2 Relevant identified uses of the substance or mixture and uses advised against

Identified uses : Laboratory chemicals, Manufacture of substances

1.3 Details of the supplier of the safety data sheet

Company : Sigma-Aldrich
3050 Spruce Street
SAINT LOUIS MO 63103
USA

Telephone : +1 800-325-5832
Fax : +1 800-325-5052

1.4 Emergency telephone number

Emergency Phone # : (314) 776-6555

2. HAZARDS IDENTIFICATION

2.1 Classification of the substance or mixture

GHS Classification in accordance with 29 CFR 1910 (OSHA HCS)
Corrosive to metals (Category 1), H290
Skin corrosion (Category 1B), H314
Serious eye damage (Category 1), H318

For the full text of the H-Statements mentioned in this Section, see Section 16.

2.2 GHS Label elements, including precautionary statements

Pictogram

Signal word Danger

Hazard statement(s)
H290 May be corrosive to metals.
H314 Causes severe skin burns and eye damage.

Precautionary statement(s)
P234 Keep only in original container.
P264 Wash skin thoroughly after handling.
P280 Wear protective gloves/ protective clothing/ eye protection/ face protection.
P301 + P330 + P331 IF SWALLOWED: Rinse mouth. Do NOT induce vomiting.
P303 + P361 + P353 IF ON SKIN (or hair): Remove/ Take off immediately all contaminated clothing. Rinse skin with water/ shower.
P304 + P340 IF INHALED: Remove victim to fresh air and keep at rest in a position comfortable for breathing.
P305 + P351 + P338 IF IN EYES: Rinse cautiously with water for several minutes. Remove

	contact lenses, if present and easy to do. Continue rinsing.
P310	Immediately call a POISON CENTER or doctor/ physician.
P321	Specific treatment (see supplemental first aid instructions on this label).
P363	Wash contaminated clothing before reuse.
P390	Absorb spillage to prevent material damage.
P405	Store locked up.
P406	Store in corrosive resistant stainless steel container with a resistant inner liner.
P501	Dispose of contents/ container to an approved waste disposal plant.

2.3 Hazards not otherwise classified (HNOC) or not covered by GHS - none

3. COMPOSITION/INFORMATION ON INGREDIENTS

3.2 Mixtures

Molecular weight : 98 g/mol

Hazardous components

Component		Classification	Concentration
Phosphoric acid			
CAS-No. EC-No. Index-No.	7664-38-2 231-633-2 015-011-00-6	Met. Corr. 1; Skin Corr. 1B; Eye Dam. 1; H290, H314, H318	>= 70 - < 90 %

For the full text of the H-Statements mentioned in this Section, see Section 16.

4. FIRST AID MEASURES

4.1 Description of first aid measures

General advice
Consult a physician. Show this safety data sheet to the doctor in attendance.Move out of dangerous area.

If inhaled
If breathed in, move person into fresh air. If not breathing, give artificial respiration. Consult a physician.

In case of skin contact
Take off contaminated clothing and shoes immediately. Wash off with soap and plenty of water. Consult a physician.

In case of eye contact
Rinse thoroughly with plenty of water for at least 15 minutes and consult a physician.Continue rinsing eyes during transport to hospital.

If swallowed
Do NOT induce vomiting. Never give anything by mouth to an unconscious person. Rinse mouth with water. Consult a physician.

4.2 Most important symptoms and effects, both acute and delayed
The most important known symptoms and effects are described in the labelling (see section 2.2) and/or in section 11

4.3 Indication of any immediate medical attention and special treatment needed
No data available

5. FIREFIGHTING MEASURES

5.1 Extinguishing media

Suitable extinguishing media
Use water spray, alcohol-resistant foam, dry chemical or carbon dioxide.

5.2 Special hazards arising from the substance or mixture
Oxides of phosphorus

5.3 Advice for firefighters
Wear self-contained breathing apparatus for firefighting if necessary.

5.4 Further information
No data available

6. ACCIDENTAL RELEASE MEASURES

6.1 Personal precautions, protective equipment and emergency procedures
Wear respiratory protection. Avoid breathing vapours, mist or gas. Ensure adequate ventilation. Evacuate personnel to safe areas.
For personal protection see section 8.

6.2 Environmental precautions
Do not let product enter drains.

6.3 Methods and materials for containment and cleaning up
Soak up with inert absorbent material and dispose of as hazardous waste. Keep in suitable, closed containers for disposal.

6.4 Reference to other sections
For disposal see section 13.

7. HANDLING AND STORAGE

7.1 Precautions for safe handling
Avoid inhalation of vapour or mist.
For precautions see section 2.2.

7.2 Conditions for safe storage, including any incompatibilities
Keep container tightly closed in a dry and well-ventilated place. Containers which are opened must be carefully resealed and kept upright to prevent leakage.

7.3 Specific end use(s)
Apart from the uses mentioned in section 1.2 no other specific uses are stipulated

8. EXPOSURE CONTROLS/PERSONAL PROTECTION

8.1 Control parameters

Components with workplace control parameters

Component	CAS-No.	Value	Control parameters	Basis
Phosphoric acid	7664-38-2	TWA	1.000000 mg/m3	USA. ACGIH Threshold Limit Values (TLV)
	Remarks	Upper Respiratory Tract irritation Eye irritation Skin irritation		
		TWA	1 mg/m3	USA. ACGIH Threshold Limit Values (TLV)
		Upper Respiratory Tract irritation Eye irritation Skin irritation		
		STEL	3.000000 mg/m3	USA. ACGIH Threshold Limit Values (TLV)
		Upper Respiratory Tract irritation Eye irritation Skin irritation		
		STEL	3 mg/m3	USA. ACGIH Threshold Limit Values (TLV)
		Upper Respiratory Tract irritation Eye irritation Skin irritation		

		TWA	1.000000 mg/m3	USA. Occupational Exposure Limits (OSHA) - Table Z-1 Limits for Air Contaminants
		TWA	1.000000 mg/m3	USA. NIOSH Recommended Exposure Limits
		ST	3.000000 mg/m3	USA. NIOSH Recommended Exposure Limits

8.2 Exposure controls

Appropriate engineering controls
Handle in accordance with good industrial hygiene and safety practice. Wash hands before breaks and at the end of workday.

Personal protective equipment

Eye/face protection
Tightly fitting safety goggles. Faceshield (8-inch minimum). Use equipment for eye protection tested and approved under appropriate government standards such as NIOSH (US) or EN 166(EU).

Skin protection
Handle with gloves. Gloves must be inspected prior to use. Use proper glove removal technique (without touching glove's outer surface) to avoid skin contact with this product. Dispose of contaminated gloves after use in accordance with applicable laws and good laboratory practices. Wash and dry hands.

Full contact
Material: Nitrile rubber
Minimum layer thickness: 0.11 mm
Break through time: 480 min
Material tested:Dermatril® (KCL 740 / Aldrich Z677272, Size M)

Splash contact
Material: Nitrile rubber
Minimum layer thickness: 0.11 mm
Break through time: 480 min
Material tested:Dermatril® (KCL 740 / Aldrich Z677272, Size M)

data source: KCL GmbH, D-36124 Eichenzell, phone +49 (0)6659 87300, e-mail sales@kcl.de, test method: EN374
If used in solution, or mixed with other substances, and under conditions which differ from EN 374, contact the supplier of the CE approved gloves. This recommendation is advisory only and must be evaluated by an industrial hygienist and safety officer familiar with the specific situation of anticipated use by our customers. It should not be construed as offering an approval for any specific use scenario.

Body Protection
Complete suit protecting against chemicals, The type of protective equipment must be selected according to the concentration and amount of the dangerous substance at the specific workplace.

Respiratory protection
Where risk assessment shows air-purifying respirators are appropriate use a full-face respirator with multi-purpose combination (US) or type ABEK (EN 14387) respirator cartridges as a backup to engineering controls. If the respirator is the sole means of protection, use a full-face supplied air respirator. Use respirators and components tested and approved under appropriate government standards such as NIOSH (US) or CEN (EU).

Control of environmental exposure
Do not let product enter drains.

9. PHYSICAL AND CHEMICAL PROPERTIES

9.1 Information on basic physical and chemical properties

a)	Appearance	Form: clear, liquid
b)	Odour	No data available
c)	Odour Threshold	No data available
d)	pH	No data available

e)	Melting point/freezing point	No data available
f)	Initial boiling point and boiling range	No data available
g)	Flash point	No data available
h)	Evaporation rate	No data available
i)	Flammability (solid, gas)	No data available
j)	Upper/lower flammability or explosive limits	No data available
k)	Vapour pressure	No data available
l)	Vapour density	No data available
m)	Relative density	1.685 g/cm3
n)	Water solubility	No data available
o)	Partition coefficient: n-octanol/water	No data available
p)	Auto-ignition temperature	No data available
q)	Decomposition temperature	No data available
r)	Viscosity	No data available
s)	Explosive properties	No data available
t)	Oxidizing properties	No data available

9.2 Other safety information
No data available

10. STABILITY AND REACTIVITY

10.1 Reactivity
No data available

10.2 Chemical stability
Stable under recommended storage conditions.

10.3 Possibility of hazardous reactions
No data available

10.4 Conditions to avoid
No data available

10.5 Incompatible materials
Strong bases, Powdered metals

10.6 Hazardous decomposition products
Other decomposition products - No data available
In the event of fire: see section 5

11. TOXICOLOGICAL INFORMATION

11.1 Information on toxicological effects

Acute toxicity
No data available

Inhalation: No data available

Dermal: No data available

No data available

Skin corrosion/irritation
No data available

Serious eye damage/eye irritation
No data available

Respiratory or skin sensitisation
No data available

Germ cell mutagenicity
No data available

Carcinogenicity

IARC: No component of this product present at levels greater than or equal to 0.1% is identified as probable, possible or confirmed human carcinogen by IARC.

ACGIH: No component of this product present at levels greater than or equal to 0.1% is identified as a carcinogen or potential carcinogen by ACGIH.

NTP: No component of this product present at levels greater than or equal to 0.1% is identified as a known or anticipated carcinogen by NTP.

OSHA: No component of this product present at levels greater than or equal to 0.1% is identified as a carcinogen or potential carcinogen by OSHA.

Reproductive toxicity
No data available
No data available

Specific target organ toxicity - single exposure
No data available

Specific target organ toxicity - repeated exposure
No data available

Aspiration hazard
No data available

Additional Information
RTECS: Not available

Material is extremely destructive to tissue of the mucous membranes and upper respiratory tract, eyes, and skin., spasm, inflammation and edema of the larynx, spasm, inflammation and edema of the bronchi, pneumonitis, pulmonary edema, burning sensation, Cough, wheezing, laryngitis, Shortness of breath, Headache, Nausea

Stomach - Irregularities - Based on Human Evidence
Stomach - Irregularities - Based on Human Evidence (Phosphoric acid)

12. ECOLOGICAL INFORMATION

12.1 Toxicity
No data available

12.2 Persistence and degradability
No data available

12.3 Bioaccumulative potential
No data available

12.4 Mobility in soil
No data available

12.5 Results of PBT and vPvB assessment
PBT/vPvB assessment not available as chemical safety assessment not required/not conducted

12.6 Other adverse effects
No data available

13. DISPOSAL CONSIDERATIONS

13.1 Waste treatment methods

Product
Offer surplus and non-recyclable solutions to a licensed disposal company. Contact a licensed professional waste disposal service to dispose of this material. Dissolve or mix the material with a combustible solvent and burn in a chemical incinerator equipped with an afterburner and scrubber.

Contaminated packaging
Dispose of as unused product.

14. TRANSPORT INFORMATION

DOT (US)
UN number: 1805 Class: 8 Packing group: III
Proper shipping name: Phosphoric acid solution
Reportable Quantity (RQ): 5882 lbs

Poison Inhalation Hazard: No

IMDG
UN number: 1805 Class: 8 Packing group: III EMS-No: F-A, S-B
Proper shipping name: PHOSPHORIC ACID SOLUTION

IATA
UN number: 1805 Class: 8 Packing group: III
Proper shipping name: Phosphoric acid, solution

15. REGULATORY INFORMATION

SARA 302 Components
No chemicals in this material are subject to the reporting requirements of SARA Title III, Section 302.

SARA 313 Components
This material does not contain any chemical components with known CAS numbers that exceed the threshold (De Minimis) reporting levels established by SARA Title III, Section 313.

SARA 311/312 Hazards
Acute Health Hazard, Chronic Health Hazard

Massachusetts Right To Know Components

	CAS-No.	Revision Date
Phosphoric acid	7664-38-2	1993-04-24

Pennsylvania Right To Know Components

	CAS-No.	Revision Date
Phosphoric acid	7664-38-2	1993-04-24
Water	7732-18-5	

New Jersey Right To Know Components

	CAS-No.	Revision Date
Phosphoric acid	7664-38-2	1993-04-24
Water	7732-18-5	

California Prop. 65 Components
This product does not contain any chemicals known to State of California to cause cancer, birth defects, or any other reproductive harm.

16. OTHER INFORMATION

Full text of H-Statements referred to under sections 2 and 3.

Eye Dam.	Serious eye damage
H290	May be corrosive to metals.
H314	Causes severe skin burns and eye damage.
H318	Causes serious eye damage.
Met. Corr.	Corrosive to metals
Skin Corr.	Skin corrosion

HMIS Rating

Health hazard:	3
Chronic Health Hazard:	*
Flammability:	0
Physical Hazard	0

NFPA Rating

Health hazard:	3
Fire Hazard:	0
Reactivity Hazard:	0

Further information

The above information is believed to be correct but does not purport to be all inclusive and shall be used only as a guide. The information in this document is based on the present state of our knowledge and is applicable to the product with regard to appropriate safety precautions. It does not represent any guarantee of the properties of the product. Sigma-Aldrich Corporation and its Affiliates shall not be held liable for any damage resulting from handling or from contact with the above product. See www.sigma-aldrich.com and/or the reverse side of invoice or packing slip for additional terms and conditions of sale.

Preparation Information

Sigma-Aldrich Corporation
Product Safety – Americas Region
1-800-521-8956

Version: 3.12 Revision Date: 03/06/2015 Print Date: 04/06/2015

SAFETY DATA SHEET

Version 5.9
Revision Date 02/26/2015
Print Date 04/06/2015

1. PRODUCT AND COMPANY IDENTIFICATION

1.1 Product identifiers

Product name : Sodium hydroxide solution

Product Number : 72082
Brand : Fluka

1.2 Relevant identified uses of the substance or mixture and uses advised against

Identified uses : Laboratory chemicals, Manufacture of substances

1.3 Details of the supplier of the safety data sheet

Company : Sigma-Aldrich
3050 Spruce Street
SAINT LOUIS MO 63103
USA

Telephone : +1 800-325-5832
Fax : +1 800-325-5052

1.4 Emergency telephone number

Emergency Phone # : (314) 776-6555

2. HAZARDS IDENTIFICATION

2.1 Classification of the substance or mixture

GHS Classification in accordance with 29 CFR 1910 (OSHA HCS)
Corrosive to metals (Category 1), H290
Skin corrosion (Category 1A), H314
Serious eye damage (Category 1), H318

For the full text of the H-Statements mentioned in this Section, see Section 16.

2.2 GHS Label elements, including precautionary statements

Pictogram

Signal word Danger

Hazard statement(s)

H290	May be corrosive to metals.
H314	Causes severe skin burns and eye damage.
H318	Causes serious eye damage.

Precautionary statement(s)

P234	Keep only in original container.
P264	Wash skin thoroughly after handling.
P280	Wear protective gloves/ protective clothing/ eye protection/ face protection.
P301 + P330 + P331	IF SWALLOWED: Rinse mouth. Do NOT induce vomiting.
P303 + P361 + P353	IF ON SKIN (or hair): Take off immediately all contaminated clothing. Rinse skin with water/shower.
P304 + P340 + P310	IF INHALED: Remove person to fresh air and keep comfortable for breathing. Immediately call a POISON CENTER or doctor/ physician.

P305 + P351 + P338 + P310	IF IN EYES: Rinse cautiously with water for several minutes. Remove contact lenses, if present and easy to do. Continue rinsing. Immediately call a POISON CENTER or doctor/ physician.
P363	Wash contaminated clothing before reuse.
P390	Absorb spillage to prevent material damage.
P405	Store locked up.
P406	Store in corrosive resistant stainless steel container with a resistant inner liner.
P501	Dispose of contents/ container to an approved waste disposal plant.

2.3 Hazards not otherwise classified (HNOC) or not covered by GHS - none

3. COMPOSITION/INFORMATION ON INGREDIENTS

3.2 Mixtures

Formula : HNaO
Molecular weight : 40.00 g/mol

Hazardous components

Component		Classification	Concentration
Sodium hydroxide			
CAS-No.	1310-73-2	Met. Corr. 1; Skin Corr. 1A; Eye Dam. 1; Aquatic Acute 3; H290, H314, H318, H402	>= 5 - < 10 %
EC-No.	215-185-5		
Index-No.	011-002-00-6		
Registration number	01-2119457892-27-XXXX		

For the full text of the H-Statements mentioned in this Section, see Section 16.

4. FIRST AID MEASURES

4.1 Description of first aid measures

General advice
Consult a physician. Show this safety data sheet to the doctor in attendance.Move out of dangerous area.

If inhaled
If breathed in, move person into fresh air. If not breathing, give artificial respiration. Consult a physician.

In case of skin contact
Take off contaminated clothing and shoes immediately. Wash off with soap and plenty of water. Consult a physician.

In case of eye contact
Rinse thoroughly with plenty of water for at least 15 minutes and consult a physician.Continue rinsing eyes during transport to hospital.

If swallowed
Do NOT induce vomiting. Never give anything by mouth to an unconscious person. Rinse mouth with water. Consult a physician.

4.2 Most important symptoms and effects, both acute and delayed
The most important known symptoms and effects are described in the labelling (see section 2.2) and/or in section 11

4.3 Indication of any immediate medical attention and special treatment needed
No data available

5. FIREFIGHTING MEASURES

5.1 Extinguishing media

Suitable extinguishing media
Use water spray, alcohol-resistant foam, dry chemical or carbon dioxide.

5.2 Special hazards arising from the substance or mixture
Sodium oxides
Sodium oxides

5.3 Advice for firefighters
Wear self-contained breathing apparatus for firefighting if necessary.

5.4 Further information
No data available

6. ACCIDENTAL RELEASE MEASURES

6.1 Personal precautions, protective equipment and emergency procedures
Use personal protective equipment. Avoid breathing vapours, mist or gas. Ensure adequate ventilation. Evacuate personnel to safe areas.
For personal protection see section 8.

6.2 Environmental precautions
Do not let product enter drains.

6.3 Methods and materials for containment and cleaning up
Soak up with inert absorbent material and dispose of as hazardous waste. Keep in suitable, closed containers for disposal.

6.4 Reference to other sections
For disposal see section 13.

7. HANDLING AND STORAGE

7.1 Precautions for safe handling
Avoid inhalation of vapour or mist.
For precautions see section 2.2.

7.2 Conditions for safe storage, including any incompatibilities
Keep container tightly closed in a dry and well-ventilated place. Containers which are opened must be carefully resealed and kept upright to prevent leakage.

7.3 Specific end use(s)
Apart from the uses mentioned in section 1.2 no other specific uses are stipulated

8. EXPOSURE CONTROLS/PERSONAL PROTECTION

8.1 Control parameters

Components with workplace control parameters

Component	CAS-No.	Value	Control parameters	Basis
Sodium hydroxide	1310-73-2	TWA	2.000000 mg/m3	USA. Occupational Exposure Limits (OSHA) - Table Z-1 Limits for Air Contaminants
		C	2.000000 mg/m3	USA. ACGIH Threshold Limit Values (TLV)
	Remarks	Upper Respiratory Tract irritation Eye irritation Skin irritation		
		C	2 mg/m3	USA. ACGIH Threshold Limit Values (TLV)
		Upper Respiratory Tract irritation Eye irritation Skin irritation		
		C	2.000000 mg/m3	USA. NIOSH Recommended Exposure Limits

8.2 Exposure controls

Appropriate engineering controls
Handle in accordance with good industrial hygiene and safety practice. Wash hands before breaks and at the end of workday.

Personal protective equipment

Eye/face protection
Tightly fitting safety goggles. Faceshield (8-inch minimum). Use equipment for eye protection tested and approved under appropriate government standards such as NIOSH (US) or EN 166(EU).

Skin protection
Handle with gloves. Gloves must be inspected prior to use. Use proper glove removal technique (without touching glove's outer surface) to avoid skin contact with this product. Dispose of contaminated gloves after use in accordance with applicable laws and good laboratory practices. Wash and dry hands.

Full contact
Material: Nitrile rubber
Minimum layer thickness: 0.11 mm
Break through time: 480 min
Material tested:Dermatril® (KCL 740 / Aldrich Z677272, Size M)

Splash contact
Material: Nitrile rubber
Minimum layer thickness: 0.11 mm
Break through time: 480 min
Material tested:Dermatril® (KCL 740 / Aldrich Z677272, Size M)

data source: KCL GmbH, D-36124 Eichenzell, phone +49 (0)6659 87300, e-mail sales@kcl.de, test method: EN374
If used in solution, or mixed with other substances, and under conditions which differ from EN 374, contact the supplier of the CE approved gloves. This recommendation is advisory only and must be evaluated by an industrial hygienist and safety officer familiar with the specific situation of anticipated use by our customers. It should not be construed as offering an approval for any specific use scenario.

Body Protection
Complete suit protecting against chemicals, The type of protective equipment must be selected according to the concentration and amount of the dangerous substance at the specific workplace.

Respiratory protection
Where risk assessment shows air-purifying respirators are appropriate use a full-face respirator with multi-purpose combination (US) or type ABEK (EN 14387) respirator cartridges as a backup to engineering controls. If the respirator is the sole means of protection, use a full-face supplied air respirator. Use respirators and components tested and approved under appropriate government standards such as NIOSH (US) or CEN (EU).

Control of environmental exposure
Do not let product enter drains.

9. PHYSICAL AND CHEMICAL PROPERTIES

9.1 Information on basic physical and chemical properties

a)	Appearance	Form: liquid
b)	Odour	No data available
c)	Odour Threshold	No data available
d)	pH	No data available
e)	Melting point/freezing point	No data available
f)	Initial boiling point and boiling range	No data available
g)	Flash point	No data available
h)	Evaporation rate	No data available
i)	Flammability (solid, gas)	No data available
j)	Upper/lower flammability or explosive limits	No data available

k)	Vapour pressure	No data available
l)	Vapour density	No data available
m)	Relative density	No data available
n)	Water solubility	No data available
o)	Partition coefficient: n-octanol/water	No data available
p)	Auto-ignition temperature	No data available
q)	Decomposition temperature	No data available
r)	Viscosity	No data available
s)	Explosive properties	No data available
t)	Oxidizing properties	No data available

9.2 Other safety information
No data available

10. STABILITY AND REACTIVITY

10.1 Reactivity
No data available

10.2 Chemical stability
Stable under recommended storage conditions.

10.3 Possibility of hazardous reactions
No data available

10.4 Conditions to avoid
No data available

10.5 Incompatible materials
acids, Organic materials, Chlorinated solvents, Aluminum, Phosphorus, Tin/tin oxides, Zinc

10.6 Hazardous decomposition products
Other decomposition products - No data available
In the event of fire: see section 5

11. TOXICOLOGICAL INFORMATION

11.1 Information on toxicological effects

Acute toxicity
No data available

Inhalation: No data available

No data available

Skin corrosion/irritation
No data available

Serious eye damage/eye irritation
No data available

Respiratory or skin sensitisation
No data available

Germ cell mutagenicity
No data available

Carcinogenicity

IARC: No component of this product present at levels greater than or equal to 0.1% is identified as probable, possible or confirmed human carcinogen by IARC.

ACGIH: No component of this product present at levels greater than or equal to 0.1% is identified as a carcinogen or potential carcinogen by ACGIH.

NTP: No component of this product present at levels greater than or equal to 0.1% is identified as a known or anticipated carcinogen by NTP.

OSHA: No component of this product present at levels greater than or equal to 0.1% is identified as a carcinogen or potential carcinogen by OSHA.

Reproductive toxicity
No data available
No data available

Specific target organ toxicity - single exposure
No data available

Specific target organ toxicity - repeated exposure
No data available

Aspiration hazard
No data available

Additional Information
RTECS: Not available

Material is extremely destructive to tissue of the mucous membranes and upper respiratory tract, eyes, and skin., Inhalation of vapors may cause:, spasm, inflammation and edema of the bronchi, spasm, inflammation and edema of the larynx, Symptoms of exposure may include burning sensation, coughing, wheezing, laryngitis, shortness of breath, headache, nausea, and vomiting.

12. ECOLOGICAL INFORMATION

12.1 Toxicity
No data available

12.2 Persistence and degradability
No data available

12.3 Bioaccumulative potential
No data available

12.4 Mobility in soil
No data available

12.5 Results of PBT and vPvB assessment
PBT/vPvB assessment not available as chemical safety assessment not required/not conducted

12.6 Other adverse effects
No data available

13. DISPOSAL CONSIDERATIONS

13.1 Waste treatment methods

Product
Offer surplus and non-recyclable solutions to a licensed disposal company. Contact a licensed professional waste disposal service to dispose of this material. Dissolve or mix the material with a combustible solvent and burn in a chemical incinerator equipped with an afterburner and scrubber.

Contaminated packaging
Dispose of as unused product.

14. TRANSPORT INFORMATION

DOT (US)
UN number: 1824 Class: 8 Packing group: II

Proper shipping name: Sodium hydroxide solution

Poison Inhalation Hazard: No

IMDG
UN number: 1824 Class: 8 Packing group: II EMS-No: F-A, S-B
Proper shipping name: SODIUM HYDROXIDE SOLUTION

IATA
UN number: 1824 Class: 8 Packing group: II
Proper shipping name: Sodium hydroxide solution

15. REGULATORY INFORMATION

SARA 302 Components
No chemicals in this material are subject to the reporting requirements of SARA Title III, Section 302.

SARA 313 Components
This material does not contain any chemical components with known CAS numbers that exceed the threshold (De Minimis) reporting levels established by SARA Title III, Section 313.

Massachusetts Right To Know Components

	CAS-No.	Revision Date
Sodium hydroxide	1310-73-2	2007-03-01

Pennsylvania Right To Know Components

	CAS-No.	Revision Date
Water	7732-18-5	
Sodium hydroxide	1310-73-2	2007-03-01

New Jersey Right To Know Components

	CAS-No.	Revision Date
Water	7732-18-5	
Sodium hydroxide	1310-73-2	2007-03-01

California Prop. 65 Components
This product does not contain any chemicals known to State of California to cause cancer, birth defects, or any other reproductive harm.

16. OTHER INFORMATION

Full text of H-Statements referred to under sections 2 and 3.

Aquatic Acute	Acute aquatic toxicity
Eye Dam.	Serious eye damage
H290	May be corrosive to metals.
H314	Causes severe skin burns and eye damage.
H318	Causes serious eye damage.
H402	Harmful to aquatic life.
Met. Corr.	Corrosive to metals
Skin Corr.	Skin corrosion

HMIS Rating

Health hazard:	3
Chronic Health Hazard:	
Flammability:	0
Physical Hazard	1

NFPA Rating

Health hazard:	3
Fire Hazard:	0
Reactivity Hazard:	0

Further information

The above information is believed to be correct but does not purport to be all inclusive and shall be used only as a guide. The information in this document is based on the present state of our knowledge and is applicable to the product with regard to appropriate safety precautions. It does not represent any guarantee of the properties of the product. Sigma-Aldrich Corporation and its Affiliates shall not be held liable for any damage resulting from handling or from contact with the above product. See www.sigma-aldrich.com and/or the reverse side of invoice or packing slip for additional terms and conditions of sale.

Preparation Information

Sigma-Aldrich Corporation
Product Safety – Americas Region
1-800-521-8956

Version: 5.9 Revision Date: 02/26/2015 Print Date: 04/06/2015

SAFETY DATA SHEET

BupH™ Phosphate Buffered Saline

Section 1. Identification

GHS product identifier : BupH™ Phosphate Buffered Saline

Other means of identification : Not available.

Product type : Solid.

Product code : 0028372 0028372B 1858082 1887850 1890535

SDS # : 1076

Chemical formula : Not applicable.

CAS # : Not applicable.

Relevant identified uses of the substance or mixture and uses advised against

Not applicable.

Supplier's details : Thermo Fisher Scientific
Pierce Biotechnology
P.O. Box 117
Rockford, IL 61105
United States
815.968.0747 or
800.874.3723
7 AM - 5 PM Central Time (GMT -06:00)

Emergency telephone number (with hours of operation) : CHEMTREC: 800.424.9300
Outside US: 703.527.3887

Section 2. Hazards identification

OSHA/HCS status : This material is considered hazardous by the OSHA Hazard Communication Standard (29 CFR 1910.1200).

Classification of the substance or mixture : SERIOUS EYE DAMAGE/ EYE IRRITATION - Category 2A

GHS label elements

Hazard pictograms :

Signal word : Warning

Hazard statements : Causes serious eye irritation.

Precautionary statements

Prevention : Wear eye or face protection. Wash hands thoroughly after handling.

Response : IF IN EYES: Rinse cautiously with water for several minutes. Remove contact lenses, if present and easy to do. Continue rinsing. If eye irritation persists: Get medical attention.

Storage : Not applicable.

Disposal : Not applicable.

Hazards not otherwise classified : None known.

Section 3. Composition/information on ingredients

Substance/mixture : Mixture

Other means of identification : Not available.

CAS number/other identifiers

CAS number : Not applicable.

Ingredient name	%	CAS number
disodium hydrogenorthophosphate	25 - 45	7558-79-4
sodium chloride	25 - 45	7647-14-5

Any concentration shown as a range is to protect confidentiality or is due to batch variation.

There are no additional ingredients present which, within the current knowledge of the supplier and in the concentrations applicable, are classified as hazardous to health or the environment and hence require reporting in this section.

Occupational exposure limits, if available, are listed in Section 8.

Section 4. First aid measures

Description of necessary first aid measures

Eye contact : Immediately flush eyes with plenty of water, occasionally lifting the upper and lower eyelids. Check for and remove any contact lenses. Continue to rinse for at least 10 minutes. Get medical attention.

Inhalation : Remove victim to fresh air and keep at rest in a position comfortable for breathing. If not breathing, if breathing is irregular or if respiratory arrest occurs, provide artificial respiration or oxygen by trained personnel. It may be dangerous to the person providing aid to give mouth-to-mouth resuscitation. Get medical attention if adverse health effects persist or are severe. If unconscious, place in recovery position and get medical attention immediately. Maintain an open airway. Loosen tight clothing such as a collar, tie, belt or waistband.

Skin contact : Flush contaminated skin with plenty of water. Remove contaminated clothing and shoes. Get medical attention if symptoms occur. Wash clothing before reuse. Clean shoes thoroughly before reuse.

Ingestion : Wash out mouth with water. Remove dentures if any. Remove victim to fresh air and keep at rest in a position comfortable for breathing. If material has been swallowed and the exposed person is conscious, give small quantities of water to drink. Stop if the exposed person feels sick as vomiting may be dangerous. Do not induce vomiting unless directed to do so by medical personnel. If vomiting occurs, the head should be kept low so that vomit does not enter the lungs. Get medical attention if adverse health effects persist or are severe. Never give anything by mouth to an unconscious person. If unconscious, place in recovery position and get medical attention immediately. Maintain an open airway. Loosen tight clothing such as a collar, tie, belt or waistband.

Most important symptoms/effects, acute and delayed

Potential acute health effects

Eye contact : Causes serious eye irritation.

Inhalation : No known significant effects or critical hazards.

Skin contact : No known significant effects or critical hazards.

Ingestion : Irritating to mouth, throat and stomach.

Over-exposure signs/symptoms

Eye contact : Adverse symptoms may include the following:
pain or irritation
watering
redness

Inhalation : No specific data.

Skin contact : No specific data.

Ingestion : No specific data.

Section 4. First aid measures

Indication of immediate medical attention and special treatment needed, if necessary

Notes to physician : Treat symptomatically. Contact poison treatment specialist immediately if large quantities have been ingested or inhaled.

Specific treatments : No specific treatment.

Protection of first-aiders : No action shall be taken involving any personal risk or without suitable training. It may be dangerous to the person providing aid to give mouth-to-mouth resuscitation.

See toxicological information (Section 11)

Section 5. Fire-fighting measures

Extinguishing media

Suitable extinguishing media : Use an extinguishing agent suitable for the surrounding fire.

Unsuitable extinguishing media : None known.

Specific hazards arising from the chemical : No specific fire or explosion hazard.

Hazardous thermal decomposition products : Decomposition products may include the following materials:
phosphorus oxides
halogenated compounds
metal oxide/oxides

Special protective actions for fire-fighters : Promptly isolate the scene by removing all persons from the vicinity of the incident if there is a fire. No action shall be taken involving any personal risk or without suitable training.

Special protective equipment for fire-fighters : Fire-fighters should wear appropriate protective equipment and self-contained breathing apparatus (SCBA) with a full face-piece operated in positive pressure mode.

Section 6. Accidental release measures

Personal precautions, protective equipment and emergency procedures

For non-emergency personnel : No action shall be taken involving any personal risk or without suitable training. Evacuate surrounding areas. Keep unnecessary and unprotected personnel from entering. Do not touch or walk through spilled material. Provide adequate ventilation. Wear appropriate respirator when ventilation is inadequate. Put on appropriate personal protective equipment.

For emergency responders : If specialised clothing is required to deal with the spillage, take note of any information in Section 8 on suitable and unsuitable materials. See also the information in "For non-emergency personnel".

Environmental precautions : Avoid dispersal of spilled material and runoff and contact with soil, waterways, drains and sewers. Inform the relevant authorities if the product has caused environmental pollution (sewers, waterways, soil or air).

Methods and materials for containment and cleaning up

Small spill : Move containers from spill area. Avoid dust generation. Using a vacuum with HEPA filter will reduce dust dispersal. Place spilled material in a designated, labeled waste container. Dispose of via a licensed waste disposal contractor.

Large spill : Move containers from spill area. Approach release from upwind. Prevent entry into sewers, water courses, basements or confined areas. Avoid dust generation. Do not dry sweep. Vacuum dust with equipment fitted with a HEPA filter and place in a closed, labeled waste container. Dispose of via a licensed waste disposal contractor. Note: see Section 1 for emergency contact information and Section 13 for waste disposal.

Section 7. Handling and storage

Precautions for safe handling

Protective measures : Put on appropriate personal protective equipment (see Section 8). Do not ingest. Avoid contact with eyes, skin and clothing. Keep in the original container or an approved alternative made from a compatible material, kept tightly closed when not in use. Empty containers retain product residue and can be hazardous. Do not reuse container.

Advice on general occupational hygiene : Eating, drinking and smoking should be prohibited in areas where this material is handled, stored and processed. Workers should wash hands and face before eating, drinking and smoking. Remove contaminated clothing and protective equipment before entering eating areas. See also Section 8 for additional information on hygiene measures.

Conditions for safe storage, including any incompatibilities : Store between the following temperatures: 20 to 25°C (68 to 77°F). Store in accordance with local regulations. Store in original container protected from direct sunlight in a dry, cool and well-ventilated area, away from incompatible materials (see Section 10) and food and drink. Keep container tightly closed and sealed until ready for use. Containers that have been opened must be carefully resealed and kept upright to prevent leakage. Do not store in unlabeled containers. Use appropriate containment to avoid environmental contamination.

Section 8. Exposure controls/personal protection

Control parameters

Occupational exposure limits

None.

Appropriate engineering controls : Good general ventilation should be sufficient to control worker exposure to airborne contaminants.

Environmental exposure controls : Emissions from ventilation or work process equipment should be checked to ensure they comply with the requirements of environmental protection legislation. In some cases, fume scrubbers, filters or engineering modifications to the process equipment will be necessary to reduce emissions to acceptable levels.

Individual protection measures

Hygiene measures : Wash hands, forearms and face thoroughly after handling chemical products, before eating, smoking and using the lavatory and at the end of the working period. Appropriate techniques should be used to remove potentially contaminated clothing. Wash contaminated clothing before reusing. Ensure that eyewash stations and safety showers are close to the workstation location.

Eye/face protection : Safety eyewear complying with an approved standard should be used when a risk assessment indicates this is necessary to avoid exposure to liquid splashes, mists, gases or dusts. If contact is possible, the following protection should be worn, unless the assessment indicates a higher degree of protection: chemical splash goggles.

Skin protection

Hand protection : Chemical-resistant, impervious gloves complying with an approved standard should be worn at all times when handling chemical products if a risk assessment indicates this is necessary. Considering the parameters specified by the glove manufacturer, check during use that the gloves are still retaining their protective properties. It should be noted that the time to breakthrough for any glove material may be different for different glove manufacturers. In the case of mixtures, consisting of several substances, the protection time of the gloves cannot be accurately estimated.

Body protection : Personal protective equipment for the body should be selected based on the task being performed and the risks involved and should be approved by a specialist before handling this product.

Other skin protection : Appropriate footwear and any additional skin protection measures should be selected based on the task being performed and the risks involved and should be approved by a specialist before handling this product.

Respiratory protection : Use a properly fitted, particulate filter respirator complying with an approved standard if a risk assessment indicates this is necessary. Respirator selection must be based on known or anticipated exposure levels, the hazards of the product and the safe working limits of the selected respirator.

Section 9. Physical and chemical properties

Appearance

Physical state : Solid. [Granular.]

Color : White.

Odor : Not available.

Odor threshold : Not available.

pH : 6.9 to 7.2 [Conc. (% w/w): 2.3%]

Melting point : Not available.

Boiling point : Not available.

Flash point : Not available.

Burning time : Not available.

Burning rate : Not available.

Evaporation rate : Not available.

Flammability (solid, gas) : Not available.

Lower and upper explosive (flammable) limits : Not available.

Vapor pressure : Not available.

Vapor density : Not available.

Relative density : Not available.

Solubility : Easily soluble in the following materials: cold water and hot water.

Solubility in water : Not available.

Partition coefficient: n-octanol/water : Not available.

Auto-ignition temperature : Not available.

Decomposition temperature : Not available.

SADT : Not available.

Viscosity : Not available.

Section 10. Stability and reactivity

Reactivity : No specific test data related to reactivity available for this product or its ingredients.

Chemical stability : The product is stable.

Possibility of hazardous reactions : Under normal conditions of storage and use, hazardous reactions will not occur.

Conditions to avoid : No specific data.

Incompatible materials : No specific data.

Hazardous decomposition products : Under normal conditions of storage and use, hazardous decomposition products should not be produced.

Section 11. Toxicological information

Information on toxicological effects

Acute toxicity

Product/ingredient name	Result	Species	Dose	Exposure
disodium hydrogenorthophosphate	LD50 Oral	Rat	17000 mg/kg	-
sodium chloride	LD50 Dermal	Rabbit	10000 mg/kg	-
	LD50 Oral	Rat	3000 mg/kg	-
	LDLo Intra-arterial	Guinea pig	300 mg/kg	-

Section 11. Toxicological information

Conclusion/Summary : To the best of our knowledge, the toxicological properties of this product have not been thoroughly investigated.

Irritation/Corrosion

Product/ingredient name	Result	Species	Score	Exposure	Observation
disodium hydrogenorthophosphate	Eyes - Mild irritant	Rabbit	-	24 hours 500 milligrams	-
	Skin - Mild irritant	Rabbit	-	24 hours 500 milligrams	-
sodium chloride	Eyes - Moderate irritant	Rabbit	-	24 hours 100 milligrams	-
	Eyes - Moderate irritant	Rabbit	-	10 milligrams	-
	Skin - Mild irritant	Rabbit	-	24 hours 500 milligrams	-

Sensitization

Not available.

Mutagenicity

Not available.

Carcinogenicity

Not available.

Classification

Product/ingredient name	OSHA	IARC	NTP
disodium hydrogenorthophosphate	None.	-	-
sodium chloride	None.	-	-

Reproductive toxicity

Not available.

Teratogenicity

Not available.

Specific target organ toxicity (single exposure)

Not available.

Specific target organ toxicity (repeated exposure)

Not available.

Aspiration hazard

Not available.

Information on the likely routes of exposure : Routes of entry anticipated: Oral, Inhalation.

Potential acute health effects

Eye contact : Causes serious eye irritation.

Inhalation : No known significant effects or critical hazards.

Skin contact : No known significant effects or critical hazards.

Ingestion : Irritating to mouth, throat and stomach.

Symptoms related to the physical, chemical and toxicological characteristics

Eye contact : Adverse symptoms may include the following:
pain or irritation
watering
redness

Inhalation : No specific data.

Skin contact : No specific data.

Section 11. Toxicological information

Ingestion : No specific data.

Delayed and immediate effects and also chronic effects from short and long term exposure

Short term exposure

Potential immediate effects : Not available.

Potential delayed effects : Not available.

Long term exposure

Potential immediate effects : Not available.

Potential delayed effects : Not available.

Potential chronic health effects

Not available.

General : No known significant effects or critical hazards.

Carcinogenicity : No known significant effects or critical hazards.

Mutagenicity : No known significant effects or critical hazards.

Teratogenicity : No known significant effects or critical hazards.

Developmental effects : No known significant effects or critical hazards.

Fertility effects : No known significant effects or critical hazards.

Numerical measures of toxicity

Acute toxicity estimates

Route	ATE value
Oral	8000 mg/kg

Section 12. Ecological information

Toxicity

Product/ingredient name	Result	Species	Exposure
disodium hydrogenorthophosphate	Acute LC50 3580000 µg/l Fresh water	Daphnia - Daphnia magna	48 hours
sodium chloride	Acute EC50 2430000 µg/l Fresh water	Algae - Navicula seminulum	96 hours
	Acute EC50 519.6 mg/l Fresh water	Crustaceans - Cypris subglobosa	48 hours
	Acute IC50 6.87 g/L Fresh water	Aquatic plants - Lemna minor	96 hours
	Acute LC50 1661 mg/l Fresh water	Daphnia - Daphnia magna	48 hours
	Acute LC50 1000000 µg/l Fresh water	Fish - Morone saxatilis - Larvae	96 hours
	Chronic NOEC 6 g/L Fresh water	Aquatic plants - Lemna minor	96 hours
	Chronic NOEC 0.314 g/L Fresh water	Daphnia - Daphnia pulex	21 days
	Chronic NOEC 100 mg/l Fresh water	Fish - Gambusia holbrooki - Adult	8 weeks

Persistence and degradability

Not available.

Bioaccumulative potential

Product/ingredient name	$LogP_{ow}$	BCF	Potential
disodium hydrogenorthophosphate	-5.8	-	low

Mobility in soil

Section 12. Ecological information

Soil/water partition coefficient (K_{OC}) : Not available.

Other adverse effects : No known significant effects or critical hazards.

Section 13. Disposal considerations

Disposal methods : The generation of waste should be avoided or minimized wherever possible. Disposal of this product, solutions and any by-products should at all times comply with the requirements of environmental protection and waste disposal legislation and any regional local authority requirements. Dispose of surplus and non-recyclable products via a licensed waste disposal contractor. Waste should not be disposed of untreated to the sewer unless fully compliant with the requirements of all authorities with jurisdiction. Waste packaging should be recycled. Incineration or landfill should only be considered when recycling is not feasible. This material and its container must be disposed of in a safe way. Care should be taken when handling emptied containers that have not been cleaned or rinsed out. Empty containers or liners may retain some product residues. Avoid dispersal of spilled material and runoff and contact with soil, waterways, drains and sewers.

Section 14. Transport information

	DOT Classification	IATA
UN number	Not regulated.	Not regulated.
UN proper shipping name	-	-
Transport hazard class(es)	-	-
Packing group	-	-
Environmental hazards	No.	No.
Additional information		-

Special precautions for user : **Transport within user's premises:** always transport in closed containers that are upright and secure. Ensure that persons transporting the product know what to do in the event of an accident or spillage.

Transport in bulk according to Annex II of MARPOL 73/78 and the IBC Code : Not available.

Section 15. Regulatory information

U.S. Federal regulations : **TSCA 8(a) CDR Exempt/Partial exemption**: Not determined

United States inventory (TSCA 8b): All components are listed or exempted.

Clean Water Act (CWA) 311: disodium hydrogenorthophosphate

Clean Air Act Section 112 (b) Hazardous Air Pollutants (HAPs) : Not listed

Clean Air Act Section 602 Class I Substances : Not listed

Section 15. Regulatory information

Clean Air Act Section 602 Class II Substances : Not listed

DEA List I Chemicals (Precursor Chemicals) : Not listed

DEA List II Chemicals (Essential Chemicals) : Not listed

SARA 302/304

Composition/information on ingredients

No products were found.

SARA 304 RQ : Not applicable.

SARA 311/312

Classification : Immediate (acute) health hazard

Composition/information on ingredients

Name	%	Fire hazard	Sudden release of pressure	Reactive	Immediate (acute) health hazard	Delayed (chronic) health hazard
disodium hydrogenorthophosphate sodium chloride	25 - 45 25 - 45	No. No.	No. No.	No. No.	Yes. Yes.	No. No.

State regulations

Massachusetts : The following components are listed: PHOSPHORIC ACID, DISODIUM SALT

New York : The following components are listed: Sodium phosphate, dibasic

New Jersey : The following components are listed: SODIUM PHOSPHATE, DIBASIC; PHOSPHORIC ACID, DISODIUM SALT

Pennsylvania : The following components are listed: PHOSPHORIC ACID, DISODIUM SALT

Canada inventory : All components are listed or exempted.

International regulations

International lists : **Australia inventory (AICS)**: All components are listed or exempted.
China inventory (IECSC): All components are listed or exempted.
Japan inventory: All components are listed or exempted.
Korea inventory: All components are listed or exempted.
Malaysia Inventory (EHS Register): Not determined.
New Zealand Inventory of Chemicals (NZIoC): All components are listed or exempted.
Philippines inventory (PICCS): All components are listed or exempted.
Taiwan inventory (CSNN): Not determined.

Chemical Weapons Convention List Schedule I Chemicals : Not listed

Chemical Weapons Convention List Schedule II Chemicals : Not listed

Chemical Weapons Convention List Schedule III Chemicals : Not listed

Section 16. Other information

Hazardous Material Information System (U.S.A.)

Health 1
Chronic Health Hazard
Flammability 0
Physical hazards 0

National Fire Protection Association (U.S.A.)

Health 1

Section 16. Other information

Flammability	0
Instability/Reactivity	0
Special	

The customer is responsible for determining the PPE code for this material.

Caution: HMIS® ratings are based on a 0-4 rating scale, with 0 representing minimal hazards or risks, and 4 representing significant hazards or risks Although HMIS® ratings are not required on SDSs under 29 CFR 1910. 1200, the preparer may choose to provide them. HMIS® ratings are to be used with a fully implemented HMIS® program. HMIS® is a registered mark of the National Paint & Coatings Association (NPCA). HMIS® materials may be purchased exclusively from J. J. Keller (800) 327-6868.

History

Date of printing	:	1/9/2014.
Date of issue/Date of revision	:	1/9/2014.
Date of previous issue	:	No previous validation.
Version	:	1
Prepared by	:	SDS Specialist
Key to abbreviations	:	ATE = Acute Toxicity Estimate BCF = Bioconcentration Factor GHS = Globally Harmonized System of Classification and Labelling of Chemicals IATA = International Air Transport Association IBC = Intermediate Bulk Container IMDG = International Maritime Dangerous Goods LogPow = logarithm of the octanol/water partition coefficient MARPOL 73/78 = International Convention for the Prevention of Pollution From Ships, 1973 as modified by the Protocol of 1978. ("Marpol" = marine pollution) UN = United Nations
References	:	Not available.

Indicates information that has changed from previously issued version.

Notice to reader

To the best of our knowledge, the information contained herein is accurate. However, neither the above-named supplier, nor any of its subsidiaries, assumes any liability whatsoever for the accuracy or completeness of the information contained herein.
Final determination of suitability of any material is the sole responsibility of the user. All materials may present unknown hazards and should be used with caution. Although certain hazards are described herein, we cannot guarantee that these are the only hazards that exist.

SAFETY DATA SHEET

Version 4.10
Revision Date 06/24/2014
Print Date 04/06/2015

1. PRODUCT AND COMPANY IDENTIFICATION

1.1 Product identifiers

Product name : Sodium azide

Product Number : 438456
Brand : Aldrich
Index-No. : 011-004-00-7

CAS-No. : 26628-22-8

1.2 Relevant identified uses of the substance or mixture and uses advised against

Identified uses : Laboratory chemicals, Manufacture of substances

1.3 Details of the supplier of the safety data sheet

Company : Sigma-Aldrich
3050 Spruce Street
SAINT LOUIS MO 63103
USA

Telephone : +1 800-325-5832
Fax : +1 800-325-5052

1.4 Emergency telephone number

Emergency Phone # : (314) 776-6555

2. HAZARDS IDENTIFICATION

2.1 Classification of the substance or mixture

GHS Classification in accordance with 29 CFR 1910 (OSHA HCS)
Acute toxicity, Oral (Category 2), H300
Acute toxicity, Dermal (Category 1), H310
Acute aquatic toxicity (Category 1), H400
Chronic aquatic toxicity (Category 1), H410

For the full text of the H-Statements mentioned in this Section, see Section 16.

2.2 GHS Label elements, including precautionary statements

Pictogram

Signal word Danger

Hazard statement(s)
H300 + H310 Fatal if swallowed or in contact with skin
H410 Very toxic to aquatic life with long lasting effects.

Precautionary statement(s)
P262 Do not get in eyes, on skin, or on clothing.
P264 Wash skin thoroughly after handling.
P270 Do not eat, drink or smoke when using this product.
P273 Avoid release to the environment.
P280 Wear protective gloves/ protective clothing.
P301 + P310 IF SWALLOWED: Immediately call a POISON CENTER or doctor/ physician.

P302 + P350	IF ON SKIN: Gently wash with plenty of soap and water.
P310	Immediately call a POISON CENTER or doctor/ physician.
P322	Specific measures (see supplemental first aid instructions on this label).
P330	Rinse mouth.
P361	Remove/Take off immediately all contaminated clothing.
P363	Wash contaminated clothing before reuse.
P391	Collect spillage.
P405	Store locked up.
P501	Dispose of contents/ container to an approved waste disposal plant.

2.3 Hazards not otherwise classified (HNOC) or not covered by GHS

Contact with acids liberates very toxic gas.
Sodium Azide may react with lead and copper plumbing to form highly explosive metal azides., Rapidly absorbed through skin.

3. COMPOSITION/INFORMATION ON INGREDIENTS

3.1 Substances

Formula	:	N_3Na
Molecular Weight	:	65.01 g/mol
CAS-No.	:	26628-22-8
EC-No.	:	247-852-1
Index-No.	:	011-004-00-7

Hazardous components

Component	Classification	Concentration
Sodium azide		
	Acute Tox. 2; Acute Tox. 1; Aquatic Acute 1; Aquatic Chronic 1; H300 + H310, H410	-

For the full text of the H-Statements mentioned in this Section, see Section 16.

4. FIRST AID MEASURES

4.1 Description of first aid measures

General advice
Consult a physician. Show this safety data sheet to the doctor in attendance.Move out of dangerous area.

If inhaled
If breathed in, move person into fresh air. If not breathing, give artificial respiration. Consult a physician.

In case of skin contact
Wash off with soap and plenty of water. Take victim immediately to hospital. Consult a physician.

In case of eye contact
Flush eyes with water as a precaution.

If swallowed
Never give anything by mouth to an unconscious person. Rinse mouth with water. Consult a physician.

4.2 Most important symptoms and effects, both acute and delayed

The most important known symptoms and effects are described in the labelling (see section 2.2) and/or in section 11

4.3 Indication of any immediate medical attention and special treatment needed

no data available

5. FIREFIGHTING MEASURES

5.1 Extinguishing media

Suitable extinguishing media
Dry powder

5.2 Special hazards arising from the substance or mixture
no data available

5.3 Advice for firefighters
Wear self contained breathing apparatus for fire fighting if necessary.

5.4 Further information
no data available

6. ACCIDENTAL RELEASE MEASURES

6.1 Personal precautions, protective equipment and emergency procedures
Wear respiratory protection. Avoid dust formation. Avoid breathing vapours, mist or gas. Ensure adequate ventilation. Evacuate personnel to safe areas. Avoid breathing dust.
For personal protection see section 8.

6.2 Environmental precautions
Prevent further leakage or spillage if safe to do so. Do not let product enter drains. Discharge into the environment must be avoided.

6.3 Methods and materials for containment and cleaning up
Pick up and arrange disposal without creating dust. Sweep up and shovel. Do not flush with water. Keep in suitable, closed containers for disposal.

6.4 Reference to other sections
For disposal see section 13.

7. HANDLING AND STORAGE

7.1 Precautions for safe handling
Avoid contact with skin and eyes. Avoid formation of dust and aerosols.
Provide appropriate exhaust ventilation at places where dust is formed.
For precautions see section 2.2.

7.2 Conditions for safe storage, including any incompatibilities
Keep container tightly closed in a dry and well-ventilated place.
Never allow product to get in contact with water during storage. Do not store near acids.

Heat sensitive.

7.3 Specific end use(s)
Apart from the uses mentioned in section 1.2 no other specific uses are stipulated

8. EXPOSURE CONTROLS/PERSONAL PROTECTION

8.1 Control parameters

Components with workplace control parameters

Component	CAS-No.	Value	Control parameters	Basis
Sodium azide	26628-22-8	C	0.1 ppm	USA. NIOSH Recommended Exposure Limits
	Remarks	Potential for dermal absorption		
		C	0.3 mg/m3	USA. NIOSH Recommended Exposure Limits
		Potential for dermal absorption		
		C	0.1 ppm	USA. OSHA - TABLE Z-1 Limits for Air Contaminants - 1910.1000
		Skin notation		
		Skin notation		
		C	0.11 ppm	USA. ACGIH Threshold Limit Values (TLV)
		Lung damage Cardiac impairment Not classifiable as a human carcinogen		

		C	0.29 mg/m3	USA. ACGIH Threshold Limit Values (TLV)
		Lung damage Cardiac impairment Not classifiable as a human carcinogen		

8.2 Exposure controls

Appropriate engineering controls
Avoid contact with skin, eyes and clothing. Wash hands before breaks and immediately after handling the product.

Personal protective equipment

Eye/face protection
Face shield and safety glasses Use equipment for eye protection tested and approved under appropriate government standards such as NIOSH (US) or EN 166(EU).

Skin protection
Handle with gloves. Gloves must be inspected prior to use. Use proper glove removal technique (without touching glove's outer surface) to avoid skin contact with this product. Dispose of contaminated gloves after use in accordance with applicable laws and good laboratory practices. Wash and dry hands.

Full contact
Material: Nitrile rubber
Minimum layer thickness: 0.11 mm
Break through time: 480 min
Material tested:Dermatril® (KCL 740 / Aldrich Z677272, Size M)

Splash contact
Material: Nitrile rubber
Minimum layer thickness: 0.11 mm
Break through time: 480 min
Material tested:Dermatril® (KCL 740 / Aldrich Z677272, Size M)

data source: KCL GmbH, D-36124 Eichenzell, phone +49 (0)6659 87300, e-mail sales@kcl.de, test method: EN374
If used in solution, or mixed with other substances, and under conditions which differ from EN 374, contact the supplier of the CE approved gloves. This recommendation is advisory only and must be evaluated by an industrial hygienist and safety officer familiar with the specific situation of anticipated use by our customers. It should not be construed as offering an approval for any specific use scenario.

Body Protection
Complete suit protecting against chemicals, The type of protective equipment must be selected according to the concentration and amount of the dangerous substance at the specific workplace.

Respiratory protection
Where risk assessment shows air-purifying respirators are appropriate use a full-face particle respirator type N100 (US) or type P3 (EN 143) respirator cartridges as a backup to engineering controls. If the respirator is the sole means of protection, use a full-face supplied air respirator. Use respirators and components tested and approved under appropriate government standards such as NIOSH (US) or CEN (EU).

Control of environmental exposure
Prevent further leakage or spillage if safe to do so. Do not let product enter drains. Discharge into the environment must be avoided.

9. PHYSICAL AND CHEMICAL PROPERTIES

9.1 Information on basic physical and chemical properties

a)	Appearance	Form: crystalline Colour: white
b)	Odour	no data available
c)	Odour Threshold	no data available
d)	pH	10 at 65 g/l at 25 °C (77 °F)
e)	Melting point/freezing	275 °C (527 °F)

	point	
f)	Initial boiling point and boiling range	no data available
g)	Flash point	no data available
h)	Evapouration rate	no data available
i)	Flammability (solid, gas)	no data available
j)	Upper/lower flammability or explosive limits	no data available
k)	Vapour pressure	0.01 hPa (0.01 mmHg) at 20 °C (68 °F)
l)	Vapour density	no data available
m)	Relative density	1.850 g/cm3
n)	Water solubility	65 g/l at 20 °C (68 °F) - completely soluble
o)	Partition coefficient: n-octanol/water	no data available
p)	Auto-ignition temperature	no data available
q)	Decomposition temperature	300 °C (572 °F) -
r)	Viscosity	no data available
s)	Explosive properties	no data available
t)	Oxidizing properties	no data available

9.2 Other safety information

Bulk density	0.8 kg/m3

10. STABILITY AND REACTIVITY

10.1 Reactivity
no data available

10.2 Chemical stability
Stable under recommended storage conditions.

10.3 Possibility of hazardous reactions
no data available

10.4 Conditions to avoid
An explosion occurred when a mixture of sodium azide, methylene chloride, dimethyl sulfoxide, and sulfuric acid were being concentrated on a rotary evaporator.

10.5 Incompatible materials
Halogenated hydrocarbon, Metals, Acids, Acid chlorides

10.6 Hazardous decomposition products
Other decomposition products - no data available
In the event of fire: see section 5

11. TOXICOLOGICAL INFORMATION

11.1 Information on toxicological effects

Acute toxicity
LD50 Oral - rabbit - 10 mg/kg

LC50 Inhalation - rat - 37 mg/m3
Remarks: Sense Organs and Special Senses (Nose, Eye, Ear, and Taste):Eye:Other. Behavioral:Convulsions or effect on seizure threshold. Lungs, Thorax, or Respiration:Structural or functional change in trachea or bronchi.

LD50 Dermal - rabbit - 20 mg/kg

no data available

Skin corrosion/irritation
no data available

Serious eye damage/eye irritation
no data available

Respiratory or skin sensitisation
no data available

Germ cell mutagenicity
no data available

Carcinogenicity

IARC: No component of this product present at levels greater than or equal to 0.1% is identified as probable, possible or confirmed human carcinogen by IARC.

NTP: No component of this product present at levels greater than or equal to 0.1% is identified as a known or anticipated carcinogen by NTP.

OSHA: No component of this product present at levels greater than or equal to 0.1% is identified as a carcinogen or potential carcinogen by OSHA.

Reproductive toxicity
no data available

no data available

Specific target organ toxicity - single exposure
no data available

Specific target organ toxicity - repeated exposure
no data available

Aspiration hazard
no data available

Additional Information
RTECS: VY8050000

Nausea, Headache, Vomiting, Laboratory experiments in animals have shown sodium azide to produce a profound hypotensive effect, demyelination of myelinated nerve fibers in the central nervous system, testicular damage, blindness, attacks of rigidity, and hepatic and cerebral effects.

Liver - Irregularities - Based on Human Evidence
Liver - Irregularities - Based on Human Evidence

12. ECOLOGICAL INFORMATION

12.1 Toxicity
no data available

Toxicity to daphnia and other aquatic invertebrates	EC50 - Daphnia pulex (Water flea) - 4.2 mg/l - 48 h

12.2 Persistence and degradability
no data available

12.3 Bioaccumulative potential
no data available

12.4 Mobility in soil
no data available

12.5 Results of PBT and vPvB assessment

PBT/vPvB assessment not available as chemical safety assessment not required/not conducted

12.6 Other adverse effects

An environmental hazard cannot be excluded in the event of unprofessional handling or disposal.
Very toxic to aquatic life with long lasting effects.

13. DISPOSAL CONSIDERATIONS

13.1 Waste treatment methods

Product

Offer surplus and non-recyclable solutions to a licensed disposal company. Contact a licensed professional waste disposal service to dispose of this material. Dissolve or mix the material with a combustible solvent and burn in a chemical incinerator equipped with an afterburner and scrubber.

Contaminated packaging

Dispose of as unused product.

14. TRANSPORT INFORMATION

DOT (US)

UN number: 1687 Class: 6.1 Packing group: II
Proper shipping name: Sodium azide
Reportable Quantity (RQ): 1000 lbs
Marine pollutant: No
Poison Inhalation Hazard: No

IMDG

UN number: 1687 Class: 6.1 Packing group: II EMS-No: F-A, S-A
Proper shipping name: SODIUM AZIDE
Marine pollutant: No

IATA

UN number: 1687 Class: 6.1 Packing group: II
Proper shipping name: Sodium azide

15. REGULATORY INFORMATION

SARA 302 Components

The following components are subject to reporting levels established by SARA Title III, Section 302:

	CAS-No.	Revision Date
Sodium azide	26628-22-8	2007-07-01

SARA 313 Components

The following components are subject to reporting levels established by SARA Title III, Section 313:

	CAS-No.	Revision Date
Sodium azide	26628-22-8	2007-07-01

SARA 311/312 Hazards

Acute Health Hazard, Chronic Health Hazard

Massachusetts Right To Know Components

	CAS-No.	Revision Date
Sodium azide	26628-22-8	2007-07-01

Pennsylvania Right To Know Components

	CAS-No.	Revision Date
Sodium azide	26628-22-8	2007-07-01

New Jersey Right To Know Components

	CAS-No.	Revision Date
Sodium azide	26628-22-8	2007-07-01

California Prop. 65 Components

This product does not contain any chemicals known to State of California to cause cancer, birth defects, or any other reproductive harm.

16. OTHER INFORMATION

Full text of H-Statements referred to under sections 2 and 3.

Acute Tox.	Acute toxicity
Aquatic Acute	Acute aquatic toxicity
Aquatic Chronic	Chronic aquatic toxicity
H300	Fatal if swallowed.
H300 + H310	Fatal if swallowed or in contact with skin
H310	Fatal in contact with skin.

HMIS Rating

Health hazard:	4
Chronic Health Hazard:	*
Flammability:	0
Physical Hazard	0

NFPA Rating

Health hazard:	4
Fire Hazard:	0
Reactivity Hazard:	0

Further information

The above information is believed to be correct but does not purport to be all inclusive and shall be used only as a guide. The information in this document is based on the present state of our knowledge and is applicable to the product with regard to appropriate safety precautions. It does not represent any guarantee of the properties of the product. Sigma-Aldrich Corporation and its Affiliates shall not be held liable for any damage resulting from handling or from contact with the above product. See www.sigma-aldrich.com and/or the reverse side of invoice or packing slip for additional terms and conditions of sale.

Preparation Information

Sigma-Aldrich Corporation
Product Safety – Americas Region
1-800-521-8956

Version: 4.10 Revision Date: 06/24/2014 Print Date: 04/06/2015

SAFETY DATA SHEET

Version 4.7
Revision Date 08/20/2014
Print Date 04/06/2015

1. PRODUCT AND COMPANY IDENTIFICATION

1.1 Product identifiers

Product name : Tris(hydroxymethyl)aminomethane

Product Number : 252859
Brand : Sigma-Aldrich

CAS-No. : 77-86-1

1.2 Relevant identified uses of the substance or mixture and uses advised against

Identified uses : Laboratory chemicals, Manufacture of substances

1.3 Details of the supplier of the safety data sheet

Company : Sigma-Aldrich
3050 Spruce Street
SAINT LOUIS MO 63103
USA

Telephone : +1 800-325-5832
Fax : +1 800-325-5052

1.4 Emergency telephone number

Emergency Phone # : (314) 776-6555

2. HAZARDS IDENTIFICATION

2.1 Classification of the substance or mixture

Not a hazardous substance or mixture.

2.2 GHS Label elements, including precautionary statements

Not a hazardous substance or mixture.

2.3 Hazards not otherwise classified (HNOC) or not covered by GHS

This substance is not considered to be persistent, bioaccumulating and toxic (PBT).

3. COMPOSITION/INFORMATION ON INGREDIENTS

3.1 Substances

Formula : $C_4H_{11}NO_3$
Molecular weight : 121.14 g/mol
CAS-No. : 77-86-1
EC-No. : 201-064-4
Registration number : 01-2119957659-16-XXXX

No components need to be disclosed according to the applicable regulations.

4. FIRST AID MEASURES

4.1 Description of first aid measures

If inhaled
If breathed in, move person into fresh air. If not breathing, give artificial respiration.

In case of skin contact
Wash off with soap and plenty of water.

In case of eye contact
Flush eyes with water as a precaution.

If swallowed
Never give anything by mouth to an unconscious person. Rinse mouth with water.

4.2 Most important symptoms and effects, both acute and delayed
The most important known symptoms and effects are described in the labelling (see section 2.2) and/or in section 11

4.3 Indication of any immediate medical attention and special treatment needed
No data available

5. FIREFIGHTING MEASURES

5.1 Extinguishing media

Suitable extinguishing media
Use water spray, alcohol-resistant foam, dry chemical or carbon dioxide.

5.2 Special hazards arising from the substance or mixture
No data available

5.3 Advice for firefighters
Wear self-contained breathing apparatus for firefighting if necessary.

5.4 Further information
No data available

6. ACCIDENTAL RELEASE MEASURES

6.1 Personal precautions, protective equipment and emergency procedures
Avoid dust formation. Avoid breathing vapours, mist or gas.
For personal protection see section 8.

6.2 Environmental precautions
Do not let product enter drains.

6.3 Methods and materials for containment and cleaning up
Sweep up and shovel. Keep in suitable, closed containers for disposal.

6.4 Reference to other sections
For disposal see section 13.

7. HANDLING AND STORAGE

7.1 Precautions for safe handling
Provide appropriate exhaust ventilation at places where dust is formed.
For precautions see section 2.2.

7.2 Conditions for safe storage, including any incompatibilities
Keep container tightly closed in a dry and well-ventilated place.

Hygroscopic.

7.3 Specific end use(s)
Apart from the uses mentioned in section 1.2 no other specific uses are stipulated

8. EXPOSURE CONTROLS/PERSONAL PROTECTION

8.1 Control parameters

Components with workplace control parameters
Contains no substances with occupational exposure limit values.

8.2 Exposure controls

Appropriate engineering controls
General industrial hygiene practice.

Personal protective equipment

Eye/face protection
Use equipment for eye protection tested and approved under appropriate government standards such as NIOSH (US) or EN 166(EU).

Skin protection
Handle with gloves. Gloves must be inspected prior to use. Use proper glove removal technique (without touching glove's outer surface) to avoid skin contact with this product. Dispose of contaminated gloves after use in accordance with applicable laws and good laboratory practices. Wash and dry hands.

Full contact
Material: Nitrile rubber
Minimum layer thickness: 0.11 mm
Break through time: 480 min
Material tested:Dermatril® (KCL 740 / Aldrich Z677272, Size M)

Splash contact
Material: Nitrile rubber
Minimum layer thickness: 0.11 mm
Break through time: 480 min
Material tested:Dermatril® (KCL 740 / Aldrich Z677272, Size M)

data source: KCL GmbH, D-36124 Eichenzell, phone +49 (0)6659 87300, e-mail sales@kcl.de, test method: EN374
If used in solution, or mixed with other substances, and under conditions which differ from EN 374, contact the supplier of the CE approved gloves. This recommendation is advisory only and must be evaluated by an industrial hygienist and safety officer familiar with the specific situation of anticipated use by our customers. It should not be construed as offering an approval for any specific use scenario.

Body Protection
Choose body protection in relation to its type, to the concentration and amount of dangerous substances, and to the specific work-place., The type of protective equipment must be selected according to the concentration and amount of the dangerous substance at the specific workplace.

Respiratory protection
Respiratory protection is not required. Where protection from nuisance levels of dusts are desired, use type N95 (US) or type P1 (EN 143) dust masks. Use respirators and components tested and approved under appropriate government standards such as NIOSH (US) or CEN (EU).

Control of environmental exposure
Do not let product enter drains.

9. PHYSICAL AND CHEMICAL PROPERTIES

9.1 Information on basic physical and chemical properties

a)	Appearance	Form: crystalline Colour: colourlesswhite
b)	Odour	No data available
c)	Odour Threshold	No data available
d)	pH	10.5 - 12
e)	Melting point/freezing point	Melting point/range: 169 °C (336 °F)
f)	Initial boiling point and boiling range	288 °C (550 °F) at 1,013 hPa (760 mmHg) - Decomposes below the boiling point.
g)	Flash point	No data available
h)	Evaporation rate	No data available
i)	Flammability (solid, gas)	No data available
j)	Upper/lower flammability or	No data available

	explosive limits	
k)	Vapour pressure	No data available
l)	Vapour density	No data available
m)	Relative density	No data available
n)	Water solubility	678 g/l at 20 °C (68 °F)
o)	Partition coefficient: n-octanol/water	log Pow: -2.31 at 20 °C (68 °F)
p)	Auto-ignition temperature	The substance or mixture is not classified as self heating.
q)	Decomposition temperature	No data available
r)	Viscosity	Not applicable
s)	Explosive properties	Not explosive
t)	Oxidizing properties	The substance or mixture is not classified as oxidizing.

9.2 Other safety information

Bulk density	800 kg/m3
Dissociation constant	8.22 at 25 °C (77 °F)

10. STABILITY AND REACTIVITY

10.1 Reactivity
No data available

10.2 Chemical stability
Stable under recommended storage conditions.

10.3 Possibility of hazardous reactions
No data available

10.4 Conditions to avoid
hygroscopic

10.5 Incompatible materials
Strong oxidizing agents

10.6 Hazardous decomposition products
Other decomposition products - No data available
In the event of fire: see section 5

11. TOXICOLOGICAL INFORMATION

11.1 Information on toxicological effects

Acute toxicity
LD50 Oral - Rat - > 3,000 mg/kg

Inhalation: No data available

LD50 Dermal - Rat - > 5,000 mg/kg
(OECD Test Guideline 402)

No data available

Skin corrosion/irritation
Skin - Rabbit
Result: No skin irritation
(OECD Test Guideline 404)

Serious eye damage/eye irritation
Eyes - Rabbit
Result: No eye irritation
(OECD Test Guideline 405)

Respiratory or skin sensitisation
Buehler Test - Guinea pig
Does not cause skin sensitisation.
(OECD Test Guideline 406)

Germ cell mutagenicity
Result: Not mutagenic in Ames Test.

in vitro assay
Result: negative
In vitro tests did not show mutagenic effects

Result: In vivo tests did not show any chromosomal changes.

Carcinogenicity

IARC: No component of this product present at levels greater than or equal to 0.1% is identified as probable, possible or confirmed human carcinogen by IARC.

ACGIH: No component of this product present at levels greater than or equal to 0.1% is identified as a carcinogen or potential carcinogen by ACGIH.

NTP: No component of this product present at levels greater than or equal to 0.1% is identified as a known or anticipated carcinogen by NTP.

OSHA: No component of this product present at levels greater than or equal to 0.1% is identified as a carcinogen or potential carcinogen by OSHA.

Reproductive toxicity
No data available

No data available

Specific target organ toxicity - single exposure
No data available

Specific target organ toxicity - repeated exposure
No data available

Aspiration hazard
No data available

Additional Information

Repeated dose toxicity - Rat - Oral - No observed adverse effect level - 1,000 mg/kg
RTECS: TY2900000

To the best of our knowledge, the chemical, physical, and toxicological properties have not been thoroughly investigated.

12. ECOLOGICAL INFORMATION

12.1 Toxicity

Toxicity to daphnia and other aquatic invertebrates	EC50 - Daphnia (water flea) - > 980 mg/l - 48 h
Toxicity to algae	EC50 - Algae - 397 mg/l - 72 h
	NOEC - Algae - 100 mg/l - 72 h

12.2 Persistence and degradability

Biodegradability Result: - Readily biodegradable.

(OECD Test Guideline 301F)

12.3 Bioaccumulative potential
No bioaccumulation is to be expected (log Pow <= 4).

12.4 Mobility in soil
No data available

12.5 Results of PBT and vPvB assessment
This substance is not considered to be persistent, bioaccumulating and toxic (PBT).

12.6 Other adverse effects

No data available

13. DISPOSAL CONSIDERATIONS

13.1 Waste treatment methods

Product
Offer surplus and non-recyclable solutions to a licensed disposal company.

Contaminated packaging
Dispose of as unused product.

14. TRANSPORT INFORMATION

DOT (US)
Not dangerous goods

IMDG
Not dangerous goods

IATA
Not dangerous goods

15. REGULATORY INFORMATION

SARA 302 Components
No chemicals in this material are subject to the reporting requirements of SARA Title III, Section 302.

SARA 313 Components
This material does not contain any chemical components with known CAS numbers that exceed the threshold (De Minimis) reporting levels established by SARA Title III, Section 313.

SARA 311/312 Hazards
No SARA Hazards

Massachusetts Right To Know Components
No components are subject to the Massachusetts Right to Know Act.

Pennsylvania Right To Know Components

	CAS-No.	Revision Date
Tris (hydroxymethyl) aminomethane	77-86-1	

New Jersey Right To Know Components

	CAS-No.	Revision Date
Tris (hydroxymethyl) aminomethane	77-86-1	

California Prop. 65 Components
This product does not contain any chemicals known to State of California to cause cancer, birth defects, or any other reproductive harm.

16. OTHER INFORMATION

HMIS Rating

Health hazard:	0
Chronic Health Hazard:	
Flammability:	0
Physical Hazard	0

NFPA Rating

Health hazard:	0
Fire Hazard:	0
Reactivity Hazard:	0

Further information

The above information is believed to be correct but does not purport to be all inclusive and shall be used only as a guide. The information in this document is based on the present state of our knowledge and is applicable to the product with regard to appropriate safety precautions. It does not represent any guarantee of the properties of the product. Sigma-Aldrich Corporation and its Affiliates shall not be held liable for any damage resulting from handling or from contact with the above product. See www.sigma-aldrich.com and/or the reverse side of invoice or packing slip for additional terms and conditions of sale.

Preparation Information

Sigma-Aldrich Corporation
Product Safety – Americas Region
1-800-521-8956

Version: 4.7 Revision Date: 08/20/2014 Print Date: 04/06/2015

Material Safety Data Sheet
Sodium cyanoborohydride

MSDS# 17430

Section 1 - Chemical Product and Company Identification

MSDS Name:	Sodium cyanoborohydride
Catalog Numbers:	AC168550000, AC168550100, AC168550500, AC9556139, AC9584945, AC9584951
Synonyms:	Sodium cyanotrihydroborate

Company Identification:	Acros Organics BVBA Janssen Pharmaceuticalaan 3a 2440 Geel, Belgium
Company Identification: (USA)	Acros Organics One Reagent Lane Fair Lawn, NJ 07410
For information in the US, call:	800-ACROS-01
For information in Europe, call:	+32 14 57 52 11
Emergency Number, Europe:	+32 14 57 52 99
Emergency Number US:	201-796-7100
CHEMTREC Phone Number, US:	800-424-9300
CHEMTREC Phone Number, Europe:	703-527-3887

Section 2 - Composition, Information on Ingredients

CAS#:	25895-60-7
Chemical Name:	Sodium cyanoborohydride
%:	>95.0
EINECS#:	247-317-2

Hazard Symbols: T+ F N



Risk Phrases: 11 15 16 26/27/28 32 34 50/53

Section 3 - Hazards Identification

EMERGENCY OVERVIEW

Danger! Flammable solid. Water-reactive. Causes burns by all exposure routes. Contact with acids liberates toxic gas. Very toxic to aquatic organisms. Very toxic by inhalation, in contact with skin and if swallowed. Contact with water liberates extremely flammable gases. Target Organs: Respiratory system, eyes, skin.

Potential Health Effects

Eye:	Causes eye burns.
Skin:	Toxic in contact with skin. May be metabolized to cyanide which in turn acts by inhibiting cytochrome oxidase impairing cellular respiration. Causes skin irritation and burns.
Ingestion:	Poison by ingestion. Causes gastrointestinal tract burns. Ingestion may result in symptoms similar to cyanide poisoning which is characterized by asphyxiation. Toxic if swallowed.
Inhalation:	Causes chemical burns to the respiratory tract. Toxic if inhaled. May be metabolized to cyanide which in turns act by inhibiting cytochrome oxidase impairing cellular respiration.
Chronic:	No information found.

Section 4 - First Aid Measures

Eyes:	Get medical aid immediately. Do NOT allow victim to rub eyes or keep eyes closed. Extensive irrigation with water is required (at least 30 minutes).
Skin:	Get medical aid immediately. Immediately flush skin with plenty of water for at least 15 minutes while removing contaminated clothing and shoes.
Ingestion:	Do not induce vomiting. If victim is conscious and alert, give 2-4 cupfuls of milk or water. Never give anything by mouth to an unconscious person. Get medical aid immediately. Treat patient as for inhalation.
Inhalation:	Get medical aid immediately. Remove from exposure and move to fresh air immediately. If breathing is difficult, give oxygen. Do NOT use mouth-to-mouth resuscitation. If breathing has ceased apply artificial respiration using oxygen and a suitable mechanical device such as a bag and a mask. If inhaled, do NOT induce vomiting, and seek medical aid immediately. If breathing has ceased apply artificial respiration using oxygen and a suitable mechanical device such as a bag and a mask.
Notes to Physician:	

Section 5 - Fire Fighting Measures

General Information:	As in any fire, wear a self-contained breathing apparatus in pressure-demand, MSHA/NIOSH (approved or equivalent), and full protective gear. Exposure to heat may promote violent decomposition. Water reactive. Material will react with water and may release a flammable and/or toxic gas. Flammable solid. Containers may explode when heated. May react with metal surfaces to form flammable and explosive hydrogen gas.
Extinguishing Media:	Contact professional fire-fighters immediately. DO NOT USE WATER OR FOAM. Use dry powder or carbon dioxide.
Autoignition Temperature:	Not available
Flash Point:	Not available
Explosion Limits: Lower:	Not available
Explosion Limits: Upper:	Not available

NFPA Rating: ; Special Hazard: -W-

Section 6 - Accidental Release Measures

General Information:	Use proper personal protective equipment as indicated in Section 8.
Spills/Leaks:	Vacuum or sweep up material and place into a suitable disposal container. Avoid generating dusty conditions. Remove all sources of ignition. Provide ventilation. Do not let this chemical enter the environment.

Section 7 - Handling and Storage

Handling:	Wash thoroughly after handling. Use with adequate ventilation. Minimize dust generation and accumulation. Avoid contact with eyes, skin, and clothing. Empty containers retain product residue, (liquid and/or vapor), and can be dangerous. Keep container tightly closed. Keep away from heat, sparks and flame. Do not ingest or inhale. Do not pressurize, cut, weld, braze, solder, drill, grind, or expose empty containers to heat, sparks or open flames.
Storage:	Keep away from sources of ignition. Store in a tightly closed container. Keep under a nitrogen blanket. Store in a cool, dry, well-ventilated area away from incompatible substances. Water free area.

Section 8 - Exposure Controls, Personal Protection

Chemical Name	ACGIH	NIOSH	OSHA - Final PELs
Sodium cyanoborohydride	none listed	none listed	none listed

OSHA Vacated PELs: Sodium cyanoborohydride: None listed

Engineering Controls:

Facilities storing or utilizing this material should be equipped with an eyewash facility and a safety shower. Use adequate ventilation to keep airborne concentrations low.

Exposure Limits

Personal Protective Equipment

Eyes:	Wear appropriate protective eyeglasses or chemical safety goggles as described by OSHA's eye and face protection regulations in 29 CFR 1910.133 or European Standard EN166.
Skin:	Wear appropriate protective gloves to prevent skin exposure.
Clothing:	Wear appropriate protective clothing to prevent skin exposure.
Respirators:	Follow the OSHA respirator regulations found in 29 CFR 1910.134 or European Standard EN 149. Use a NIOSH/MSHA or European Standard EN 149 approved respirator if exposure limits are exceeded or if irritation or other symptoms are experienced.

Section 9 - Physical and Chemical Properties

Physical State:	Powder
Color:	white
Odor:	Not available
pH:	8-9 (10% aq. solution)
Vapor Pressure:	Not available
Vapor Density:	Not available
Evaporation Rate:	Not available
Viscosity:	Not available
Boiling Point:	Not available
Freezing/Melting Point:	>242 deg C dec
Decomposition Temperature:	Not available
Solubility in water:	Reacts
Specific Gravity/Density:	
Molecular Formula:	CH3BNNa
Molecular Weight:	62.84

Section 10 - Stability and Reactivity

Chemical Stability:	Stable.
Conditions to Avoid:	High temperatures, incompatible materials, ignition sources, dust generation, contact with water.
Incompatibilities with Other Materials	Not available
Hazardous Decomposition Products	Hydrogen cyanide, nitrogen oxides, carbon monoxide, carbon dioxide, oxides of boron, borane, hydrogen gas.
Hazardous Polymerization	Has not been reported.

Section 11 - Toxicological Information

RTECS#:	CAS# 25895-60-7: None listed
LD50/LC50:	RTECS: Not available.
Carcinogenicity:	Sodium cyanoborohydride - Not listed as a carcinogen by ACGIH, IARC, NTP, or CA Prop 65.
Other:	The hazards associated with cyanide may be seen in this product. The toxicological properties have not been fully investigated.

Section 12 - Ecological Information

Not available

Section 13 - Disposal Considerations

Dispose of in a manner consistent with federal, state, and local regulations.

Section 14 - Transport Information

US DOT
Shipping Name: WATER-REACTIVE SOLID, TOXIC, N.O.S.
Hazard Class: 4.3
UN Number: UN3134
Packing Group: II

Canada TDG
Shipping Name: Not available
Hazard Class:
UN Number:
Packing Group:

Section 15 - Regulatory Information

European/International Regulations

European Labeling in Accordance with EC Directives

Hazard Symbols: T+ F N

Risk Phrases:

R 11 Highly flammable.

R 15 Contact with water liberates extremely flammable gases.

R 16 Explosive when mixed with oxidizing substances.

R 26/27/28 Very toxic by inhalation, in contact with skin and if swallowed.

R 32 Contact with acids liberates very toxic gas.

R 34 Causes burns.

R 50/53 Very toxic to aquatic organisms, may cause long-term adverse effects in the aquatic environment.

Safety Phrases:

S 1 Keep locked up.

S 8 Keep container dry.

S 26 In case of contact with eyes, rinse immediately with plenty of water and seek medical advice.

S 28A After contact with skin, wash immediately with plenty of water.

S 36/37/39 Wear suitable protective clothing, gloves and eye/face protection.

S 43 In case of fire, use ... (indicate in the space the precise type of fire-fighting equipment. If water increases the risk, add - never use water).

S 45 In case of accident or if you feel unwell, seek medical advice immediately (show the label where possible).

S 50A Do not mix with acids.

S 60 This material and its container must be disposed of as hazardous waste.

S 61 Avoid release to the environment. Refer to special instructions/safety data sheets.

WGK (Water Danger/Protection)

CAS# 25895-60-7: 2

Canada

CAS# 25895-60-7 is listed on Canada's NDSL List

Canadian WHMIS Classifications: D1A, E, F

This product has been classified in accordance with the hazard criteria of the Controlled Products Regulations and the MSDS contains all of the information required by those regulations.

CAS# 25895-60-7 is not listed on Canada's Ingredient Disclosure List.

US Federal

TSCA

CAS# 25895-60-7 is listed on the TSCA Inventory.

Section 16 - Other Information

MSDS Creation Date: 8/10/1998

Revision #5 Date 7/20/2009

The information above is believed to be accurate and represents the best information currently available

to us. However, we make no warranty of merchantibility or any other warranty, express or implied, with respect to such information, and we assume no liability resulting from its use. Users should make their own investigations to determine the suitability of the information for their particular purposes. In no event shall the company be liable for any claims, losses, or damages of any third party or for lost profits or any special, indirect, incidental, consequential, or exemplary damages howsoever arising, even if the company has been advised of the possibility of such damages.

SAFETY DATA SHEET

Version 4.4
Revision Date 06/27/2014
Print Date 04/06/2015

1. PRODUCT AND COMPANY IDENTIFICATION

1.1 Product identifiers

Product name : Benzamidine hydrochloride

Product Number : 434760
Brand : Sigma-Aldrich

CAS-No. : 1670-14-0

1.2 Relevant identified uses of the substance or mixture and uses advised against

Identified uses : Laboratory chemicals, Manufacture of substances

1.3 Details of the supplier of the safety data sheet

Company : Sigma-Aldrich
3050 Spruce Street
SAINT LOUIS MO 63103
USA

Telephone : +1 800-325-5832
Fax : +1 800-325-5052

1.4 Emergency telephone number

Emergency Phone # : (314) 776-6555

2. HAZARDS IDENTIFICATION

2.1 Classification of the substance or mixture

GHS Classification in accordance with 29 CFR 1910 (OSHA HCS)
Skin irritation (Category 2), H315
Eye irritation (Category 2A), H319
Specific target organ toxicity - single exposure (Category 3), Respiratory system, H335

For the full text of the H-Statements mentioned in this Section, see Section 16.

2.2 GHS Label elements, including precautionary statements

Pictogram

Signal word Warning

Hazard statement(s)
H315 Causes skin irritation.
H319 Causes serious eye irritation.
H335 May cause respiratory irritation.

Precautionary statement(s)
P261 Avoid breathing dust/ fume/ gas/ mist/ vapours/ spray.
P264 Wash skin thoroughly after handling.
P271 Use only outdoors or in a well-ventilated area.
P280 Wear protective gloves/ eye protection/ face protection.
P302 + P352 IF ON SKIN: Wash with plenty of soap and water.
P304 + P340 IF INHALED: Remove victim to fresh air and keep at rest in a position comfortable for breathing.
P305 + P351 + P338 IF IN EYES: Rinse cautiously with water for several minutes. Remove

	contact lenses, if present and easy to do. Continue rinsing.
P312	Call a POISON CENTER or doctor/ physician if you feel unwell.
P321	Specific treatment (see supplemental first aid instructions on this label).
P332 + P313	If skin irritation occurs: Get medical advice/ attention.
P337 + P313	If eye irritation persists: Get medical advice/ attention.
P362	Take off contaminated clothing and wash before reuse.
P403 + P233	Store in a well-ventilated place. Keep container tightly closed.
P405	Store locked up.
P501	Dispose of contents/ container to an approved waste disposal plant.

2.3 Hazards not otherwise classified (HNOC) or not covered by GHS - none

3. COMPOSITION/INFORMATION ON INGREDIENTS

3.1 Substances

Formula	:	$C_7H_8N_2 \cdot HCl$
Molecular Weight	:	156.61 g/mol
CAS-No.	:	1670-14-0
EC-No.	:	216-795-4

Hazardous components

Component	Classification	Concentration
Benzamidinium chloride		
	Skin Irrit. 2; Eye Irrit. 2A; STOT SE 3; H315, H319, H335	-

For the full text of the H-Statements mentioned in this Section, see Section 16.

4. FIRST AID MEASURES

4.1 Description of first aid measures

General advice
Consult a physician. Show this safety data sheet to the doctor in attendance.Move out of dangerous area.

If inhaled
If breathed in, move person into fresh air. If not breathing, give artificial respiration. Consult a physician.

In case of skin contact
Wash off with soap and plenty of water. Consult a physician.

In case of eye contact
Rinse thoroughly with plenty of water for at least 15 minutes and consult a physician.

If swallowed
Never give anything by mouth to an unconscious person. Rinse mouth with water. Consult a physician.

4.2 Most important symptoms and effects, both acute and delayed
The most important known symptoms and effects are described in the labelling (see section 2.2) and/or in section 11

4.3 Indication of any immediate medical attention and special treatment needed
no data available

5. FIREFIGHTING MEASURES

5.1 Extinguishing media

Suitable extinguishing media
Use water spray, alcohol-resistant foam, dry chemical or carbon dioxide.

5.2 Special hazards arising from the substance or mixture
Carbon oxides, nitrogen oxides (NOx), Hydrogen chloride gas

5.3 Advice for firefighters
Wear self contained breathing apparatus for fire fighting if necessary.

5.4 Further information
no data available

6. ACCIDENTAL RELEASE MEASURES

6.1 Personal precautions, protective equipment and emergency procedures
Use personal protective equipment. Avoid dust formation. Avoid breathing vapours, mist or gas. Ensure adequate ventilation. Evacuate personnel to safe areas. Avoid breathing dust.
For personal protection see section 8.

6.2 Environmental precautions
Do not let product enter drains.

6.3 Methods and materials for containment and cleaning up
Pick up and arrange disposal without creating dust. Sweep up and shovel. Keep in suitable, closed containers for disposal.

6.4 Reference to other sections
For disposal see section 13.

7. HANDLING AND STORAGE

7.1 Precautions for safe handling
Avoid contact with skin and eyes. Avoid formation of dust and aerosols.
Provide appropriate exhaust ventilation at places where dust is formed.
For precautions see section 2.2.

7.2 Conditions for safe storage, including any incompatibilities
Keep container tightly closed in a dry and well-ventilated place.

Store under inert gas. Store with desiccant. Hygroscopic.

7.3 Specific end use(s)
Apart from the uses mentioned in section 1.2 no other specific uses are stipulated

8. EXPOSURE CONTROLS/PERSONAL PROTECTION

8.1 Control parameters

Components with workplace control parameters
Contains no substances with occupational exposure limit values.

8.2 Exposure controls

Appropriate engineering controls
Handle in accordance with good industrial hygiene and safety practice. Wash hands before breaks and at the end of workday.

Personal protective equipment

Eye/face protection
Safety glasses with side-shields conforming to EN166 Use equipment for eye protection tested and approved under appropriate government standards such as NIOSH (US) or EN 166(EU).

Skin protection
Handle with gloves. Gloves must be inspected prior to use. Use proper glove removal technique (without touching glove's outer surface) to avoid skin contact with this product. Dispose of contaminated gloves after use in accordance with applicable laws and good laboratory practices. Wash and dry hands.

Body Protection
impervious clothing, The type of protective equipment must be selected according to the concentration and amount of the dangerous substance at the specific workplace.

Respiratory protection
For nuisance exposures use type P95 (US) or type P1 (EU EN 143) particle respirator.For higher level protection use type OV/AG/P99 (US) or type ABEK-P2 (EU EN 143) respirator cartridges. Use respirators and components tested and approved under appropriate government standards such as NIOSH (US) or CEN (EU).

Control of environmental exposure
Do not let product enter drains.

9. PHYSICAL AND CHEMICAL PROPERTIES

9.1 Information on basic physical and chemical properties

a)	Appearance	Form: crystalline Colour: beige
b)	Odour	no data available
c)	Odour Threshold	no data available
d)	pH	no data available
e)	Melting point/freezing point	Melting point/range: 169 - 173 °C (336 - 343 °F) - lit.
f)	Initial boiling point and boiling range	no data available
g)	Flash point	no data available
h)	Evapouration rate	no data available
i)	Flammability (solid, gas)	no data available
j)	Upper/lower flammability or explosive limits	no data available
k)	Vapour pressure	no data available
l)	Vapour density	no data available
m)	Relative density	no data available
n)	Water solubility	soluble
o)	Partition coefficient: n-octanol/water	no data available
p)	Auto-ignition temperature	no data available
q)	Decomposition temperature	no data available
r)	Viscosity	no data available
s)	Explosive properties	no data available
t)	Oxidizing properties	no data available

9.2 Other safety information
no data available

10. STABILITY AND REACTIVITY

10.1 Reactivity
no data available

10.2 Chemical stability
Stable under recommended storage conditions.

10.3 Possibility of hazardous reactions
no data available

10.4 Conditions to avoid
no data available

10.5 Incompatible materials
alkalines

10.6 Hazardous decomposition products

Other decomposition products - no data available
In the event of fire: see section 5

11. TOXICOLOGICAL INFORMATION

11.1 Information on toxicological effects

Acute toxicity
Dermal: no data available

LD50 Intraperitoneal - mouse - 580 mg/kg
Remarks: Brain and Coverings:Meningeal changes. Behavioral:Somnolence (general depressed activity). Lungs, Thorax, or Respiration:Other changes.

Skin corrosion/irritation
no data available

Serious eye damage/eye irritation
no data available

Respiratory or skin sensitisation
no data available

Germ cell mutagenicity
no data available

Carcinogenicity

IARC: No component of this product present at levels greater than or equal to 0.1% is identified as probable, possible or confirmed human carcinogen by IARC.

ACGIH: No component of this product present at levels greater than or equal to 0.1% is identified as a carcinogen or potential carcinogen by ACGIH.

NTP: No component of this product present at levels greater than or equal to 0.1% is identified as a known or anticipated carcinogen by NTP.

OSHA: No component of this product present at levels greater than or equal to 0.1% is identified as a carcinogen or potential carcinogen by OSHA.

Reproductive toxicity
no data available

no data available

Specific target organ toxicity - single exposure
Inhalation - May cause respiratory irritation.

Specific target organ toxicity - repeated exposure
no data available

Aspiration hazard
no data available

Additional Information
RTECS: CV6260000

To the best of our knowledge, the chemical, physical, and toxicological properties have not been thoroughly investigated.

12. ECOLOGICAL INFORMATION

12.1 Toxicity
no data available

12.2 Persistence and degradability
no data available

12.3 Bioaccumulative potential
no data available

12.4 Mobility in soil
no data available

12.5 Results of PBT and vPvB assessment
PBT/vPvB assessment not available as chemical safety assessment not required/not conducted

12.6 Other adverse effects

no data available

13. DISPOSAL CONSIDERATIONS

13.1 Waste treatment methods

Product
Offer surplus and non-recyclable solutions to a licensed disposal company. Contact a licensed professional waste disposal service to dispose of this material.

Contaminated packaging
Dispose of as unused product.

14. TRANSPORT INFORMATION

DOT (US)
Not dangerous goods

IMDG
Not dangerous goods

IATA
Not dangerous goods

15. REGULATORY INFORMATION

SARA 302 Components
SARA 302: No chemicals in this material are subject to the reporting requirements of SARA Title III, Section 302.

SARA 313 Components
SARA 313: This material does not contain any chemical components with known CAS numbers that exceed the threshold (De Minimis) reporting levels established by SARA Title III, Section 313.

SARA 311/312 Hazards
Acute Health Hazard

Massachusetts Right To Know Components
No components are subject to the Massachusetts Right to Know Act.

Pennsylvania Right To Know Components

	CAS-No.	Revision Date
Benzamidinium chloride	1670-14-0	

New Jersey Right To Know Components

	CAS-No.	Revision Date
Benzamidinium chloride	1670-14-0	

California Prop. 65 Components
This product does not contain any chemicals known to State of California to cause cancer, birth defects, or any other reproductive harm.

16. OTHER INFORMATION

Full text of H-Statements referred to under sections 2 and 3.

Eye Irrit.	Eye irritation
H315	Causes skin irritation.
H319	Causes serious eye irritation.

H335	May cause respiratory irritation.
Skin Irrit.	Skin irritation
STOT SE	Specific target organ toxicity - single exposure

HMIS Rating

Health hazard:	2
Chronic Health Hazard:	
Flammability:	0
Physical Hazard	0

NFPA Rating

Health hazard:	2
Fire Hazard:	0
Reactivity Hazard:	0

Further information

The above information is believed to be correct but does not purport to be all inclusive and shall be used only as a guide. The information in this document is based on the present state of our knowledge and is applicable to the product with regard to appropriate safety precautions. It does not represent any guarantee of the properties of the product. Sigma-Aldrich Corporation and its Affiliates shall not be held liable for any damage resulting from handling or from contact with the above product. See www.sigma-aldrich.com and/or the reverse side of invoice or packing slip for additional terms and conditions of sale.

Preparation Information

Sigma-Aldrich Corporation
Product Safety – Americas Region
1-800-521-8956

Version: 4.4 Revision Date: 06/27/2014 Print Date: 04/06/2015

SAFETY DATA SHEET

Version 3.7
Revision Date 06/25/2014
Print Date 04/06/2015

1. PRODUCT AND COMPANY IDENTIFICATION

1.1 Product identifiers

Product name : Sodium citrate dihydrate

Product Number : W302600
Brand : Aldrich

CAS-No. : 6132-04-3

1.2 Relevant identified uses of the substance or mixture and uses advised against

Identified uses : Laboratory chemicals, Manufacture of substances

1.3 Details of the supplier of the safety data sheet

Company : Sigma-Aldrich
3050 Spruce Street
SAINT LOUIS MO 63103
USA

Telephone : +1 800-325-5832
Fax : +1 800-325-5052

1.4 Emergency telephone number

Emergency Phone # : (314) 776-6555

2. HAZARDS IDENTIFICATION

2.1 Classification of the substance or mixture

Not a hazardous substance or mixture.

2.2 GHS Label elements, including precautionary statements

Not a hazardous substance or mixture.

2.3 Hazards not otherwise classified (HNOC) or not covered by GHS - none

3. COMPOSITION/INFORMATION ON INGREDIENTS

3.1 Substances

Synonyms : Sodium citrate tribasicdihydrate
Trisodium citratedihydrate
Citric acidtrisodium saltdihydrate

Formula : $C_6H_5Na_3O_7$ Â· $2H_2O$
Molecular Weight : 294.1 g/mol
CAS-No. : 6132-04-3
EC-No. : 200-675-3

No ingredients are hazardous according to OSHA criteria.
No components need to be disclosed according to the applicable regulations.

4. FIRST AID MEASURES

4.1 Description of first aid measures

If inhaled
If breathed in, move person into fresh air. If not breathing, give artificial respiration.

In case of skin contact
Wash off with soap and plenty of water.

In case of eye contact
Flush eyes with water as a precaution.

If swallowed
Never give anything by mouth to an unconscious person. Rinse mouth with water.

4.2 Most important symptoms and effects, both acute and delayed
The most important known symptoms and effects are described in the labelling (see section 2.2) and/or in section 11

4.3 Indication of any immediate medical attention and special treatment needed
no data available

5. FIREFIGHTING MEASURES

5.1 Extinguishing media

Suitable extinguishing media
Use water spray, alcohol-resistant foam, dry chemical or carbon dioxide.

5.2 Special hazards arising from the substance or mixture
Carbon oxides, Sodium oxides

5.3 Advice for firefighters
Wear self contained breathing apparatus for fire fighting if necessary.

5.4 Further information
no data available

6. ACCIDENTAL RELEASE MEASURES

6.1 Personal precautions, protective equipment and emergency procedures
Avoid dust formation. Avoid breathing vapours, mist or gas.
For personal protection see section 8.

6.2 Environmental precautions
Do not let product enter drains.

6.3 Methods and materials for containment and cleaning up
Sweep up and shovel. Keep in suitable, closed containers for disposal.

6.4 Reference to other sections
For disposal see section 13.

7. HANDLING AND STORAGE

7.1 Precautions for safe handling
Provide appropriate exhaust ventilation at places where dust is formed.
For precautions see section 2.2.

7.2 Conditions for safe storage, including any incompatibilities
Keep container tightly closed in a dry and well-ventilated place.

Keep in a dry place.

7.3 Specific end use(s)
Apart from the uses mentioned in section 1.2 no other specific uses are stipulated

8. EXPOSURE CONTROLS/PERSONAL PROTECTION

8.1 Control parameters

Components with workplace control parameters
Contains no substances with occupational exposure limit values.

8.2 Exposure controls

Appropriate engineering controls
General industrial hygiene practice.

Personal protective equipment

Eye/face protection
Use equipment for eye protection tested and approved under appropriate government standards such as NIOSH (US) or EN 166(EU).

Skin protection
Handle with gloves. Gloves must be inspected prior to use. Use proper glove removal technique (without touching glove's outer surface) to avoid skin contact with this product. Dispose of contaminated gloves after use in accordance with applicable laws and good laboratory practices. Wash and dry hands.

Full contact
Material: Nitrile rubber
Minimum layer thickness: 0.11 mm
Break through time: 480 min
Material tested:Dermatril® (KCL 740 / Aldrich Z677272, Size M)

Splash contact
Material: Nitrile rubber
Minimum layer thickness: 0.11 mm
Break through time: 480 min
Material tested:Dermatril® (KCL 740 / Aldrich Z677272, Size M)

data source: KCL GmbH, D-36124 Eichenzell, phone +49 (0)6659 87300, e-mail sales@kcl.de, test method: EN374
If used in solution, or mixed with other substances, and under conditions which differ from EN 374, contact the supplier of the CE approved gloves. This recommendation is advisory only and must be evaluated by an industrial hygienist and safety officer familiar with the specific situation of anticipated use by our customers. It should not be construed as offering an approval for any specific use scenario.

Body Protection
Choose body protection in relation to its type, to the concentration and amount of dangerous substances, and to the specific work-place., The type of protective equipment must be selected according to the concentration and amount of the dangerous substance at the specific workplace.

Respiratory protection
Respiratory protection is not required. Where protection from nuisance levels of dusts are desired, use type N95 (US) or type P1 (EN 143) dust masks. Use respirators and components tested and approved under appropriate government standards such as NIOSH (US) or CEN (EU).

Control of environmental exposure
Do not let product enter drains.

9. PHYSICAL AND CHEMICAL PROPERTIES

9.1 Information on basic physical and chemical properties

a)	Appearance	Form: powder Colour: white
b)	Odour	no data available
c)	Odour Threshold	no data available
d)	pH	7.5 - 9 at 29.4 g/l at 25 °C (77 °F)
e)	Melting point/freezing point	Melting point/range: > 300 °C (> 572 °F) - lit.
f)	Initial boiling point and boiling range	309.6 °C (589.3 °F) at 1,013 hPa (760 mmHg)
g)	Flash point	no data available
h)	Evapouration rate	no data available
i)	Flammability (solid, gas)	no data available
j)	Upper/lower flammability or	no data available

	explosive limits	
k)	Vapour pressure	no data available
l)	Vapour density	no data available
m)	Relative density	no data available
n)	Water solubility	29.4 g/l at 20 °C (68 °F) - completely soluble
o)	Partition coefficient: n-octanol/water	no data available
p)	Auto-ignition temperature	no data available
q)	Decomposition temperature	no data available
r)	Viscosity	no data available
s)	Explosive properties	no data available
t)	Oxidizing properties	no data available

9.2 Other safety information
no data available

10. STABILITY AND REACTIVITY

10.1 Reactivity
no data available

10.2 Chemical stability
Stable under recommended storage conditions.

10.3 Possibility of hazardous reactions
no data available

10.4 Conditions to avoid
no data available

10.5 Incompatible materials
Strong oxidizing agents

10.6 Hazardous decomposition products
Other decomposition products - no data available
In the event of fire: see section 5

11. TOXICOLOGICAL INFORMATION

11.1 Information on toxicological effects

Acute toxicity
no data available

Inhalation: no data available

Dermal: no data available

no data available

Skin corrosion/irritation
no data available

Serious eye damage/eye irritation
no data available

Respiratory or skin sensitisation
no data available

Germ cell mutagenicity
no data available

Carcinogenicity

IARC: No component of this product present at levels greater than or equal to 0.1% is identified as probable, possible or confirmed human carcinogen by IARC.

ACGIH: No component of this product present at levels greater than or equal to 0.1% is identified as a carcinogen or potential carcinogen by ACGIH.

NTP: No component of this product present at levels greater than or equal to 0.1% is identified as a known or anticipated carcinogen by NTP.

OSHA: No component of this product present at levels greater than or equal to 0.1% is identified as a carcinogen or potential carcinogen by OSHA.

Reproductive toxicity
no data available

no data available

Specific target organ toxicity - single exposure
no data available

Specific target organ toxicity - repeated exposure
no data available

Aspiration hazard
no data available

Additional Information
RTECS: Not available

To the best of our knowledge, the chemical, physical, and toxicological properties have not been thoroughly investigated.

12. ECOLOGICAL INFORMATION

12.1 Toxicity
no data available

12.2 Persistence and degradability
no data available

12.3 Bioaccumulative potential
no data available

12.4 Mobility in soil
no data available

12.5 Results of PBT and vPvB assessment
PBT/vPvB assessment not available as chemical safety assessment not required/not conducted

12.6 Other adverse effects

no data available

13. DISPOSAL CONSIDERATIONS

13.1 Waste treatment methods

Product
Offer surplus and non-recyclable solutions to a licensed disposal company.

Contaminated packaging
Dispose of as unused product.

14. TRANSPORT INFORMATION

DOT (US)
Not dangerous goods

IMDG

Not dangerous goods

IATA
Not dangerous goods

15. REGULATORY INFORMATION

SARA 302 Components
SARA 302: No chemicals in this material are subject to the reporting requirements of SARA Title III, Section 302.

SARA 313 Components
SARA 313: This material does not contain any chemical components with known CAS numbers that exceed the threshold (De Minimis) reporting levels established by SARA Title III, Section 313.

SARA 311/312 Hazards
No SARA Hazards

Massachusetts Right To Know Components
No components are subject to the Massachusetts Right to Know Act.

Pennsylvania Right To Know Components

	CAS-No.	Revision Date
Trisodium citrate	6132-04-3	

New Jersey Right To Know Components

	CAS-No.	Revision Date
Trisodium citrate	6132-04-3	

California Prop. 65 Components
This product does not contain any chemicals known to State of California to cause cancer, birth defects, or any other reproductive harm.

16. OTHER INFORMATION

HMIS Rating

Health hazard:	0
Chronic Health Hazard:	
Flammability:	0
Physical Hazard	0

NFPA Rating

Health hazard:	0
Fire Hazard:	0
Reactivity Hazard:	0

Further information

The above information is believed to be correct but does not purport to be all inclusive and shall be used only as a guide. The information in this document is based on the present state of our knowledge and is applicable to the product with regard to appropriate safety precautions. It does not represent any guarantee of the properties of the product. Sigma-Aldrich Corporation and its Affiliates shall not be held liable for any damage resulting from handling or from contact with the above product. See www.sigma-aldrich.com and/or the reverse side of invoice or packing slip for additional terms and conditions of sale.

Preparation Information
Sigma-Aldrich Corporation
Product Safety – Americas Region
1-800-521-8956

Version: 3.7 Revision Date: 06/25/2014 Print Date: 04/06/2015

SAFETY DATA SHEET

Version 4.4
Revision Date 07/09/2014
Print Date 04/06/2015

1. PRODUCT AND COMPANY IDENTIFICATION

1.1 Product identifiers

Product name : Barium chloride

Product Number : 342920
Brand : Aldrich
Index-No. : 056-004-00-8

CAS-No. : 10361-37-2

1.2 Relevant identified uses of the substance or mixture and uses advised against

Identified uses : Laboratory chemicals, Manufacture of substances

1.3 Details of the supplier of the safety data sheet

Company : Sigma-Aldrich
3050 Spruce Street
SAINT LOUIS MO 63103
USA

Telephone : +1 800-325-5832
Fax : +1 800-325-5052

1.4 Emergency telephone number

Emergency Phone # : (314) 776-6555

2. HAZARDS IDENTIFICATION

2.1 Classification of the substance or mixture

GHS Classification in accordance with 29 CFR 1910 (OSHA HCS)
Acute toxicity, Oral (Category 3), H301
Acute toxicity, Inhalation (Category 4), H332
Eye irritation (Category 2A), H319

For the full text of the H-Statements mentioned in this Section, see Section 16.

2.2 GHS Label elements, including precautionary statements

Pictogram

Signal word Danger

Hazard statement(s)
H301 Toxic if swallowed.
H319 Causes serious eye irritation.
H332 Harmful if inhaled.

Precautionary statement(s)
P261 Avoid breathing dust/ fume/ gas/ mist/ vapours/ spray.
P264 Wash skin thoroughly after handling.
P270 Do not eat, drink or smoke when using this product.
P271 Use only outdoors or in a well-ventilated area.
P280 Wear protective gloves/ eye protection/ face protection.
P301 + P310 IF SWALLOWED: Immediately call a POISON CENTER or doctor/ physician.

P304 + P340	IF INHALED: Remove victim to fresh air and keep at rest in a position comfortable for breathing.
P305 + P351 + P338	IF IN EYES: Rinse cautiously with water for several minutes. Remove contact lenses, if present and easy to do. Continue rinsing.
P312	Call a POISON CENTER or doctor/ physician if you feel unwell.
P321	Specific treatment (see supplemental first aid instructions on this label).
P330	Rinse mouth.
P337 + P313	If eye irritation persists: Get medical advice/ attention.
P405	Store locked up.
P501	Dispose of contents/ container to an approved waste disposal plant.

2.3 Hazards not otherwise classified (HNOC) or not covered by GHS - none

3. COMPOSITION/INFORMATION ON INGREDIENTS

3.1 Substances

Formula	:	$BaCl_2$
Molecular Weight	:	208.23 g/mol
CAS-No.	:	10361-37-2
EC-No.	:	233-788-1
Index-No.	:	056-004-00-8

Hazardous components

Component	Classification	Concentration
Barium chloride		
	Acute Tox. 3; Acute Tox. 4; Eye Irrit. 2A; H301, H319, H332	90 - 100 %

For the full text of the H-Statements mentioned in this Section, see Section 16.

4. FIRST AID MEASURES

4.1 Description of first aid measures

General advice
Consult a physician. Show this safety data sheet to the doctor in attendance.Move out of dangerous area.

If inhaled
If breathed in, move person into fresh air. If not breathing, give artificial respiration. Consult a physician.

In case of skin contact
Wash off with soap and plenty of water. Take victim immediately to hospital. Consult a physician.

In case of eye contact
Rinse thoroughly with plenty of water for at least 15 minutes and consult a physician.

If swallowed
Never give anything by mouth to an unconscious person. Rinse mouth with water. Consult a physician.

4.2 Most important symptoms and effects, both acute and delayed
The most important known symptoms and effects are described in the labelling (see section 2.2) and/or in section 11

4.3 Indication of any immediate medical attention and special treatment needed
no data available

5. FIREFIGHTING MEASURES

5.1 Extinguishing media

Suitable extinguishing media
Use water spray, alcohol-resistant foam, dry chemical or carbon dioxide.

5.2 Special hazards arising from the substance or mixture
Hydrogen chloride gas, Barium oxide

5.3 Advice for firefighters
Wear self contained breathing apparatus for fire fighting if necessary.

5.4 Further information
no data available

6. ACCIDENTAL RELEASE MEASURES

6.1 Personal precautions, protective equipment and emergency procedures
Wear respiratory protection. Avoid dust formation. Avoid breathing vapours, mist or gas. Ensure adequate ventilation. Evacuate personnel to safe areas. Avoid breathing dust.
For personal protection see section 8.

6.2 Environmental precautions
Prevent further leakage or spillage if safe to do so. Do not let product enter drains.

6.3 Methods and materials for containment and cleaning up
Pick up and arrange disposal without creating dust. Sweep up and shovel. Keep in suitable, closed containers for disposal.

6.4 Reference to other sections
For disposal see section 13.

7. HANDLING AND STORAGE

7.1 Precautions for safe handling
Further processing of solid materials may result in the formation of combustible dusts. The potential for combustible dust formation should be taken into consideration before additional processing occurs.Avoid contact with skin and eyes. Avoid formation of dust and aerosols.
Provide appropriate exhaust ventilation at places where dust is formed.
For precautions see section 2.2.

7.2 Conditions for safe storage, including any incompatibilities
Keep container tightly closed in a dry and well-ventilated place.

Hygroscopic. Keep in a dry place.

7.3 Specific end use(s)
Apart from the uses mentioned in section 1.2 no other specific uses are stipulated

8. EXPOSURE CONTROLS/PERSONAL PROTECTION

8.1 Control parameters

Components with workplace control parameters

Component	CAS-No.	Value	Control parameters	Basis
Barium chloride	10361-37-2	TWA	0.5 mg/m3	USA. NIOSH Recommended Exposure Limits
		TWA	0.5 mg/m3	USA. Occupational Exposure Limits (OSHA) - Table Z-1 Limits for Air Contaminants
		TWA	0.5 mg/m3	USA. ACGIH Threshold Limit Values (TLV)
	Remarks	Eye, skin, & Gastrointestinal irritation Muscular stimulation Not classifiable as a human carcinogen		
		TWA	0.5 mg/m3	USA. OSHA - TABLE Z-1 Limits for Air Contaminants - 1910.1000

8.2 Exposure controls

Appropriate engineering controls
Avoid contact with skin, eyes and clothing. Wash hands before breaks and immediately after handling the product.

Personal protective equipment

Eye/face protection
Face shield and safety glasses Use equipment for eye protection tested and approved under appropriate government standards such as NIOSH (US) or EN 166(EU).

Skin protection
Handle with gloves. Gloves must be inspected prior to use. Use proper glove removal technique (without touching glove's outer surface) to avoid skin contact with this product. Dispose of contaminated gloves after use in accordance with applicable laws and good laboratory practices. Wash and dry hands.

Full contact
Material: Nitrile rubber
Minimum layer thickness: 0.11 mm
Break through time: 480 min
Material tested:Dermatril® (KCL 740 / Aldrich Z677272, Size M)

Splash contact
Material: Nitrile rubber
Minimum layer thickness: 0.11 mm
Break through time: 480 min
Material tested:Dermatril® (KCL 740 / Aldrich Z677272, Size M)

data source: KCL GmbH, D-36124 Eichenzell, phone +49 (0)6659 87300, e-mail sales@kcl.de, test method: EN374
If used in solution, or mixed with other substances, and under conditions which differ from EN 374, contact the supplier of the CE approved gloves. This recommendation is advisory only and must be evaluated by an industrial hygienist and safety officer familiar with the specific situation of anticipated use by our customers. It should not be construed as offering an approval for any specific use scenario.

Body Protection
Complete suit protecting against chemicals, The type of protective equipment must be selected according to the concentration and amount of the dangerous substance at the specific workplace.

Respiratory protection
Where risk assessment shows air-purifying respirators are appropriate use a full-face particle respirator type N99 (US) or type P2 (EN 143) respirator cartridges as a backup to engineering controls. If the respirator is the sole means of protection, use a full-face supplied air respirator. Use respirators and components tested and approved under appropriate government standards such as NIOSH (US) or CEN (EU).

Control of environmental exposure
Prevent further leakage or spillage if safe to do so. Do not let product enter drains.

9. PHYSICAL AND CHEMICAL PROPERTIES

9.1 Information on basic physical and chemical properties

a)	Appearance	Form: powder Colour: white
b)	Odour	odourless
c)	Odour Threshold	no data available
d)	pH	no data available
e)	Melting point/freezing point	Melting point/range: 963 °C (1,765 °F) - lit.
f)	Initial boiling point and boiling range	1,560 °C (2,840 °F) at ca.1,013.25 hPa (760.00 mmHg)
g)	Flash point	not applicable
h)	Evapouration rate	no data available
i)	Flammability (solid, gas)	no data available
j)	Upper/lower flammability or	no data available

	explosive limits	
k)	Vapour pressure	no data available
l)	Vapour density	no data available
m)	Relative density	3.856 g/cm3 at 25 °C (77 °F)
n)	Water solubility	370 g/l at 25 °C (77 °F) - soluble
o)	Partition coefficient: n-octanol/water	no data available
p)	Auto-ignition temperature	no data available
q)	Decomposition temperature	no data available
r)	Viscosity	no data available
s)	Explosive properties	no data available
t)	Oxidizing properties	no data available

9.2 Other safety information
no data available

10. STABILITY AND REACTIVITY

10.1 Reactivity
no data available

10.2 Chemical stability
Stable under recommended storage conditions.

10.3 Possibility of hazardous reactions
no data available

10.4 Conditions to avoid
no data available

10.5 Incompatible materials
Strong oxidizing agents

10.6 Hazardous decomposition products
Other decomposition products - no data available
In the event of fire: see section 5

11. TOXICOLOGICAL INFORMATION

11.1 Information on toxicological effects

Acute toxicity
LD50 Oral - rat - male and female - 100 - 300 mg/kg
(OECD Test Guideline 401)

Inhalation: no data available

Dermal: no data available

no data available

Skin corrosion/irritation
no data available

Serious eye damage/eye irritation
no data available

Respiratory or skin sensitisation
no data available

Germ cell mutagenicity
Ames test
S. typhimurium
Result: negative

Carcinogenicity

This product is or contains a component that is not classifiable as to its carcinogenicity based on its IARC, ACGIH, NTP, or EPA classification.

IARC: No component of this product present at levels greater than or equal to 0.1% is identified as probable, possible or confirmed human carcinogen by IARC.

NTP: No component of this product present at levels greater than or equal to 0.1% is identified as a known or anticipated carcinogen by NTP.

OSHA: No component of this product present at levels greater than or equal to 0.1% is identified as a carcinogen or potential carcinogen by OSHA.

Reproductive toxicity

Reproductive toxicity - rat - Intratesticular
Paternal Effects: Testes, epididymis, sperm duct.

Specific target organ toxicity - single exposure
no data available

Specific target organ toxicity - repeated exposure
no data available

Aspiration hazard
no data available

Additional Information

Repeated dose toxicity - rat - male and female - Oral - No observed adverse effect level - 209 mg/kg
RTECS: CQ8750000

Vomiting, To the best of our knowledge, the chemical, physical, and toxicological properties have not been thoroughly investigated.

Stomach - Irregularities - Based on Human Evidence
Stomach - Irregularities - Based on Human Evidence

12. ECOLOGICAL INFORMATION

12.1 Toxicity

Toxicity to fish	static test LC50 - Danio rerio (zebra fish) - > 174 mg/l - 96 h (OECD Test Guideline 203)
Toxicity to daphnia and other aquatic invertebrates	EC50 - Daphnia magna (Water flea) - 14.5 mg/l - 48 h
Toxicity to algae	Growth inhibition EC50 - Pseudokirchneriella subcapitata (green algae) - > 100 mg/l - 72 h (OECD Test Guideline 201)
Toxicity to bacteria	Respiration inhibition EC50 - Sludge Treatment - > 1,000 mg/l - 3 h (OECD Test Guideline 209)

12.2 Persistence and degradability
no data available

12.3 Bioaccumulative potential
no data available

12.4 Mobility in soil
no data available

12.5 Results of PBT and vPvB assessment

PBT/vPvB assessment not available as chemical safety assessment not required/not conducted

12.6 Other adverse effects

no data available

13. DISPOSAL CONSIDERATIONS

13.1 Waste treatment methods

Product

Offer surplus and non-recyclable solutions to a licensed disposal company. Contact a licensed professional waste disposal service to dispose of this material. Dissolve or mix the material with a combustible solvent and burn in a chemical incinerator equipped with an afterburner and scrubber.

Contaminated packaging

Dispose of as unused product.

14. TRANSPORT INFORMATION

DOT (US)

UN number: 1564 Class: 6.1 Packing group: III
Proper shipping name: Barium compounds, n.o.s. (Barium chloride)
Reportable Quantity (RQ):
Marine pollutant: No
Poison Inhalation Hazard: No

IMDG

UN number: 1564 Class: 6.1 Packing group: III EMS-No: F-A, S-A
Proper shipping name: BARIUM COMPOUND, N.O.S. (Barium chloride)
Marine pollutant: No

IATA

UN number: 1564 Class: 6.1 Packing group: III
Proper shipping name: Barium compound, n.o.s. (Barium chloride)

15. REGULATORY INFORMATION

SARA 302 Components

SARA 302: No chemicals in this material are subject to the reporting requirements of SARA Title III, Section 302.

SARA 313 Components

The following components are subject to reporting levels established by SARA Title III, Section 313:

	CAS-No.	Revision Date
Barium chloride	10361-37-2	2007-07-01

SARA 311/312 Hazards

Acute Health Hazard, Chronic Health Hazard

Massachusetts Right To Know Components

No components are subject to the Massachusetts Right to Know Act.

Pennsylvania Right To Know Components

	CAS-No.	Revision Date
Barium chloride	10361-37-2	2007-07-01

New Jersey Right To Know Components

	CAS-No.	Revision Date
Barium chloride	10361-37-2	2007-07-01

California Prop. 65 Components

This product does not contain any chemicals known to State of California to cause cancer, birth defects, or any other reproductive harm.

16. OTHER INFORMATION

Full text of H-Statements referred to under sections 2 and 3.

Acute Tox.	Acute toxicity
Eye Irrit.	Eye irritation
H301	Toxic if swallowed.
H319	Causes serious eye irritation.
H332	Harmful if inhaled.

HMIS Rating

Health hazard:	2
Chronic Health Hazard:	*
Flammability:	0
Physical Hazard	0

NFPA Rating

Health hazard:	2
Fire Hazard:	0
Reactivity Hazard:	0

Further information

The above information is believed to be correct but does not purport to be all inclusive and shall be used only as a guide. The information in this document is based on the present state of our knowledge and is applicable to the product with regard to appropriate safety precautions. It does not represent any guarantee of the properties of the product. Sigma-Aldrich Corporation and its Affiliates shall not be held liable for any damage resulting from handling or from contact with the above product. See www.sigma-aldrich.com and/or the reverse side of invoice or packing slip for additional terms and conditions of sale.

Preparation Information

Sigma-Aldrich Corporation
Product Safety – Americas Region
1-800-521-8956

Version: 4.4 Revision Date: 07/09/2014 Print Date: 04/06/2015

SAFETY DATA SHEET

Version 5.2
Revision Date 11/12/2014
Print Date 04/06/2015

1. PRODUCT AND COMPANY IDENTIFICATION

1.1 Product identifiers

Product name : Sodium chloride

Product Number : RES0926S-A7
Brand : Sigma

CAS-No. : 7647-14-5

1.2 Relevant identified uses of the substance or mixture and uses advised against

Identified uses : Laboratory chemicals, Manufacture of substances

1.3 Details of the supplier of the safety data sheet

Company : Sigma-Aldrich
3050 Spruce Street
SAINT LOUIS MO 63103
USA

Telephone : +1 800-325-5832
Fax : +1 800-325-5052

1.4 Emergency telephone number

Emergency Phone # : (314) 776-6555

2. HAZARDS IDENTIFICATION

2.1 Classification of the substance or mixture

Not a hazardous substance or mixture.

2.2 GHS Label elements, including precautionary statements

Not a hazardous substance or mixture.

2.3 Hazards not otherwise classified (HNOC) or not covered by GHS - none

3. COMPOSITION/INFORMATION ON INGREDIENTS

3.1 Substances

Formula : NaCl
Molecular weight : 58.44 g/mol
CAS-No. : 7647-14-5
EC-No. : 231-598-3

No components need to be disclosed according to the applicable regulations.

4. FIRST AID MEASURES

4.1 Description of first aid measures

If inhaled
If breathed in, move person into fresh air. If not breathing, give artificial respiration.

In case of skin contact
Wash off with soap and plenty of water.

In case of eye contact
Flush eyes with water as a precaution.

If swallowed
Never give anything by mouth to an unconscious person. Rinse mouth with water.

4.2 Most important symptoms and effects, both acute and delayed
The most important known symptoms and effects are described in the labelling (see section 2.2) and/or in section 11

4.3 Indication of any immediate medical attention and special treatment needed
No data available

5. FIREFIGHTING MEASURES

5.1 Extinguishing media

Suitable extinguishing media
Use water spray, alcohol-resistant foam, dry chemical or carbon dioxide.

5.2 Special hazards arising from the substance or mixture
Hydrogen chloride gas, Sodium oxides

5.3 Advice for firefighters
Wear self-contained breathing apparatus for firefighting if necessary.

5.4 Further information
No data available

6. ACCIDENTAL RELEASE MEASURES

6.1 Personal precautions, protective equipment and emergency procedures
Avoid dust formation. Avoid breathing vapours, mist or gas.
For personal protection see section 8.

6.2 Environmental precautions
Do not let product enter drains.

6.3 Methods and materials for containment and cleaning up
Sweep up and shovel. Keep in suitable, closed containers for disposal.

6.4 Reference to other sections
For disposal see section 13.

7. HANDLING AND STORAGE

7.1 Precautions for safe handling
Further processing of solid materials may result in the formation of combustible dusts. The potential for combustible dust formation should be taken into consideration before additional processing occurs.
Provide appropriate exhaust ventilation at places where dust is formed.
For precautions see section 2.2.

7.2 Conditions for safe storage, including any incompatibilities
Keep container tightly closed in a dry and well-ventilated place.

7.3 Specific end use(s)
Apart from the uses mentioned in section 1.2 no other specific uses are stipulated

8. EXPOSURE CONTROLS/PERSONAL PROTECTION

8.1 Control parameters

Components with workplace control parameters
Contains no substances with occupational exposure limit values.

8.2 Exposure controls

Appropriate engineering controls
General industrial hygiene practice.

Personal protective equipment

Eye/face protection
Use equipment for eye protection tested and approved under appropriate government standards such as NIOSH (US) or EN 166(EU).

Skin protection
Handle with gloves. Gloves must be inspected prior to use. Use proper glove removal technique (without touching glove's outer surface) to avoid skin contact with this product. Dispose of contaminated gloves after use in accordance with applicable laws and good laboratory practices. Wash and dry hands.

Full contact
Material: Nitrile rubber
Minimum layer thickness: 0.11 mm
Break through time: 480 min
Material tested:Dermatril® (KCL 740 / Aldrich Z677272, Size M)

Splash contact
Material: Nitrile rubber
Minimum layer thickness: 0.11 mm
Break through time: 480 min
Material tested:Dermatril® (KCL 740 / Aldrich Z677272, Size M)

data source: KCL GmbH, D-36124 Eichenzell, phone +49 (0)6659 87300, e-mail sales@kcl.de, test method: EN374
If used in solution, or mixed with other substances, and under conditions which differ from EN 374, contact the supplier of the CE approved gloves. This recommendation is advisory only and must be evaluated by an industrial hygienist and safety officer familiar with the specific situation of anticipated use by our customers. It should not be construed as offering an approval for any specific use scenario.

Body Protection
Choose body protection in relation to its type, to the concentration and amount of dangerous substances, and to the specific work-place., The type of protective equipment must be selected according to the concentration and amount of the dangerous substance at the specific workplace.

Respiratory protection
Respiratory protection is not required. Where protection from nuisance levels of dusts are desired, use type N95 (US) or type P1 (EN 143) dust masks. Use respirators and components tested and approved under appropriate government standards such as NIOSH (US) or CEN (EU).

Control of environmental exposure
Do not let product enter drains.

9. PHYSICAL AND CHEMICAL PROPERTIES

9.1 Information on basic physical and chemical properties

a)	Appearance	Form: solid Colour: colourless
b)	Odour	No data available
c)	Odour Threshold	No data available
d)	pH	7
e)	Melting point/freezing point	801 °C (1,474 °F)
f)	Initial boiling point and boiling range	1,413 °C (2,575 °F)
g)	Flash point	No data available
h)	Evaporation rate	No data available
i)	Flammability (solid, gas)	No data available
j)	Upper/lower flammability or	No data available

	explosive limits	
k)	Vapour pressure	1.33 hPa (1.00 mmHg) at 865 °C (1,589 °F)
l)	Vapour density	No data available
m)	Relative density	2.1650 g/cm3
n)	Water solubility	358 g/l at 20 °C (68 °F) - soluble
o)	Partition coefficient: n-octanol/water	No data available
p)	Auto-ignition temperature	No data available
q)	Decomposition temperature	No data available
r)	Viscosity	No data available
s)	Explosive properties	No data available
t)	Oxidizing properties	No data available

9.2 Other safety information
No data available

10. STABILITY AND REACTIVITY

10.1 Reactivity
No data available

10.2 Chemical stability
Stable under recommended storage conditions.

10.3 Possibility of hazardous reactions
No data available

10.4 Conditions to avoid
No data available

10.5 Incompatible materials
Strong oxidizing agents

10.6 Hazardous decomposition products
Other decomposition products - No data available
In the event of fire: see section 5

11. TOXICOLOGICAL INFORMATION

11.1 Information on toxicological effects

Acute toxicity
LD50 Oral - Rat - 3,550 mg/kg

LC50 Inhalation - Rat - 1 h - > 42,000 mg/m3

LD50 Dermal - Rabbit - > 10,000 mg/kg

No data available

Skin corrosion/irritation
No data available

Serious eye damage/eye irritation
No data available

Respiratory or skin sensitisation
No data available

Germ cell mutagenicity
No data available

Carcinogenicity

IARC: No component of this product present at levels greater than or equal to 0.1% is identified as probable, possible or confirmed human carcinogen by IARC.

ACGIH: No component of this product present at levels greater than or equal to 0.1% is identified as a carcinogen or potential carcinogen by ACGIH.

NTP: No component of this product present at levels greater than or equal to 0.1% is identified as a known or anticipated carcinogen by NTP.

OSHA: No component of this product present at levels greater than or equal to 0.1% is identified as a carcinogen or potential carcinogen by OSHA.

Reproductive toxicity
No data available

No data available

Specific target organ toxicity - single exposure
No data available

Specific target organ toxicity - repeated exposure
No data available

Aspiration hazard
No data available

Additional Information
RTECS: VZ4725000

Vomiting, Diarrhoea, Dehydration and congestion may occur in internal organs. Hypertonic salt solutions can produce inflammatory reactions in the gastrointestinal tract.

12. ECOLOGICAL INFORMATION

12.1 Toxicity

Toxicity to fish	LC50 - Lepomis macrochirus (Bluegill) - 5,840 mg/l - 96 h
Toxicity to daphnia and other aquatic invertebrates	NOEC - Daphnia (water flea) - 1,500 mg/l - 7 d
	LC50 - Daphnia magna (Water flea) - 1,661 mg/l - 48 h

12.2 Persistence and degradability
No data available

12.3 Bioaccumulative potential
No data available

12.4 Mobility in soil
No data available

12.5 Results of PBT and vPvB assessment
PBT/vPvB assessment not available as chemical safety assessment not required/not conducted

12.6 Other adverse effects

No data available

13. DISPOSAL CONSIDERATIONS

13.1 Waste treatment methods

Product
Offer surplus and non-recyclable solutions to a licensed disposal company.

Contaminated packaging
Dispose of as unused product.

14. TRANSPORT INFORMATION

DOT (US)
Not dangerous goods

IMDG
Not dangerous goods

IATA
Not dangerous goods

15. REGULATORY INFORMATION

SARA 302 Components
No chemicals in this material are subject to the reporting requirements of SARA Title III, Section 302.

SARA 313 Components
This material does not contain any chemical components with known CAS numbers that exceed the threshold (De Minimis) reporting levels established by SARA Title III, Section 313.

SARA 311/312 Hazards
No SARA Hazards

Massachusetts Right To Know Components
No components are subject to the Massachusetts Right to Know Act.

Pennsylvania Right To Know Components

	CAS-No.	Revision Date
Sodium chloride	7647-14-5	

New Jersey Right To Know Components

	CAS-No.	Revision Date
Sodium chloride	7647-14-5	

California Prop. 65 Components
This product does not contain any chemicals known to State of California to cause cancer, birth defects, or any other reproductive harm.

16. OTHER INFORMATION

HMIS Rating

Health hazard:	1
Chronic Health Hazard:	
Flammability:	0
Physical Hazard	0

NFPA Rating

Health hazard:	1
Fire Hazard:	0
Reactivity Hazard:	0

Further information

The above information is believed to be correct but does not purport to be all inclusive and shall be used only as a guide. The information in this document is based on the present state of our knowledge and is applicable to the product with regard to appropriate safety precautions. It does not represent any guarantee of the properties of the product. Sigma-Aldrich Corporation and its Affiliates shall not be held liable for any damage resulting from handling or from contact with the above product. See www.sigma-aldrich.com and/or the reverse side of invoice or packing slip for additional terms and conditions of sale.

Preparation Information
Sigma-Aldrich Corporation
Product Safety – Americas Region
1-800-521-8956

Version: 5.2 Revision Date: 11/12/2014 Print Date: 04/06/2015

SAFETY DATA SHEET

Version 5.0
Revision Date 05/01/2014
Print Date 04/06/2015

1. PRODUCT AND COMPANY IDENTIFICATION

1.1 Product identifiers

Product name : Ammonium sulfate, NF Grade

Product Number : RES1427A-A7
Brand : Sigma
REACH No. : A registration number is not available for this substance as the substance or its uses are exempted from registration, the annual tonnage does not require a registration or the registration is envisaged for a later registration deadline.
CAS-No. : 7783-20-2

1.2 Relevant identified uses of the substance or mixture and uses advised against

Identified uses : Laboratory chemicals, Manufacture of substances

1.3 Details of the supplier of the safety data sheet

Company : Sigma-Aldrich
3050 Spruce Street
SAINT LOUIS MO 63103
USA

Telephone : +1 800-325-5832
Fax : +1 800-325-5052

1.4 Emergency telephone number

Emergency Phone # : (314) 776-6555

2. HAZARDS IDENTIFICATION

2.1 Classification of the substance or mixture

GHS Classification in accordance with 29 CFR 1910 (OSHA HCS)
Acute aquatic toxicity (Category 3), H402
Chronic aquatic toxicity (Category 3), H412

For the full text of the H-Statements mentioned in this Section, see Section 16.

2.2 GHS Label elements, including precautionary statements

Pictogram none

Signal word none

Hazard statement(s)
H412 Harmful to aquatic life with long lasting effects.

Precautionary statement(s)
P273 Avoid release to the environment.
P501 Dispose of contents/ container to an approved waste disposal plant.

2.3 Hazards not otherwise classified (HNOC) or not covered by GHS - none

3. COMPOSITION/INFORMATION ON INGREDIENTS

3.1 Substances

Formula : H8N2O4S
Molecular Weight : 132.14 g/mol

CAS-No.	:	7783-20-2
EC-No.	:	231-984-1

No ingredients are hazardous according to OSHA criteria.
No components need to be disclosed according to the applicable regulations.
For the full text of the H-Statements mentioned in this Section, see Section 16.

4. FIRST AID MEASURES

4.1 Description of first aid measures

General advice
Consult a physician. Show this safety data sheet to the doctor in attendance.

If inhaled
If breathed in, move person into fresh air. If not breathing, give artificial respiration. Consult a physician.

In case of skin contact
Wash off with soap and plenty of water. Consult a physician.

In case of eye contact
Rinse thoroughly with plenty of water for at least 15 minutes and consult a physician.

If swallowed
Never give anything by mouth to an unconscious person. Rinse mouth with water. Consult a physician.

4.2 Most important symptoms and effects, both acute and delayed
The most important known symptoms and effects are described in the labelling (see section 2.2) and/or in section 11

4.3 Indication of any immediate medical attention and special treatment needed
no data available

5. FIREFIGHTING MEASURES

5.1 Extinguishing media

Suitable extinguishing media
Use water spray, alcohol-resistant foam, dry chemical or carbon dioxide.

5.2 Special hazards arising from the substance or mixture
nitrogen oxides (NOx), Sulphur oxides

5.3 Advice for firefighters
Wear self contained breathing apparatus for fire fighting if necessary.

5.4 Further information
no data available

6. ACCIDENTAL RELEASE MEASURES

6.1 Personal precautions, protective equipment and emergency procedures
Use personal protective equipment. Avoid dust formation. Avoid breathing vapours, mist or gas. Ensure adequate ventilation. Avoid breathing dust.
For personal protection see section 8.

6.2 Environmental precautions
Prevent further leakage or spillage if safe to do so. Do not let product enter drains. Discharge into the environment must be avoided.

6.3 Methods and materials for containment and cleaning up
Pick up and arrange disposal without creating dust. Sweep up and shovel. Keep in suitable, closed containers for disposal.

6.4 Reference to other sections
For disposal see section 13.

7. HANDLING AND STORAGE

7.1 Precautions for safe handling

Avoid contact with skin and eyes. Avoid formation of dust and aerosols.Further processing of solid materials may result in the formation of combustible dusts. The potential for combustible dust formation should be taken into consideration before additional processing occurs.
Provide appropriate exhaust ventilation at places where dust is formed.
For precautions see section 2.2.

7.2 Conditions for safe storage, including any incompatibilities

Keep container tightly closed in a dry and well-ventilated place.

7.3 Specific end use(s)

Apart from the uses mentioned in section 1.2 no other specific uses are stipulated

8. EXPOSURE CONTROLS/PERSONAL PROTECTION

8.1 Control parameters

Components with workplace control parameters
Contains no substances with occupational exposure limit values.

8.2 Exposure controls

Appropriate engineering controls
Handle in accordance with good industrial hygiene and safety practice. Wash hands before breaks and at the end of workday.

Personal protective equipment

Eye/face protection
Safety glasses with side-shields conforming to EN166 Use equipment for eye protection tested and approved under appropriate government standards such as NIOSH (US) or EN 166(EU).

Skin protection
Handle with gloves. Gloves must be inspected prior to use. Use proper glove removal technique (without touching glove's outer surface) to avoid skin contact with this product. Dispose of contaminated gloves after use in accordance with applicable laws and good laboratory practices. Wash and dry hands.

Body Protection
impervious clothing, The type of protective equipment must be selected according to the concentration and amount of the dangerous substance at the specific workplace.

Respiratory protection
For nuisance exposures use type P95 (US) or type P1 (EU EN 143) particle respirator.For higher level protection use type OV/AG/P99 (US) or type ABEK-P2 (EU EN 143) respirator cartridges. Use respirators and components tested and approved under appropriate government standards such as NIOSH (US) or CEN (EU).

Control of environmental exposure
Prevent further leakage or spillage if safe to do so. Do not let product enter drains. Discharge into the environment must be avoided.

9. PHYSICAL AND CHEMICAL PROPERTIES

9.1 Information on basic physical and chemical properties

a)	Appearance	Form: crystalline Colour: colourless
b)	Odour	no data available
c)	Odour Threshold	no data available
d)	pH	5.0 - 6 at 132 g/l at 25 °C (77 °F)
e)	Melting point/freezing point	> 280 °C (> 536 °F)
f)	Initial boiling point and boiling range	no data available

g)	Flash point	no data available
h)	Evapouration rate	no data available
i)	Flammability (solid, gas)	no data available
j)	Upper/lower flammability or explosive limits	no data available
k)	Vapour pressure	no data available
l)	Vapour density	no data available
m)	Relative density	1.770 g/cm3
n)	Water solubility	132 g/l at 20 °C (68 °F) - completely soluble
o)	Partition coefficient: n-octanol/water	log Pow: -5.1
p)	Auto-ignition temperature	no data available
q)	Decomposition temperature	no data available
r)	Viscosity	no data available
s)	Explosive properties	no data available
t)	Oxidizing properties	no data available

9.2 Other safety information
no data available

10. STABILITY AND REACTIVITY

10.1 Reactivity
no data available

10.2 Chemical stability
Stable under recommended storage conditions.

10.3 Possibility of hazardous reactions
no data available

10.4 Conditions to avoid
no data available

10.5 Incompatible materials
Strong oxidizing agents, Strong bases

10.6 Hazardous decomposition products
Other decomposition products - no data available
In the event of fire: see section 5

11. TOXICOLOGICAL INFORMATION

11.1 Information on toxicological effects

Acute toxicity
no data available

Inhalation: no data available

Dermal: no data available

no data available

Skin corrosion/irritation
Skin - rabbit
Result: No skin irritation

Skin - Human
Result: Mild skin irritation

Serious eye damage/eye irritation
Eyes - rabbit
Result: No eye irritation

Eyes - Human
Result: Mild eye irritation

Respiratory or skin sensitisation
no data available

Germ cell mutagenicity
no data available

Carcinogenicity

IARC: No component of this product present at levels greater than or equal to 0.1% is identified as probable, possible or confirmed human carcinogen by IARC.

ACGIH: No component of this product present at levels greater than or equal to 0.1% is identified as a carcinogen or potential carcinogen by ACGIH.

NTP: No component of this product present at levels greater than or equal to 0.1% is identified as a known or anticipated carcinogen by NTP.

OSHA: No component of this product present at levels greater than or equal to 0.1% is identified as a carcinogen or potential carcinogen by OSHA.

Reproductive toxicity
no data available

no data available

Specific target organ toxicity - single exposure
no data available

Specific target organ toxicity - repeated exposure
no data available

Aspiration hazard
no data available

Additional Information
RTECS: BS4500000

To the best of our knowledge, the chemical, physical, and toxicological properties have not been thoroughly investigated.

12. ECOLOGICAL INFORMATION

12.1 Toxicity

Toxicity to fish	LC50 - Oncorhynchus mykiss (rainbow trout) - 36.7 mg/l - 96 h
Toxicity to daphnia and other aquatic invertebrates	LC50 - Daphnia magna (Water flea) - 433 mg/l - 50 h

12.2 Persistence and degradability
no data available

12.3 Bioaccumulative potential
no data available

12.4 Mobility in soil
no data available

12.5 Results of PBT and vPvB assessment
PBT/vPvB assessment not available as chemical safety assessment not required/not conducted

12.6 Other adverse effects

An environmental hazard cannot be excluded in the event of unprofessional handling or disposal.
Harmful to aquatic life with long lasting effects.

13. DISPOSAL CONSIDERATIONS

13.1 Waste treatment methods

Product
Offer surplus and non-recyclable solutions to a licensed disposal company.

Contaminated packaging
Dispose of as unused product.

14. TRANSPORT INFORMATION

DOT (US)
Not dangerous goods

IMDG
Not dangerous goods

IATA
Not dangerous goods

15. REGULATORY INFORMATION

REACH No. : A registration number is not available for this substance as the substance or its uses are exempted from registration, the annual tonnage does not require a registration or the registration is envisaged for a later registration deadline.

SARA 302 Components
SARA 302: No chemicals in this material are subject to the reporting requirements of SARA Title III, Section 302.

SARA 313 Components
SARA 313: This material does not contain any chemical components with known CAS numbers that exceed the threshold (De Minimis) reporting levels established by SARA Title III, Section 313.

SARA 311/312 Hazards
No SARA Hazards

Massachusetts Right To Know Components

	CAS-No.	Revision Date
Ammonium sulphate	7783-20-2	1993-04-24

Pennsylvania Right To Know Components

	CAS-No.	Revision Date
Ammonium sulphate	7783-20-2	1993-04-24

New Jersey Right To Know Components

	CAS-No.	Revision Date
Ammonium sulphate	7783-20-2	1993-04-24

California Prop. 65 Components
This product does not contain any chemicals known to State of California to cause cancer, birth defects, or any other reproductive harm.

16. OTHER INFORMATION

Full text of H-Statements referred to under sections 2 and 3.

H402	Harmful to aquatic life.
H412	Harmful to aquatic life with long lasting effects.

HMIS Rating
Health hazard: 1
Chronic Health Hazard:

Flammability:	0
Physical Hazard	0

NFPA Rating

Health hazard:	0
Fire Hazard:	0
Reactivity Hazard:	0

Further information

The above information is believed to be correct but does not purport to be all inclusive and shall be used only as a guide. The information in this document is based on the present state of our knowledge and is applicable to the product with regard to appropriate safety precautions. It does not represent any guarantee of the properties of the product. Sigma-Aldrich Corporation and its Affiliates shall not be held liable for any damage resulting from handling or from contact with the above product. See www.sigma-aldrich.com and/or the reverse side of invoice or packing slip for additional terms and conditions of sale.

Preparation Information

Sigma-Aldrich Corporation
Product Safety – Americas Region
1-800-521-8956

Version: 5.0 Revision Date: 05/01/2014 Print Date: 04/06/2015

SAFETY DATA SHEET

Version 4.2
Revision Date 06/25/2014
Print Date 04/06/2015

1. PRODUCT AND COMPANY IDENTIFICATION

1.1 Product identifiers

Product name : L-Lysine

Product Number : L5501
Brand : Sigma

CAS-No. : 56-87-1

1.2 Relevant identified uses of the substance or mixture and uses advised against

Identified uses : Laboratory chemicals, Manufacture of substances

1.3 Details of the supplier of the safety data sheet

Company : Sigma-Aldrich
3050 Spruce Street
SAINT LOUIS MO 63103
USA

Telephone : +1 800-325-5832
Fax : +1 800-325-5052

1.4 Emergency telephone number

Emergency Phone # : (314) 776-6555

2. HAZARDS IDENTIFICATION

2.1 Classification of the substance or mixture

Not a hazardous substance or mixture.

2.2 GHS Label elements, including precautionary statements

Not a hazardous substance or mixture.

2.3 Hazards not otherwise classified (HNOC) or not covered by GHS - none

3. COMPOSITION/INFORMATION ON INGREDIENTS

3.1 Substances

Formula : $C_6H_{14}N_2O_2$
Molecular Weight : 146.19 g/mol
CAS-No. : 56-87-1
EC-No. : 200-294-2

No ingredients are hazardous according to OSHA criteria.
No components need to be disclosed according to the applicable regulations.

4. FIRST AID MEASURES

4.1 Description of first aid measures

If inhaled
If breathed in, move person into fresh air. If not breathing, give artificial respiration.

In case of skin contact
Wash off with soap and plenty of water.

In case of eye contact
Flush eyes with water as a precaution.

If swallowed
Never give anything by mouth to an unconscious person. Rinse mouth with water.

4.2 Most important symptoms and effects, both acute and delayed
The most important known symptoms and effects are described in the labelling (see section 2.2) and/or in section 11

4.3 Indication of any immediate medical attention and special treatment needed
no data available

5. FIREFIGHTING MEASURES

5.1 Extinguishing media

Suitable extinguishing media
Use water spray, alcohol-resistant foam, dry chemical or carbon dioxide.

5.2 Special hazards arising from the substance or mixture
Carbon oxides, nitrogen oxides (NOx)

5.3 Advice for firefighters
Wear self contained breathing apparatus for fire fighting if necessary.

5.4 Further information
no data available

6. ACCIDENTAL RELEASE MEASURES

6.1 Personal precautions, protective equipment and emergency procedures
Avoid dust formation. Avoid breathing vapours, mist or gas.
For personal protection see section 8.

6.2 Environmental precautions
Do not let product enter drains.

6.3 Methods and materials for containment and cleaning up
Sweep up and shovel. Keep in suitable, closed containers for disposal.

6.4 Reference to other sections
For disposal see section 13.

7. HANDLING AND STORAGE

7.1 Precautions for safe handling
Provide appropriate exhaust ventilation at places where dust is formed.
For precautions see section 2.2.

7.2 Conditions for safe storage, including any incompatibilities
Keep container tightly closed in a dry and well-ventilated place.

strongly hygroscopic

7.3 Specific end use(s)
Apart from the uses mentioned in section 1.2 no other specific uses are stipulated

8. EXPOSURE CONTROLS/PERSONAL PROTECTION

8.1 Control parameters

Components with workplace control parameters
Contains no substances with occupational exposure limit values.

8.2 Exposure controls

Appropriate engineering controls
General industrial hygiene practice.

Personal protective equipment

Eye/face protection
Use equipment for eye protection tested and approved under appropriate government standards such as NIOSH (US) or EN 166(EU).

Skin protection
Handle with gloves. Gloves must be inspected prior to use. Use proper glove removal technique (without touching glove's outer surface) to avoid skin contact with this product. Dispose of contaminated gloves after use in accordance with applicable laws and good laboratory practices. Wash and dry hands.

Full contact
Material: Nitrile rubber
Minimum layer thickness: 0.11 mm
Break through time: 480 min
Material tested:Dermatril® (KCL 740 / Aldrich Z677272, Size M)

Splash contact
Material: Nitrile rubber
Minimum layer thickness: 0.11 mm
Break through time: 480 min
Material tested:Dermatril® (KCL 740 / Aldrich Z677272, Size M)

data source: KCL GmbH, D-36124 Eichenzell, phone +49 (0)6659 87300, e-mail sales@kcl.de, test method: EN374
If used in solution, or mixed with other substances, and under conditions which differ from EN 374, contact the supplier of the CE approved gloves. This recommendation is advisory only and must be evaluated by an industrial hygienist and safety officer familiar with the specific situation of anticipated use by our customers. It should not be construed as offering an approval for any specific use scenario.

Body Protection
Choose body protection in relation to its type, to the concentration and amount of dangerous substances, and to the specific work-place., The type of protective equipment must be selected according to the concentration and amount of the dangerous substance at the specific workplace.

Respiratory protection
Respiratory protection is not required. Where protection from nuisance levels of dusts are desired, use type N95 (US) or type P1 (EN 143) dust masks. Use respirators and components tested and approved under appropriate government standards such as NIOSH (US) or CEN (EU).

Control of environmental exposure
Do not let product enter drains.

9. PHYSICAL AND CHEMICAL PROPERTIES

9.1 Information on basic physical and chemical properties

a)	Appearance	Form: solid
b)	Odour	no data available
c)	Odour Threshold	no data available
d)	pH	no data available
e)	Melting point/freezing point	215 °C (419 °F) - Decomposes on heating.
f)	Initial boiling point and boiling range	no data available
g)	Flash point	no data available
h)	Evapouration rate	no data available
i)	Flammability (solid, gas)	no data available
j)	Upper/lower flammability or explosive limits	no data available

k)	Vapour pressure	no data available
l)	Vapour density	no data available
m)	Relative density	no data available
n)	Water solubility	no data available
o)	Partition coefficient: n-octanol/water	no data available
p)	Auto-ignition temperature	no data available
q)	Decomposition temperature	no data available
r)	Viscosity	no data available
s)	Explosive properties	no data available
t)	Oxidizing properties	no data available

9.2 Other safety information
no data available

10. STABILITY AND REACTIVITY

10.1 Reactivity
no data available

10.2 Chemical stability
Stable under recommended storage conditions.

10.3 Possibility of hazardous reactions
no data available

10.4 Conditions to avoid
no data available

10.5 Incompatible materials
Strong oxidizing agents

10.6 Hazardous decomposition products
Other decomposition products - no data available
In the event of fire: see section 5

11. TOXICOLOGICAL INFORMATION

11.1 Information on toxicological effects

Acute toxicity
no data available

Inhalation: no data available

Dermal: no data available

no data available

Skin corrosion/irritation
no data available

Serious eye damage/eye irritation
no data available

Respiratory or skin sensitisation
no data available

Germ cell mutagenicity
no data available

Carcinogenicity

IARC: No component of this product present at levels greater than or equal to 0.1% is identified as probable, possible or confirmed human carcinogen by IARC.

ACGIH: No component of this product present at levels greater than or equal to 0.1% is identified as a carcinogen or potential carcinogen by ACGIH.

NTP: No component of this product present at levels greater than or equal to 0.1% is identified as a known or anticipated carcinogen by NTP.

OSHA: No component of this product present at levels greater than or equal to 0.1% is identified as a carcinogen or potential carcinogen by OSHA.

Reproductive toxicity
no data available

no data available

Specific target organ toxicity - single exposure
no data available

Specific target organ toxicity - repeated exposure
no data available

Aspiration hazard
no data available

Additional Information
RTECS: OL5540000

To the best of our knowledge, the chemical, physical, and toxicological properties have not been thoroughly investigated.

12. ECOLOGICAL INFORMATION

12.1 Toxicity
no data available

12.2 Persistence and degradability
no data available

12.3 Bioaccumulative potential
no data available

12.4 Mobility in soil
no data available

12.5 Results of PBT and vPvB assessment
PBT/vPvB assessment not available as chemical safety assessment not required/not conducted

12.6 Other adverse effects

no data available

13. DISPOSAL CONSIDERATIONS

13.1 Waste treatment methods

Product
Offer surplus and non-recyclable solutions to a licensed disposal company.

Contaminated packaging
Dispose of as unused product.

14. TRANSPORT INFORMATION

DOT (US)
Not dangerous goods

IMDG
Not dangerous goods

IATA
Not dangerous goods

15. REGULATORY INFORMATION

SARA 302 Components
SARA 302: No chemicals in this material are subject to the reporting requirements of SARA Title III, Section 302.

SARA 313 Components
SARA 313: This material does not contain any chemical components with known CAS numbers that exceed the threshold (De Minimis) reporting levels established by SARA Title III, Section 313.

SARA 311/312 Hazards
No SARA Hazards

Massachusetts Right To Know Components
No components are subject to the Massachusetts Right to Know Act.

Pennsylvania Right To Know Components

	CAS-No.	Revision Date
L-Lysine	56-87-1	

New Jersey Right To Know Components

	CAS-No.	Revision Date
L-Lysine	56-87-1	

California Prop. 65 Components
This product does not contain any chemicals known to State of California to cause cancer, birth defects, or any other reproductive harm.

16. OTHER INFORMATION

HMIS Rating

Health hazard:	0
Chronic Health Hazard:	
Flammability:	0
Physical Hazard	0

NFPA Rating

Health hazard:	0
Fire Hazard:	0
Reactivity Hazard:	0

Further information

The above information is believed to be correct but does not purport to be all inclusive and shall be used only as a guide. The information in this document is based on the present state of our knowledge and is applicable to the product with regard to appropriate safety precautions. It does not represent any guarantee of the properties of the product. Sigma-Aldrich Corporation and its Affiliates shall not be held liable for any damage resulting from handling or from contact with the above product. See www.sigma-aldrich.com and/or the reverse side of invoice or packing slip for additional terms and conditions of sale.

Preparation Information
Sigma-Aldrich Corporation
Product Safety – Americas Region
1-800-521-8956

Version: 4.2 Revision Date: 06/25/2014 Print Date: 04/06/2015

SAFETY DATA SHEET

Version 3.6
Revision Date 06/23/2014
Print Date 04/06/2015

1. PRODUCT AND COMPANY IDENTIFICATION

1.1 Product identifiers

Product name : Ethylene glycol-bis(2-aminoethylether)-*N,N,N′,N′*-tetraacetic acid

Product Number : E4378
Brand : Sigma-Aldrich

CAS-No. : 67-42-5

1.2 Relevant identified uses of the substance or mixture and uses advised against

Identified uses : Laboratory chemicals, Manufacture of substances

1.3 Details of the supplier of the safety data sheet

Company : Sigma-Aldrich
3050 Spruce Street
SAINT LOUIS MO 63103
USA

Telephone : +1 800-325-5832
Fax : +1 800-325-5052

1.4 Emergency telephone number

Emergency Phone # : (314) 776-6555

2. HAZARDS IDENTIFICATION

2.1 Classification of the substance or mixture

Not a hazardous substance or mixture.

2.2 GHS Label elements, including precautionary statements

Not a hazardous substance or mixture.

2.3 Hazards not otherwise classified (HNOC) or not covered by GHS - none

3. COMPOSITION/INFORMATION ON INGREDIENTS

3.1 Substances

Chemical characterization : Natural product
Synonyms : Egtazic acid
EGTA
Glycol ether diamine tetraacetic acid
Ethylene-bis(oxyethylenenitrilo)tetraacetic acid
Chel™-DE

Formula : $C_{14}H_{24}N_2O_{10}$
Molecular Weight : 380.35 g/mol
CAS-No. : 67-42-5
EC-No. : 200-651-2

No ingredients are hazardous according to OSHA criteria.
No components need to be disclosed according to the applicable regulations.

4. FIRST AID MEASURES

4.1 Description of first aid measures

General advice
Consult a physician. Show this safety data sheet to the doctor in attendance.

If inhaled
If breathed in, move person into fresh air. If not breathing, give artificial respiration. Consult a physician.

In case of skin contact
Wash off with soap and plenty of water. Consult a physician.

In case of eye contact
Flush eyes with water as a precaution.

If swallowed
Never give anything by mouth to an unconscious person. Rinse mouth with water. Consult a physician.

4.2 Most important symptoms and effects, both acute and delayed
The most important known symptoms and effects are described in the labelling (see section 2.2) and/or in section 11

4.3 Indication of any immediate medical attention and special treatment needed
no data available

5. FIREFIGHTING MEASURES

5.1 Extinguishing media

Suitable extinguishing media
Use water spray, alcohol-resistant foam, dry chemical or carbon dioxide.

5.2 Special hazards arising from the substance or mixture
Carbon oxides, nitrogen oxides (NOx)

5.3 Advice for firefighters
Wear self contained breathing apparatus for fire fighting if necessary.

5.4 Further information
no data available

6. ACCIDENTAL RELEASE MEASURES

6.1 Personal precautions, protective equipment and emergency procedures
Use personal protective equipment. Avoid dust formation. Avoid breathing vapours, mist or gas. Avoid breathing dust.
For personal protection see section 8.

6.2 Environmental precautions
Do not let product enter drains.

6.3 Methods and materials for containment and cleaning up
Pick up and arrange disposal without creating dust. Sweep up and shovel. Keep in suitable, closed containers for disposal.

6.4 Reference to other sections
For disposal see section 13.

7. HANDLING AND STORAGE

7.1 Precautions for safe handling
Avoid formation of dust and aerosols.
Provide appropriate exhaust ventilation at places where dust is formed.Normal measures for preventive fire protection.
For precautions see section 2.2.

7.2 Conditions for safe storage, including any incompatibilities
Keep container tightly closed in a dry and well-ventilated place.

Keep in a dry place.

7.3 Specific end use(s)
Apart from the uses mentioned in section 1.2 no other specific uses are stipulated

8. EXPOSURE CONTROLS/PERSONAL PROTECTION

8.1 Control parameters

Components with workplace control parameters
Contains no substances with occupational exposure limit values.

8.2 Exposure controls

Appropriate engineering controls
Handle in accordance with good industrial hygiene and safety practice. Wash hands before breaks and at the end of workday.

Personal protective equipment

Eye/face protection
Use equipment for eye protection tested and approved under appropriate government standards such as NIOSH (US) or EN 166(EU).

Skin protection
Handle with gloves. Gloves must be inspected prior to use. Use proper glove removal technique (without touching glove's outer surface) to avoid skin contact with this product. Dispose of contaminated gloves after use in accordance with applicable laws and good laboratory practices. Wash and dry hands.

Full contact
Material: Nitrile rubber
Minimum layer thickness: 0.11 mm
Break through time: 480 min
Material tested:Dermatril® (KCL 740 / Aldrich Z677272, Size M)

Splash contact
Material: Nitrile rubber
Minimum layer thickness: 0.11 mm
Break through time: 480 min
Material tested:Dermatril® (KCL 740 / Aldrich Z677272, Size M)

data source: KCL GmbH, D-36124 Eichenzell, phone +49 (0)6659 87300, e-mail sales@kcl.de, test method: EN374
If used in solution, or mixed with other substances, and under conditions which differ from EN 374, contact the supplier of the CE approved gloves. This recommendation is advisory only and must be evaluated by an industrial hygienist and safety officer familiar with the specific situation of anticipated use by our customers. It should not be construed as offering an approval for any specific use scenario.

Body Protection
Choose body protection in relation to its type, to the concentration and amount of dangerous substances, and to the specific work-place., The type of protective equipment must be selected according to the concentration and amount of the dangerous substance at the specific workplace.

Respiratory protection
Respiratory protection is not required. Where protection from nuisance levels of dusts are desired, use type N95 (US) or type P1 (EN 143) dust masks. Use respirators and components tested and approved under appropriate government standards such as NIOSH (US) or CEN (EU).

Control of environmental exposure
Do not let product enter drains.

9. PHYSICAL AND CHEMICAL PROPERTIES

9.1 Information on basic physical and chemical properties

a)	Appearance	Form: powder Colour: white
b)	Odour	no data available
c)	Odour Threshold	no data available

d)	pH	no data available
e)	Melting point/freezing point	Melting point/range: 241 °C (466 °F)
f)	Initial boiling point and boiling range	no data available
g)	Flash point	no data available
h)	Evapouration rate	no data available
i)	Flammability (solid, gas)	no data available
j)	Upper/lower flammability or explosive limits	no data available
k)	Vapour pressure	no data available
l)	Vapour density	no data available
m)	Relative density	no data available
n)	Water solubility	no data available
o)	Partition coefficient: n-octanol/water	no data available
p)	Auto-ignition temperature	no data available
q)	Decomposition temperature	no data available
r)	Viscosity	no data available
s)	Explosive properties	no data available
t)	Oxidizing properties	no data available

9.2 Other safety information
no data available

10. STABILITY AND REACTIVITY

10.1 Reactivity
no data available

10.2 Chemical stability
Stable under recommended storage conditions.

10.3 Possibility of hazardous reactions
no data available

10.4 Conditions to avoid
no data available

10.5 Incompatible materials
Strong oxidizing agents

10.6 Hazardous decomposition products
Other decomposition products - no data available
In the event of fire: see section 5

11. TOXICOLOGICAL INFORMATION

11.1 Information on toxicological effects

Acute toxicity
LD50 Oral - rat - 3,587 mg/kg

Inhalation: no data available

Dermal: no data available

no data available

Skin corrosion/irritation
no data available

Serious eye damage/eye irritation
no data available

Respiratory or skin sensitisation
no data available

Germ cell mutagenicity
no data available

Carcinogenicity

IARC: No component of this product present at levels greater than or equal to 0.1% is identified as probable, possible or confirmed human carcinogen by IARC.

ACGIH: No component of this product present at levels greater than or equal to 0.1% is identified as a carcinogen or potential carcinogen by ACGIH.

NTP: No component of this product present at levels greater than or equal to 0.1% is identified as a known or anticipated carcinogen by NTP.

OSHA: No component of this product present at levels greater than or equal to 0.1% is identified as a carcinogen or potential carcinogen by OSHA.

Reproductive toxicity
no data available

no data available

Specific target organ toxicity - single exposure
no data available

Specific target organ toxicity - repeated exposure
no data available

Aspiration hazard
no data available

Additional Information
RTECS: AH3760000

To the best of our knowledge, the chemical, physical, and toxicological properties have not been thoroughly investigated.

12. ECOLOGICAL INFORMATION

12.1 Toxicity
no data available

12.2 Persistence and degradability
no data available

12.3 Bioaccumulative potential
no data available

12.4 Mobility in soil
no data available

12.5 Results of PBT and vPvB assessment
PBT/vPvB assessment not available as chemical safety assessment not required/not conducted

12.6 Other adverse effects

no data available

13. DISPOSAL CONSIDERATIONS

13.1 Waste treatment methods

Product
Offer surplus and non-recyclable solutions to a licensed disposal company.

Contaminated packaging
Dispose of as unused product.

14. TRANSPORT INFORMATION

DOT (US)
Not dangerous goods

IMDG
Not dangerous goods

IATA
Not dangerous goods

15. REGULATORY INFORMATION

SARA 302 Components
SARA 302: No chemicals in this material are subject to the reporting requirements of SARA Title III, Section 302.

SARA 313 Components
SARA 313: This material does not contain any chemical components with known CAS numbers that exceed the threshold (De Minimis) reporting levels established by SARA Title III, Section 313.

SARA 311/312 Hazards
No SARA Hazards

Massachusetts Right To Know Components
No components are subject to the Massachusetts Right to Know Act.

Pennsylvania Right To Know Components

	CAS-No.	Revision Date
Ethylenebis(oxyethylenenitrilo)tetra(acetic acid)	67-42-5	

New Jersey Right To Know Components

	CAS-No.	Revision Date
Ethylenebis(oxyethylenenitrilo)tetra(acetic acid)	67-42-5	

California Prop. 65 Components
This product does not contain any chemicals known to State of California to cause cancer, birth defects, or any other reproductive harm.

16. OTHER INFORMATION

HMIS Rating

Health hazard:	1
Chronic Health Hazard:	
Flammability:	0
Physical Hazard	0

NFPA Rating

Health hazard:	0
Fire Hazard:	0
Reactivity Hazard:	0

Further information

The above information is believed to be correct but does not purport to be all inclusive and shall be used only as a guide. The information in this document is based on the present state of our knowledge and is applicable to the product with regard to appropriate safety precautions. It does not represent any guarantee of the properties of the product. Sigma-Aldrich Corporation and its Affiliates shall not be held liable for any damage resulting from handling or from contact with the above product. See www.sigma-aldrich.com and/or the reverse side of invoice or packing slip for additional terms and conditions of sale.

Preparation Information

Sigma-Aldrich Corporation
Product Safety – Americas Region
1-800-521-8956

Version: 3.6 Revision Date: 06/23/2014 Print Date: 04/06/2015

SAFETY DATA SHEET

Version 5.2
Revision Date 03/08/2014
Print Date 04/06/2015

1. PRODUCT AND COMPANY IDENTIFICATION

1.1 Product identifiers

Product name : Sodium deoxycholate

Product Number : S1827
Brand : Sigma
REACH No. : A registration number is not available for this substance as the substance or its uses are exempted from registration, the annual tonnage does not require a registration or the registration is envisaged for a later registration deadline.
CAS-No. : 302-95-4

1.2 Relevant identified uses of the substance or mixture and uses advised against

Identified uses : Laboratory chemicals, Manufacture of substances

1.3 Details of the supplier of the safety data sheet

Company : Sigma-Aldrich
3050 Spruce Street
SAINT LOUIS MO 63103
USA

Telephone : +1 800-325-5832
Fax : +1 800-325-5052

1.4 Emergency telephone number

Emergency Phone # : (314) 776-6555

2. HAZARDS IDENTIFICATION

2.1 Classification of the substance or mixture

GHS Classification in accordance with 29 CFR 1910 (OSHA HCS)
Acute toxicity, Oral (Category 4), H302
Specific target organ toxicity - single exposure (Category 3), Respiratory system, H335

For the full text of the H-Statements mentioned in this Section, see Section 16.

2.2 GHS Label elements, including precautionary statements

Pictogram

Signal word Warning

Hazard statement(s)
H302 Harmful if swallowed.
H335 May cause respiratory irritation.

Precautionary statement(s)
P261 Avoid breathing dust/ fume/ gas/ mist/ vapours/ spray.
P264 Wash skin thoroughly after handling.
P270 Do not eat, drink or smoke when using this product.
P271 Use only outdoors or in a well-ventilated area.
P301 + P312 IF SWALLOWED: Call a POISON CENTER or doctor/ physician if you feel unwell.
P304 + P340 IF INHALED: Remove victim to fresh air and keep at rest in a position

	comfortable for breathing.
P312	Call a POISON CENTER or doctor/ physician if you feel unwell.
P330	Rinse mouth.
P403 + P233	Store in a well-ventilated place. Keep container tightly closed.
P405	Store locked up.
P501	Dispose of contents/ container to an approved waste disposal plant.

2.3 Hazards not otherwise classified (HNOC) or not covered by GHS - none

3. COMPOSITION/INFORMATION ON INGREDIENTS

3.1 Substances

Synonyms : Deoxycholic acid, sodium

Formula : $C_{24}H_{39}NaO_4$

Molecular Weight : 414.55 g/mol

CAS-No. : 302-95-4

EC-No. : 206-132-7

Hazardous components

Component	Classification	Concentration
Sodium 3-α,12-α-dihydroxy-5-β-cholan-24-oate		
	Acute Tox. 4; STOT SE 3; H302, H335	90 - 100 %

For the full text of the H-Statements mentioned in this Section, see Section 16.

4. FIRST AID MEASURES

4.1 Description of first aid measures

General advice
Consult a physician. Show this safety data sheet to the doctor in attendance.Move out of dangerous area.

If inhaled
If breathed in, move person into fresh air. If not breathing, give artificial respiration. Consult a physician.

In case of skin contact
Wash off with soap and plenty of water. Consult a physician.

In case of eye contact
Flush eyes with water as a precaution.

If swallowed
Never give anything by mouth to an unconscious person. Rinse mouth with water. Consult a physician.

4.2 Most important symptoms and effects, both acute and delayed
The most important known symptoms and effects are described in the labelling (see section 2.2) and/or in section 11

4.3 Indication of any immediate medical attention and special treatment needed
no data available

5. FIREFIGHTING MEASURES

5.1 Extinguishing media

Suitable extinguishing media
Use water spray, alcohol-resistant foam, dry chemical or carbon dioxide.

5.2 Special hazards arising from the substance or mixture
Carbon oxides, Sodium oxides

5.3 Advice for firefighters
Wear self contained breathing apparatus for fire fighting if necessary.

5.4 Further information
no data available

6. ACCIDENTAL RELEASE MEASURES

6.1 Personal precautions, protective equipment and emergency procedures

Use personal protective equipment. Avoid dust formation. Avoid breathing vapours, mist or gas. Ensure adequate ventilation. Evacuate personnel to safe areas. Avoid breathing dust.
For personal protection see section 8.

6.2 Environmental precautions

Do not let product enter drains.

6.3 Methods and materials for containment and cleaning up

Pick up and arrange disposal without creating dust. Sweep up and shovel. Keep in suitable, closed containers for disposal.

6.4 Reference to other sections

For disposal see section 13.

7. HANDLING AND STORAGE

7.1 Precautions for safe handling

Avoid contact with skin and eyes. Avoid formation of dust and aerosols.
Provide appropriate exhaust ventilation at places where dust is formed.
For precautions see section 2.2.

7.2 Conditions for safe storage, including any incompatibilities

Keep container tightly closed in a dry and well-ventilated place.

7.3 Specific end use(s)

Apart from the uses mentioned in section 1.2 no other specific uses are stipulated

8. EXPOSURE CONTROLS/PERSONAL PROTECTION

8.1 Control parameters

Components with workplace control parameters
Contains no substances with occupational exposure limit values.

8.2 Exposure controls

Appropriate engineering controls
Handle in accordance with good industrial hygiene and safety practice. Wash hands before breaks and at the end of workday.

Personal protective equipment

Eye/face protection
Safety glasses with side-shields conforming to EN166 Use equipment for eye protection tested and approved under appropriate government standards such as NIOSH (US) or EN 166(EU).

Skin protection
Handle with gloves. Gloves must be inspected prior to use. Use proper glove removal technique (without touching glove's outer surface) to avoid skin contact with this product. Dispose of contaminated gloves after use in accordance with applicable laws and good laboratory practices. Wash and dry hands.

Body Protection
Complete suit protecting against chemicals, The type of protective equipment must be selected according to the concentration and amount of the dangerous substance at the specific workplace.

Respiratory protection
For nuisance exposures use type P95 (US) or type P1 (EU EN 143) particle respirator.For higher level protection use type OV/AG/P99 (US) or type ABEK-P2 (EU EN 143) respirator cartridges. Use respirators and components tested and approved under appropriate government standards such as NIOSH (US) or CEN (EU).

Control of environmental exposure
Do not let product enter drains.

9. PHYSICAL AND CHEMICAL PROPERTIES

9.1 Information on basic physical and chemical properties

a)	Appearance	Form: solid
b)	Odour	no data available
c)	Odour Threshold	no data available
d)	pH	no data available
e)	Melting point/freezing point	no data available
f)	Initial boiling point and boiling range	no data available
g)	Flash point	no data available
h)	Evapouration rate	no data available
i)	Flammability (solid, gas)	no data available
j)	Upper/lower flammability or explosive limits	no data available
k)	Vapour pressure	no data available
l)	Vapour density	no data available
m)	Relative density	no data available
n)	Water solubility	no data available
o)	Partition coefficient: n-octanol/water	no data available
p)	Auto-ignition temperature	no data available
q)	Decomposition temperature	no data available
r)	Viscosity	no data available
s)	Explosive properties	no data available
t)	Oxidizing properties	no data available

9.2 Other safety information

no data available

10. STABILITY AND REACTIVITY

10.1 Reactivity

no data available

10.2 Chemical stability

Stable under recommended storage conditions.

10.3 Possibility of hazardous reactions

no data available

10.4 Conditions to avoid

Exposure to moisture.

10.5 Incompatible materials

Oxidizing agents

10.6 Hazardous decomposition products

Other decomposition products - no data available
In the event of fire: see section 5

11. TOXICOLOGICAL INFORMATION

11.1 Information on toxicological effects

Acute toxicity
LD50 Oral - rat - 1,370 mg/kg
Remarks: Behavioral:Altered sleep time (including change in righting reflex). Behavioral:Ataxia. Lungs, Thorax, or Respiration:Other changes.

LD50 Oral - mouse - 1,050 mg/kg
Remarks: Behavioral:Somnolence (general depressed activity). Gastrointestinal:Ulceration or bleeding from stomach. Gastrointestinal:Ulceration or bleeding from small intestine.

Inhalation: no data available

Dermal: no data available

LD50 Intraperitoneal - rat - 123 mg/kg
Remarks: Behavioral:Altered sleep time (including change in righting reflex). Behavioral:Ataxia. Lungs, Thorax, or Respiration:Other changes.

LD50 Intravenous - rat - 150 mg/kg

LD50 Intraperitoneal - mouse - 36 mg/kg
Remarks: Behavioral:Excitement. Lungs, Thorax, or Respiration:Other changes. Diarrhoea

LD50 Subcutaneous - mouse - 815 mg/kg
Remarks: Behavioral:Altered sleep time (including change in righting reflex). Behavioral:Ataxia. Lungs, Thorax, or Respiration:Other changes.

LD50 Intravenous - mouse - 107 mg/kg

LD50 Subcutaneous - rat - 2,430 mg/kg
Remarks: Behavioral:Altered sleep time (including change in righting reflex). Behavioral:Ataxia. Lungs, Thorax, or Respiration:Other changes.

Skin corrosion/irritation
no data available

Serious eye damage/eye irritation
no data available

Respiratory or skin sensitisation
no data available

Germ cell mutagenicity
no data available

Carcinogenicity

IARC: No component of this product present at levels greater than or equal to 0.1% is identified as probable, possible or confirmed human carcinogen by IARC.

ACGIH: No component of this product present at levels greater than or equal to 0.1% is identified as a carcinogen or potential carcinogen by ACGIH.

NTP: No component of this product present at levels greater than or equal to 0.1% is identified as a known or anticipated carcinogen by NTP.

OSHA: No component of this product present at levels greater than or equal to 0.1% is identified as a carcinogen or potential carcinogen by OSHA.

Reproductive toxicity
no data available

no data available

Specific target organ toxicity - single exposure
no data available

Specific target organ toxicity - repeated exposure
no data available

Aspiration hazard
no data available

Additional Information
RTECS: FZ2250000

To the best of our knowledge, the chemical, physical, and toxicological properties have not been thoroughly investigated.

12. ECOLOGICAL INFORMATION

12.1 Toxicity

Toxicity to fish	LC50 - Oryzias latipes - 115 mg/l - 48 h

12.2 Persistence and degradability
no data available

12.3 Bioaccumulative potential
no data available

12.4 Mobility in soil
no data available

12.5 Results of PBT and vPvB assessment
PBT/vPvB assessment not available as chemical safety assessment not required/not conducted

12.6 Other adverse effects

no data available

13. DISPOSAL CONSIDERATIONS

13.1 Waste treatment methods

Product
Offer surplus and non-recyclable solutions to a licensed disposal company.

Contaminated packaging
Dispose of as unused product.

14. TRANSPORT INFORMATION

DOT (US)
Not dangerous goods

IMDG
Not dangerous goods

IATA
Not dangerous goods

15. REGULATORY INFORMATION

REACH No. : A registration number is not available for this substance as the substance or its uses are exempted from registration, the annual tonnage does not require a registration or the registration is envisaged for a later registration deadline.

SARA 302 Components
SARA 302: No chemicals in this material are subject to the reporting requirements of SARA Title III, Section 302.

SARA 313 Components
SARA 313: This material does not contain any chemical components with known CAS numbers that exceed the threshold (De Minimis) reporting levels established by SARA Title III, Section 313.

SARA 311/312 Hazards
Acute Health Hazard

Massachusetts Right To Know Components
No components are subject to the Massachusetts Right to Know Act.

Pennsylvania Right To Know Components

	CAS-No.	Revision Date
Sodium 3-α,12-α-dihydroxy-5-β-cholan-24-oate	302-95-4	

New Jersey Right To Know Components

	CAS-No.	Revision Date
Sodium 3-α,12-α-dihydroxy-5-β-cholan-24-oate	302-95-4	

California Prop. 65 Components
This product does not contain any chemicals known to State of California to cause cancer, birth defects, or any other reproductive harm.

16. OTHER INFORMATION

Full text of H-Statements referred to under sections 2 and 3.

Acute Tox.	Acute toxicity
H302	Harmful if swallowed.
H335	May cause respiratory irritation.
STOT SE	Specific target organ toxicity - single exposure

HMIS Rating

Health hazard:	1
Chronic Health Hazard:	
Flammability:	0
Physical Hazard	0

NFPA Rating

Health hazard:	1
Fire Hazard:	0
Reactivity Hazard:	0

Further information

The above information is believed to be correct but does not purport to be all inclusive and shall be used only as a guide. The information in this document is based on the present state of our knowledge and is applicable to the product with regard to appropriate safety precautions. It does not represent any guarantee of the properties of the product. Sigma-Aldrich Corporation and its Affiliates shall not be held liable for any damage resulting from handling or from contact with the above product. See www.sigma-aldrich.com and/or the reverse side of invoice or packing slip for additional terms and conditions of sale.

Preparation Information
Sigma-Aldrich Corporation
Product Safety – Americas Region
1-800-521-8956

Version: 5.2 Revision Date: 03/08/2014 Print Date: 04/06/2015

SAFETY DATA SHEET

Version 5.2
Revision Date 12/15/2014
Print Date 04/06/2015

1. PRODUCT AND COMPANY IDENTIFICATION

1.1 Product identifiers

Product name : TRIS HYDROCHLORIDE, 100 GM

Product Number : RES3098T-B7
Brand : Sigma

CAS-No. : 1185-53-1

1.2 Relevant identified uses of the substance or mixture and uses advised against

Identified uses : Laboratory chemicals, Manufacture of substances

1.3 Details of the supplier of the safety data sheet

Company : Sigma-Aldrich
3050 Spruce Street
SAINT LOUIS MO 63103
USA

Telephone : +1 800-325-5832
Fax : +1 800-325-5052

1.4 Emergency telephone number

Emergency Phone # : (314) 776-6555

2. HAZARDS IDENTIFICATION

2.1 Classification of the substance or mixture

Not a hazardous substance or mixture.

2.2 GHS Label elements, including precautionary statements

Not a hazardous substance or mixture.

2.3 Hazards not otherwise classified (HNOC) or not covered by GHS - none

3. COMPOSITION/INFORMATION ON INGREDIENTS

3.1 Substances

Formula : C4H11NO3*HCl
Molecular weight : 157.60 g/mol
CAS-No. : 1185-53-1
EC-No. : 214-684-5

No components need to be disclosed according to the applicable regulations.

4. FIRST AID MEASURES

4.1 Description of first aid measures

If inhaled
If breathed in, move person into fresh air. If not breathing, give artificial respiration.

In case of skin contact
Wash off with soap and plenty of water.

In case of eye contact
Flush eyes with water as a precaution.

If swallowed
Never give anything by mouth to an unconscious person. Rinse mouth with water.

4.2 Most important symptoms and effects, both acute and delayed
The most important known symptoms and effects are described in the labelling (see section 2.2) and/or in section 11

4.3 Indication of any immediate medical attention and special treatment needed
No data available

5. FIREFIGHTING MEASURES

5.1 Extinguishing media

Suitable extinguishing media
Use water spray, alcohol-resistant foam, dry chemical or carbon dioxide.

5.2 Special hazards arising from the substance or mixture
Carbon oxides, Nitrogen oxides (NOx), Hydrogen chloride gas

5.3 Advice for firefighters
Wear self-contained breathing apparatus for firefighting if necessary.

5.4 Further information
No data available

6. ACCIDENTAL RELEASE MEASURES

6.1 Personal precautions, protective equipment and emergency procedures
Avoid dust formation. Avoid breathing vapours, mist or gas.
For personal protection see section 8.

6.2 Environmental precautions
Do not let product enter drains.

6.3 Methods and materials for containment and cleaning up
Sweep up and shovel. Keep in suitable, closed containers for disposal.

6.4 Reference to other sections
For disposal see section 13.

7. HANDLING AND STORAGE

7.1 Precautions for safe handling
Further processing of solid materials may result in the formation of combustible dusts. The potential for combustible dust formation should be taken into consideration before additional processing occurs.
Provide appropriate exhaust ventilation at places where dust is formed.
For precautions see section 2.2.

7.2 Conditions for safe storage, including any incompatibilities
Keep container tightly closed in a dry and well-ventilated place.

7.3 Specific end use(s)
Apart from the uses mentioned in section 1.2 no other specific uses are stipulated

8. EXPOSURE CONTROLS/PERSONAL PROTECTION

8.1 Control parameters

Components with workplace control parameters
Contains no substances with occupational exposure limit values.

8.2 Exposure controls

Appropriate engineering controls
General industrial hygiene practice.

Personal protective equipment

Eye/face protection
Use equipment for eye protection tested and approved under appropriate government standards such as NIOSH (US) or EN 166(EU).

Skin protection
Handle with gloves. Gloves must be inspected prior to use. Use proper glove removal technique (without touching glove's outer surface) to avoid skin contact with this product. Dispose of contaminated gloves after use in accordance with applicable laws and good laboratory practices. Wash and dry hands.

Body Protection
Choose body protection in relation to its type, to the concentration and amount of dangerous substances, and to the specific work-place., The type of protective equipment must be selected according to the concentration and amount of the dangerous substance at the specific workplace.

Respiratory protection
Respiratory protection is not required. Where protection from nuisance levels of dusts are desired, use type N95 (US) or type P1 (EN 143) dust masks. Use respirators and components tested and approved under appropriate government standards such as NIOSH (US) or CEN (EU).

Control of environmental exposure
Do not let product enter drains.

9. PHYSICAL AND CHEMICAL PROPERTIES

9.1 Information on basic physical and chemical properties

a)	Appearance	Form: solid
b)	Odour	No data available
c)	Odour Threshold	No data available
d)	pH	No data available
e)	Melting point/freezing point	150 - 152 °C (302 - 306 °F)
f)	Initial boiling point and boiling range	No data available
g)	Flash point	No data available
h)	Evaporation rate	No data available
i)	Flammability (solid, gas)	No data available
j)	Upper/lower flammability or explosive limits	No data available
k)	Vapour pressure	No data available
l)	Vapour density	No data available
m)	Relative density	No data available
n)	Water solubility	No data available
o)	Partition coefficient: n-octanol/water	No data available
p)	Auto-ignition temperature	No data available
q)	Decomposition temperature	No data available
r)	Viscosity	No data available
s)	Explosive properties	No data available
t)	Oxidizing properties	No data available

9.2 Other safety information
No data available

10. STABILITY AND REACTIVITY

10.1 Reactivity
No data available

10.2 Chemical stability
Stable under recommended storage conditions.

10.3 Possibility of hazardous reactions
No data available

10.4 Conditions to avoid
No data available

10.5 Incompatible materials
Bases, Oxidizing agents

10.6 Hazardous decomposition products
Other decomposition products - No data available
In the event of fire: see section 5

11. TOXICOLOGICAL INFORMATION

11.1 Information on toxicological effects

Acute toxicity
No data available

Inhalation: No data available

Dermal: No data available

No data available

Skin corrosion/irritation
No data available

Serious eye damage/eye irritation
Eyes - Rabbit
Result: Mild eye irritation

Respiratory or skin sensitisation
Germ cell mutagenicity
Not mutagenic in Ames Test

Carcinogenicity

IARC: No component of this product present at levels greater than or equal to 0.1% is identified as probable, possible or confirmed human carcinogen by IARC.

ACGIH: No component of this product present at levels greater than or equal to 0.1% is identified as a carcinogen or potential carcinogen by ACGIH.

NTP: No component of this product present at levels greater than or equal to 0.1% is identified as a known or anticipated carcinogen by NTP.

OSHA: No component of this product present at levels greater than or equal to 0.1% is identified as a carcinogen or potential carcinogen by OSHA.

Reproductive toxicity
No data available

No data available

Specific target organ toxicity - single exposure
No data available

Specific target organ toxicity - repeated exposure
No data available

Aspiration hazard
No data available

Additional Information
RTECS: Not available

To the best of our knowledge, the chemical, physical, and toxicological properties have not been thoroughly investigated.

12. ECOLOGICAL INFORMATION

12.1 Toxicity
No data available

Toxicity to daphnia and other aquatic invertebrates	EC50 - Daphnia (water flea) - > 100 mg/l - 48 h
Toxicity to algae	EC50 - other microorganisms - > 1,000 mg/l - 3 h

12.2 Persistence and degradability
Biodegradability
Remarks: Readily biodegradable, according to appropriate OECD test.

12.3 Bioaccumulative potential
No data available

12.4 Mobility in soil
No data available

12.5 Results of PBT and vPvB assessment
PBT/vPvB assessment not available as chemical safety assessment not required/not conducted

12.6 Other adverse effects

No data available

13. DISPOSAL CONSIDERATIONS

13.1 Waste treatment methods

Product
Offer surplus and non-recyclable solutions to a licensed disposal company.

Contaminated packaging
Dispose of as unused product.

14. TRANSPORT INFORMATION

DOT (US)
Not dangerous goods

IMDG
Not dangerous goods

IATA
Not dangerous goods

15. REGULATORY INFORMATION

SARA 302 Components
No chemicals in this material are subject to the reporting requirements of SARA Title III, Section 302.

SARA 313 Components
This material does not contain any chemical components with known CAS numbers that exceed the threshold (De Minimis) reporting levels established by SARA Title III, Section 313.

SARA 311/312 Hazards
No SARA Hazards

Massachusetts Right To Know Components
No components are subject to the Massachusetts Right to Know Act.

Pennsylvania Right To Know Components

	CAS-No.	Revision Date
2-Amino-2-(hydroxymethyl)propane-1,3-diol hydrochloride	1185-53-1	

New Jersey Right To Know Components

	CAS-No.	Revision Date
2-Amino-2-(hydroxymethyl)propane-1,3-diol hydrochloride	1185-53-1	

California Prop. 65 Components
This product does not contain any chemicals known to State of California to cause cancer, birth defects, or any other reproductive harm.

16. OTHER INFORMATION

HMIS Rating

Health hazard:	0
Chronic Health Hazard:	
Flammability:	0
Physical Hazard	0

NFPA Rating

Health hazard:	0
Fire Hazard:	0
Reactivity Hazard:	0

Further information

The above information is believed to be correct but does not purport to be all inclusive and shall be used only as a guide. The information in this document is based on the present state of our knowledge and is applicable to the product with regard to appropriate safety precautions. It does not represent any guarantee of the properties of the product. Sigma-Aldrich Corporation and its Affiliates shall not be held liable for any damage resulting from handling or from contact with the above product. See www.sigma-aldrich.com and/or the reverse side of invoice or packing slip for additional terms and conditions of sale.

Preparation Information
Sigma-Aldrich Corporation
Product Safety – Americas Region
1-800-521-8956

Version: 5.2 Revision Date: 12/15/2014 Print Date: 04/06/2015

SAFETY DATA SHEET

Version 4.5
Revision Date 06/26/2014
Print Date 04/06/2015

1. PRODUCT AND COMPANY IDENTIFICATION

1.1 Product identifiers

Product name : Trisodium citrate dihydrate

Product Number : S1804
Brand : Sigma-Aldrich

CAS-No. : 6132-04-3

1.2 Relevant identified uses of the substance or mixture and uses advised against

Identified uses : Laboratory chemicals, Manufacture of substances

1.3 Details of the supplier of the safety data sheet

Company : Sigma-Aldrich
3050 Spruce Street
SAINT LOUIS MO 63103
USA

Telephone : +1 800-325-5832
Fax : +1 800-325-5052

1.4 Emergency telephone number

Emergency Phone # : (314) 776-6555

2. HAZARDS IDENTIFICATION

2.1 Classification of the substance or mixture

Not a hazardous substance or mixture.

2.2 GHS Label elements, including precautionary statements

Not a hazardous substance or mixture.

2.3 Hazards not otherwise classified (HNOC) or not covered by GHS - none

3. COMPOSITION/INFORMATION ON INGREDIENTS

3.1 Substances

Synonyms : Sodium citrate tribasic dihydrate
Trisodium citrate dihydrate
Citric acid trisodium salt dihydrate

Formula : $C_6H_5Na_3O_7 \cdot 2H_2O$
Molecular Weight : 294.10 g/mol
CAS-No. : 6132-04-3
EC-No. : 200-675-3

No ingredients are hazardous according to OSHA criteria.
No components need to be disclosed according to the applicable regulations.

4. FIRST AID MEASURES

4.1 Description of first aid measures

If inhaled
If breathed in, move person into fresh air. If not breathing, give artificial respiration.

In case of skin contact
Wash off with soap and plenty of water.

In case of eye contact
Flush eyes with water as a precaution.

If swallowed
Never give anything by mouth to an unconscious person. Rinse mouth with water.

4.2 Most important symptoms and effects, both acute and delayed
The most important known symptoms and effects are described in the labelling (see section 2.2) and/or in section 11

4.3 Indication of any immediate medical attention and special treatment needed
no data available

5. FIREFIGHTING MEASURES

5.1 Extinguishing media

Suitable extinguishing media
Use water spray, alcohol-resistant foam, dry chemical or carbon dioxide.

5.2 Special hazards arising from the substance or mixture
Carbon oxides, Sodium oxides

5.3 Advice for firefighters
Wear self contained breathing apparatus for fire fighting if necessary.

5.4 Further information
no data available

6. ACCIDENTAL RELEASE MEASURES

6.1 Personal precautions, protective equipment and emergency procedures
Avoid dust formation. Avoid breathing vapours, mist or gas.
For personal protection see section 8.

6.2 Environmental precautions
Do not let product enter drains.

6.3 Methods and materials for containment and cleaning up
Sweep up and shovel. Keep in suitable, closed containers for disposal.

6.4 Reference to other sections
For disposal see section 13.

7. HANDLING AND STORAGE

7.1 Precautions for safe handling
Provide appropriate exhaust ventilation at places where dust is formed.
For precautions see section 2.2.

7.2 Conditions for safe storage, including any incompatibilities
Keep container tightly closed in a dry and well-ventilated place.

Keep in a dry place.

7.3 Specific end use(s)
Apart from the uses mentioned in section 1.2 no other specific uses are stipulated

8. EXPOSURE CONTROLS/PERSONAL PROTECTION

8.1 Control parameters

Components with workplace control parameters
Contains no substances with occupational exposure limit values.

8.2 Exposure controls

Appropriate engineering controls
General industrial hygiene practice.

Personal protective equipment

Eye/face protection
Use equipment for eye protection tested and approved under appropriate government standards such as NIOSH (US) or EN 166(EU).

Skin protection
Handle with gloves. Gloves must be inspected prior to use. Use proper glove removal technique (without touching glove's outer surface) to avoid skin contact with this product. Dispose of contaminated gloves after use in accordance with applicable laws and good laboratory practices. Wash and dry hands.

Full contact
Material: Nitrile rubber
Minimum layer thickness: 0.11 mm
Break through time: 480 min
Material tested:Dermatril® (KCL 740 / Aldrich Z677272, Size M)

Splash contact
Material: Nitrile rubber
Minimum layer thickness: 0.11 mm
Break through time: 480 min
Material tested:Dermatril® (KCL 740 / Aldrich Z677272, Size M)

data source: KCL GmbH, D-36124 Eichenzell, phone +49 (0)6659 87300, e-mail sales@kcl.de, test method: EN374
If used in solution, or mixed with other substances, and under conditions which differ from EN 374, contact the supplier of the CE approved gloves. This recommendation is advisory only and must be evaluated by an industrial hygienist and safety officer familiar with the specific situation of anticipated use by our customers. It should not be construed as offering an approval for any specific use scenario.

Body Protection
Choose body protection in relation to its type, to the concentration and amount of dangerous substances, and to the specific work-place., The type of protective equipment must be selected according to the concentration and amount of the dangerous substance at the specific workplace.

Respiratory protection
Respiratory protection is not required. Where protection from nuisance levels of dusts are desired, use type N95 (US) or type P1 (EN 143) dust masks. Use respirators and components tested and approved under appropriate government standards such as NIOSH (US) or CEN (EU).

Control of environmental exposure
Do not let product enter drains.

9. PHYSICAL AND CHEMICAL PROPERTIES

9.1 Information on basic physical and chemical properties

a)	Appearance	Form: powder Colour: white
b)	Odour	no data available
c)	Odour Threshold	no data available
d)	pH	7.5 - 9 at 29.4 g/l at 25 °C (77 °F)
e)	Melting point/freezing point	Melting point/range: > 300 °C (> 572 °F) - lit.
f)	Initial boiling point and boiling range	no data available
g)	Flash point	no data available
h)	Evapouration rate	no data available
i)	Flammability (solid, gas)	no data available
j)	Upper/lower flammability or	no data available

	explosive limits	
k)	Vapour pressure	no data available
l)	Vapour density	no data available
m)	Relative density	no data available
n)	Water solubility	29.4 g/l at 20 °C (68 °F) - completely soluble
o)	Partition coefficient: n-octanol/water	no data available
p)	Auto-ignition temperature	no data available
q)	Decomposition temperature	no data available
r)	Viscosity	no data available
s)	Explosive properties	no data available
t)	Oxidizing properties	no data available

9.2 Other safety information
no data available

10. STABILITY AND REACTIVITY

10.1 Reactivity
no data available

10.2 Chemical stability
Stable under recommended storage conditions.

10.3 Possibility of hazardous reactions
no data available

10.4 Conditions to avoid
no data available

10.5 Incompatible materials
Strong oxidizing agents

10.6 Hazardous decomposition products
Other decomposition products - no data available
In the event of fire: see section 5

11. TOXICOLOGICAL INFORMATION

11.1 Information on toxicological effects

Acute toxicity
no data available

Inhalation: no data available

Dermal: no data available

no data available

Skin corrosion/irritation
no data available

Serious eye damage/eye irritation
no data available

Respiratory or skin sensitisation
no data available

Germ cell mutagenicity
no data available

Carcinogenicity

IARC: No component of this product present at levels greater than or equal to 0.1% is identified as probable, possible or confirmed human carcinogen by IARC.

ACGIH: No component of this product present at levels greater than or equal to 0.1% is identified as a carcinogen or potential carcinogen by ACGIH.

NTP: No component of this product present at levels greater than or equal to 0.1% is identified as a known or anticipated carcinogen by NTP.

OSHA: No component of this product present at levels greater than or equal to 0.1% is identified as a carcinogen or potential carcinogen by OSHA.

Reproductive toxicity
no data available

no data available

Specific target organ toxicity - single exposure
no data available

Specific target organ toxicity - repeated exposure
no data available

Aspiration hazard
no data available

Additional Information
RTECS: Not available

To the best of our knowledge, the chemical, physical, and toxicological properties have not been thoroughly investigated.

12. ECOLOGICAL INFORMATION

12.1 Toxicity
no data available

12.2 Persistence and degradability
no data available

12.3 Bioaccumulative potential
no data available

12.4 Mobility in soil
no data available

12.5 Results of PBT and vPvB assessment
PBT/vPvB assessment not available as chemical safety assessment not required/not conducted

12.6 Other adverse effects

no data available

13. DISPOSAL CONSIDERATIONS

13.1 Waste treatment methods

Product
Offer surplus and non-recyclable solutions to a licensed disposal company.

Contaminated packaging
Dispose of as unused product.

14. TRANSPORT INFORMATION

DOT (US)
Not dangerous goods

IMDG

Not dangerous goods

IATA
Not dangerous goods

15. REGULATORY INFORMATION

SARA 302 Components
SARA 302: No chemicals in this material are subject to the reporting requirements of SARA Title III, Section 302.

SARA 313 Components
SARA 313: This material does not contain any chemical components with known CAS numbers that exceed the threshold (De Minimis) reporting levels established by SARA Title III, Section 313.

SARA 311/312 Hazards
No SARA Hazards

Massachusetts Right To Know Components
No components are subject to the Massachusetts Right to Know Act.

Pennsylvania Right To Know Components

	CAS-No.	Revision Date
Trisodium citrate	6132-04-3	

New Jersey Right To Know Components

	CAS-No.	Revision Date
Trisodium citrate	6132-04-3	

California Prop. 65 Components
This product does not contain any chemicals known to State of California to cause cancer, birth defects, or any other reproductive harm.

16. OTHER INFORMATION

HMIS Rating

Health hazard:	0
Chronic Health Hazard:	
Flammability:	0
Physical Hazard	0

NFPA Rating

Health hazard:	0
Fire Hazard:	0
Reactivity Hazard:	0

Further information

The above information is believed to be correct but does not purport to be all inclusive and shall be used only as a guide. The information in this document is based on the present state of our knowledge and is applicable to the product with regard to appropriate safety precautions. It does not represent any guarantee of the properties of the product. Sigma-Aldrich Corporation and its Affiliates shall not be held liable for any damage resulting from handling or from contact with the above product. See www.sigma-aldrich.com and/or the reverse side of invoice or packing slip for additional terms and conditions of sale.

Preparation Information
Sigma-Aldrich Corporation
Product Safety – Americas Region
1-800-521-8956

Version: 4.5 Revision Date: 06/26/2014 Print Date: 04/06/2015

SAFETY DATA SHEET

Version 4.6
Revision Date 11/18/2014
Print Date 04/12/2015

1. PRODUCT AND COMPANY IDENTIFICATION

1.1 Product identifiers

Product name : Citric acid

Product Number : 251275
Brand : Sigma-Aldrich

CAS-No. : 77-92-9

1.2 Relevant identified uses of the substance or mixture and uses advised against

Identified uses : Laboratory chemicals, Manufacture of substances

1.3 Details of the supplier of the safety data sheet

Company : Sigma-Aldrich
3050 Spruce Street
SAINT LOUIS MO 63103
USA

Telephone : +1 800-325-5832
Fax : +1 800-325-5052

1.4 Emergency telephone number

Emergency Phone # : (314) 776-6555

2. HAZARDS IDENTIFICATION

2.1 Classification of the substance or mixture

GHS Classification in accordance with 29 CFR 1910 (OSHA HCS)
Eye irritation (Category 2A), H319

For the full text of the H-Statements mentioned in this Section, see Section 16.

2.2 GHS Label elements, including precautionary statements

Pictogram

Signal word Warning

Hazard statement(s)
H319 Causes serious eye irritation.

Precautionary statement(s)
P264 Wash skin thoroughly after handling.
P280 Wear eye protection/ face protection.
P305 + P351 + P338 IF IN EYES: Rinse cautiously with water for several minutes. Remove contact lenses, if present and easy to do. Continue rinsing.
P337 + P313 If eye irritation persists: Get medical advice/ attention.

2.3 Hazards not otherwise classified (HNOC) or not covered by GHS - none

3. COMPOSITION/INFORMATION ON INGREDIENTS

3.1 Substances

Formula : $C_6H_8O_7$

Molecular weight	:	192.12 g/mol
CAS-No.	:	77-92-9
EC-No.	:	201-069-1

Hazardous components

Component	Classification	Concentration
Citric acid		
	Eye Irrit. 2A; H319	<= 100 %

For the full text of the H-Statements mentioned in this Section, see Section 16.

4. FIRST AID MEASURES

4.1 Description of first aid measures

General advice
Move out of dangerous area.Consult a physician. Show this safety data sheet to the doctor in attendance.

If inhaled
If breathed in, move person into fresh air. If not breathing, give artificial respiration. Consult a physician.

In case of skin contact
Wash off with soap and plenty of water. Consult a physician.

In case of eye contact
Rinse thoroughly with plenty of water for at least 15 minutes and consult a physician.

If swallowed
Never give anything by mouth to an unconscious person. Rinse mouth with water. Consult a physician.

4.2 Most important symptoms and effects, both acute and delayed
The most important known symptoms and effects are described in the labelling (see section 2.2) and/or in section 11

4.3 Indication of any immediate medical attention and special treatment needed
No data available

5. FIREFIGHTING MEASURES

5.1 Extinguishing media

Suitable extinguishing media
Use water spray, alcohol-resistant foam, dry chemical or carbon dioxide.

5.2 Special hazards arising from the substance or mixture
No data available

5.3 Advice for firefighters
Wear self-contained breathing apparatus for firefighting if necessary.

5.4 Further information
No data available

6. ACCIDENTAL RELEASE MEASURES

6.1 Personal precautions, protective equipment and emergency procedures
Use personal protective equipment. Avoid dust formation. Avoid breathing vapours, mist or gas. Ensure adequate ventilation. Avoid breathing dust.
For personal protection see section 8.

6.2 Environmental precautions
Do not let product enter drains.

6.3 Methods and materials for containment and cleaning up
Pick up and arrange disposal without creating dust. Sweep up and shovel. Keep in suitable, closed containers for disposal.

6.4 Reference to other sections
For disposal see section 13.

7. HANDLING AND STORAGE

7.1 Precautions for safe handling

Further processing of solid materials may result in the formation of combustible dusts. The potential for combustible dust formation should be taken into consideration before additional processing occurs.Avoid contact with skin and eyes. Avoid formation of dust and aerosols.
Provide appropriate exhaust ventilation at places where dust is formed.
For precautions see section 2.2.

7.2 Conditions for safe storage, including any incompatibilities

Keep container tightly closed in a dry and well-ventilated place.
Storage class (TRGS 510): Non Combustible Solids

7.3 Specific end use(s)

Apart from the uses mentioned in section 1.2 no other specific uses are stipulated

8. EXPOSURE CONTROLS/PERSONAL PROTECTION

8.1 Control parameters

Components with workplace control parameters
Contains no substances with occupational exposure limit values.

8.2 Exposure controls

Appropriate engineering controls
Handle in accordance with good industrial hygiene and safety practice. Wash hands before breaks and at the end of workday.

Personal protective equipment

Eye/face protection
Safety glasses with side-shields conforming to EN166 Use equipment for eye protection tested and approved under appropriate government standards such as NIOSH (US) or EN 166(EU).

Skin protection
Handle with gloves. Gloves must be inspected prior to use. Use proper glove removal technique (without touching glove's outer surface) to avoid skin contact with this product. Dispose of contaminated gloves after use in accordance with applicable laws and good laboratory practices. Wash and dry hands.

Full contact
Material: Nitrile rubber
Minimum layer thickness: 0.11 mm
Break through time: 480 min
Material tested:Dermatril® (KCL 740 / Aldrich Z677272, Size M)

Splash contact
Material: Nitrile rubber
Minimum layer thickness: 0.11 mm
Break through time: 480 min
Material tested:Dermatril® (KCL 740 / Aldrich Z677272, Size M)

data source: KCL GmbH, D-36124 Eichenzell, phone +49 (0)6659 87300, e-mail sales@kcl.de, test method: EN374
If used in solution, or mixed with other substances, and under conditions which differ from EN 374, contact the supplier of the CE approved gloves. This recommendation is advisory only and must be evaluated by an industrial hygienist and safety officer familiar with the specific situation of anticipated use by our customers. It should not be construed as offering an approval for any specific use scenario.

Body Protection
impervious clothing, The type of protective equipment must be selected according to the concentration and amount of the dangerous substance at the specific workplace.

Respiratory protection
For nuisance exposures use type P95 (US) or type P1 (EU EN 143) particle respirator.For higher level protection use type OV/AG/P99 (US) or type ABEK-P2 (EU EN 143) respirator cartridges. Use respirators and components tested and approved under appropriate government standards such as NIOSH (US) or CEN (EU).

Control of environmental exposure
Do not let product enter drains.

9. PHYSICAL AND CHEMICAL PROPERTIES

9.1 Information on basic physical and chemical properties

a)	Appearance	Form: crystalline Colour: white
b)	Odour	No data available
c)	Odour Threshold	No data available
d)	pH	1.8 at ca.50 g/l at 25 °C (77 °F)
e)	Melting point/freezing point	Melting point/range: 153 - 159 °C (307 - 318 °F) - lit.
f)	Initial boiling point and boiling range	No data available
g)	Flash point	No data available
h)	Evaporation rate	No data available
i)	Flammability (solid, gas)	No data available
j)	Upper/lower flammability or explosive limits	Lower explosion limit: 8 %(V)
k)	Vapour pressure	No data available
l)	Vapour density	No data available
m)	Relative density	No data available
n)	Water solubility	383 g/l at 25 °C (77 °F)
o)	Partition coefficient: n-octanol/water	log Pow: -1.639 at 20 °C (68 °F)
p)	Auto-ignition temperature	No data available
q)	Decomposition temperature	No data available
r)	Viscosity	No data available
s)	Explosive properties	No data available
t)	Oxidizing properties	No data available

9.2 Other safety information
No data available

10. STABILITY AND REACTIVITY

10.1 Reactivity
No data available

10.2 Chemical stability
Stable under recommended storage conditions.

10.3 Possibility of hazardous reactions
No data available

10.4 Conditions to avoid
No data available

10.5 Incompatible materials
Oxidizing agents, Bases, Reducing agents, Nitrates

10.6 Hazardous decomposition products

Other decomposition products - No data available
In the event of fire: see section 5

11. TOXICOLOGICAL INFORMATION

11.1 Information on toxicological effects

Acute toxicity
LD50 Oral - Rat - 5,400 mg/kg
(OECD Test Guideline 401)

Inhalation: No data available

LD50 Dermal - Rat - > 2,000 mg/kg
(OECD Test Guideline 402)

No data available

Skin corrosion/irritation
Skin - Rabbit
Result: Mild skin irritation
(OECD Test Guideline 404)

Serious eye damage/eye irritation
Eyes - Rabbit
Result: Irritating to eyes.
(OECD Test Guideline 405)

Respiratory or skin sensitisation
Prolonged or repeated exposure may cause allergic reactions in certain sensitive individuals.

Germ cell mutagenicity
No data available

Carcinogenicity

IARC:	No component of this product present at levels greater than or equal to 0.1% is identified as probable, possible or confirmed human carcinogen by IARC.
ACGIH:	No component of this product present at levels greater than or equal to 0.1% is identified as a carcinogen or potential carcinogen by ACGIH.
NTP:	No component of this product present at levels greater than or equal to 0.1% is identified as a known or anticipated carcinogen by NTP.
OSHA:	No component of this product present at levels greater than or equal to 0.1% is identified as a carcinogen or potential carcinogen by OSHA.

Reproductive toxicity
No data available

No data available

Specific target organ toxicity - single exposure
No data available

Specific target organ toxicity - repeated exposure
No data available

Aspiration hazard
No data available

Additional Information
RTECS: GE7350000

Vomiting, Diarrhoea, Damage to tooth enamel., Dermatitis, To the best of our knowledge, the chemical, physical, and toxicological properties have not been thoroughly investigated.

12. ECOLOGICAL INFORMATION

12.1 Toxicity

Toxicity to fish	mortality LC50 - Leuciscus idus melanotus - 440 mg/l - 48 h (OECD Test Guideline 203)
Toxicity to daphnia and other aquatic invertebrates	static test - Daphnia magna (Water flea) - 1,535 mg/l - 24 h

12.2 Persistence and degradability
No data available

12.3 Bioaccumulative potential
No data available

12.4 Mobility in soil
No data available

12.5 Results of PBT and vPvB assessment
PBT/vPvB assessment not available as chemical safety assessment not required/not conducted

12.6 Other adverse effects

No data available

13. DISPOSAL CONSIDERATIONS

13.1 Waste treatment methods

Product
Offer surplus and non-recyclable solutions to a licensed disposal company. Contact a licensed professional waste disposal service to dispose of this material.

Contaminated packaging
Dispose of as unused product.

14. TRANSPORT INFORMATION

DOT (US)
Not dangerous goods

IMDG
Not dangerous goods

IATA
Not dangerous goods

15. REGULATORY INFORMATION

SARA 302 Components
No chemicals in this material are subject to the reporting requirements of SARA Title III, Section 302.

SARA 313 Components
This material does not contain any chemical components with known CAS numbers that exceed the threshold (De Minimis) reporting levels established by SARA Title III, Section 313.

SARA 311/312 Hazards
Acute Health Hazard

Massachusetts Right To Know Components
No components are subject to the Massachusetts Right to Know Act.

Pennsylvania Right To Know Components

	CAS-No.	Revision Date
Citric acid	77-92-9	

New Jersey Right To Know Components

	CAS-No.	Revision Date
Citric acid	77-92-9	

California Prop. 65 Components
This product does not contain any chemicals known to State of California to cause cancer, birth defects, or any other reproductive harm.

16. OTHER INFORMATION

Full text of H-Statements referred to under sections 2 and 3.

Eye Irrit.	Eye irritation
H319	Causes serious eye irritation.

HMIS Rating

Health hazard:	2
Chronic Health Hazard:	
Flammability:	0
Physical Hazard	0

NFPA Rating

Health hazard:	2
Fire Hazard:	0
Reactivity Hazard:	0

Further information

The above information is believed to be correct but does not purport to be all inclusive and shall be used only as a guide. The information in this document is based on the present state of our knowledge and is applicable to the product with regard to appropriate safety precautions. It does not represent any guarantee of the properties of the product. Sigma-Aldrich Corporation and its Affiliates shall not be held liable for any damage resulting from handling or from contact with the above product. See www.sigma-aldrich.com and/or the reverse side of invoice or packing slip for additional terms and conditions of sale.

Preparation Information
Sigma-Aldrich Corporation
Product Safety – Americas Region
1-800-521-8956

Version: 4.6 Revision Date: 11/18/2014 Print Date: 04/12/2015

SAFETY DATA SHEET

Version 5.2
Revision Date 07/16/2014
Print Date 04/13/2015

1. PRODUCT AND COMPANY IDENTIFICATION

1.1 Product identifiers

Product name : Fibrinogen, from human plasma

Product Number : F4129
Brand : Sigma

CAS-No. : 9001-32-5

1.2 Relevant identified uses of the substance or mixture and uses advised against

Identified uses : Laboratory chemicals, Manufacture of substances

1.3 Details of the supplier of the safety data sheet

Company : Sigma-Aldrich
3050 Spruce Street
SAINT LOUIS MO 63103
USA

Telephone : +1 800-325-5832
Fax : +1 800-325-5052

1.4 Emergency telephone number

Emergency Phone # : (314) 776-6555

2. HAZARDS IDENTIFICATION

2.1 Classification of the substance or mixture

Not a hazardous substance or mixture.

2.2 GHS Label elements, including precautionary statements

Not a hazardous substance or mixture.

2.3 Hazards not otherwise classified (HNOC) or not covered by GHS

Handle as if capable of transmitting infectious agents.

3. COMPOSITION/INFORMATION ON INGREDIENTS

3.2 Mixtures

Synonyms : Factor I

No ingredients are hazardous according to OSHA criteria.
No components need to be disclosed according to the applicable regulations.

4. FIRST AID MEASURES

4.1 Description of first aid measures

If inhaled
If breathed in, move person into fresh air. If not breathing, give artificial respiration.

In case of skin contact
Wash off with soap and plenty of water.

In case of eye contact
Flush eyes with water as a precaution.

If swallowed
Never give anything by mouth to an unconscious person. Rinse mouth with water.

4.2 Most important symptoms and effects, both acute and delayed
The most important known symptoms and effects are described in the labelling (see section 2.2) and/or in section 11

4.3 Indication of any immediate medical attention and special treatment needed
no data available

5. FIREFIGHTING MEASURES

5.1 Extinguishing media

Suitable extinguishing media
Use water spray, alcohol-resistant foam, dry chemical or carbon dioxide.

5.2 Special hazards arising from the substance or mixture
Carbon oxides, Hydrogen chloride gas, Sodium oxides

5.3 Advice for firefighters
Wear self contained breathing apparatus for fire fighting if necessary.

5.4 Further information
no data available

6. ACCIDENTAL RELEASE MEASURES

6.1 Personal precautions, protective equipment and emergency procedures
Avoid dust formation. Avoid breathing vapours, mist or gas.
For personal protection see section 8.

6.2 Environmental precautions
Do not let product enter drains.

6.3 Methods and materials for containment and cleaning up
Sweep up and shovel. Keep in suitable, closed containers for disposal.

6.4 Reference to other sections
For disposal see section 13.

7. HANDLING AND STORAGE

7.1 Precautions for safe handling
Provide appropriate exhaust ventilation at places where dust is formed.
For precautions see section 2.2.

7.2 Conditions for safe storage, including any incompatibilities
Keep container tightly closed in a dry and well-ventilated place.

Recommended storage temperature: -20 °C

7.3 Specific end use(s)
Apart from the uses mentioned in section 1.2 no other specific uses are stipulated

8. EXPOSURE CONTROLS/PERSONAL PROTECTION

8.1 Control parameters

Components with workplace control parameters
Contains no substances with occupational exposure limit values.

8.2 Exposure controls

Appropriate engineering controls
General industrial hygiene practice.

Personal protective equipment

Eye/face protection
Use equipment for eye protection tested and approved under appropriate government standards such as NIOSH (US) or EN 166(EU).

Skin protection
Handle with gloves. Gloves must be inspected prior to use. Use proper glove removal technique (without touching glove's outer surface) to avoid skin contact with this product. Dispose of contaminated gloves after use in accordance with applicable laws and good laboratory practices. Wash and dry hands.

Body Protection
Choose body protection in relation to its type, to the concentration and amount of dangerous substances, and to the specific work-place., The type of protective equipment must be selected according to the concentration and amount of the dangerous substance at the specific workplace.

Respiratory protection
Respiratory protection is not required. Where protection from nuisance levels of dusts are desired, use type N95 (US) or type P1 (EN 143) dust masks. Use respirators and components tested and approved under appropriate government standards such as NIOSH (US) or CEN (EU).

Control of environmental exposure
Do not let product enter drains.

9. PHYSICAL AND CHEMICAL PROPERTIES

9.1 Information on basic physical and chemical properties

a)	Appearance	Form: solid
b)	Odour	no data available
c)	Odour Threshold	no data available
d)	pH	no data available
e)	Melting point/freezing point	no data available
f)	Initial boiling point and boiling range	no data available
g)	Flash point	no data available
h)	Evapouration rate	no data available
i)	Flammability (solid, gas)	no data available
j)	Upper/lower flammability or explosive limits	no data available
k)	Vapour pressure	no data available
l)	Vapour density	no data available
m)	Relative density	no data available
n)	Water solubility	no data available
o)	Partition coefficient: n-octanol/water	no data available
p)	Auto-ignition temperature	no data available
q)	Decomposition temperature	no data available
r)	Viscosity	no data available
s)	Explosive properties	no data available
t)	Oxidizing properties	no data available

9.2 Other safety information
no data available

10. STABILITY AND REACTIVITY

10.1 Reactivity
no data available

10.2 Chemical stability
Stable under recommended storage conditions.

10.3 Possibility of hazardous reactions
no data available

10.4 Conditions to avoid
no data available

10.5 Incompatible materials
Strong oxidizing agents

10.6 Hazardous decomposition products
Other decomposition products - no data available
In the event of fire: see section 5

11. TOXICOLOGICAL INFORMATION

11.1 Information on toxicological effects

Acute toxicity
no data available

Inhalation: no data available

Dermal: no data available

no data available

Skin corrosion/irritation
no data available

Serious eye damage/eye irritation
no data available

Respiratory or skin sensitisation
no data available

Germ cell mutagenicity
no data available

Carcinogenicity

IARC: No component of this product present at levels greater than or equal to 0.1% is identified as probable, possible or confirmed human carcinogen by IARC.

ACGIH: No component of this product present at levels greater than or equal to 0.1% is identified as a carcinogen or potential carcinogen by ACGIH.

NTP: No component of this product present at levels greater than or equal to 0.1% is identified as a known or anticipated carcinogen by NTP.

OSHA: No component of this product present at levels greater than or equal to 0.1% is identified as a carcinogen or potential carcinogen by OSHA.

Reproductive toxicity
no data available
no data available

Specific target organ toxicity - single exposure
no data available

Specific target organ toxicity - repeated exposure
no data available

Aspiration hazard
no data available

Additional Information
RTECS: Not available

To the best of our knowledge, the chemical, physical, and toxicological properties have not been thoroughly investigated.

12. ECOLOGICAL INFORMATION

12.1 Toxicity
no data available

12.2 Persistence and degradability
no data available

12.3 Bioaccumulative potential
no data available

12.4 Mobility in soil
no data available

12.5 Results of PBT and vPvB assessment
PBT/vPvB assessment not available as chemical safety assessment not required/not conducted

12.6 Other adverse effects
no data available

13. DISPOSAL CONSIDERATIONS

13.1 Waste treatment methods

Product
Offer surplus and non-recyclable solutions to a licensed disposal company.

Contaminated packaging
Dispose of as unused product.

14. TRANSPORT INFORMATION

DOT (US)
Not dangerous goods

IMDG
Not dangerous goods

IATA
Not dangerous goods

15. REGULATORY INFORMATION

SARA 302 Components
SARA 302: No chemicals in this material are subject to the reporting requirements of SARA Title III, Section 302.

SARA 313 Components
SARA 313: This material does not contain any chemical components with known CAS numbers that exceed the threshold (De Minimis) reporting levels established by SARA Title III, Section 313.

SARA 311/312 Hazards
No SARA Hazards

Massachusetts Right To Know Components
No components are subject to the Massachusetts Right to Know Act.

Pennsylvania Right To Know Components

	CAS-No.	Revision Date
Fibrinogens	9001-32-5	

Sodium chloride	7647-14-5
Trisodium citrate	6132-04-3

New Jersey Right To Know Components

	CAS-No.	Revision Date
Fibrinogens	9001-32-5	
Sodium chloride	7647-14-5	
Trisodium citrate	6132-04-3	

California Prop. 65 Components

This product does not contain any chemicals known to State of California to cause cancer, birth defects, or any other reproductive harm.

16. OTHER INFORMATION

HMIS Rating

Health hazard:	1
Chronic Health Hazard:	
Flammability:	0
Physical Hazard	0

NFPA Rating

Health hazard:	1
Fire Hazard:	0
Reactivity Hazard:	0

Further information

The above information is believed to be correct but does not purport to be all inclusive and shall be used only as a guide. The information in this document is based on the present state of our knowledge and is applicable to the product with regard to appropriate safety precautions. It does not represent any guarantee of the properties of the product. Sigma-Aldrich Corporation and its Affiliates shall not be held liable for any damage resulting from handling or from contact with the above product. See www.sigma-aldrich.com and/or the reverse side of invoice or packing slip for additional terms and conditions of sale.

Preparation Information

Sigma-Aldrich Corporation
Product Safety – Americas Region
1-800-521-8956

Version: 5.2 Revision Date: 07/16/2014 Print Date: 04/13/2015

SAFETY DATA SHEET

Version 4.5
Revision Date 06/28/2014
Print Date 04/13/2015

1. PRODUCT AND COMPANY IDENTIFICATION

1.1 Product identifiers

Product name : Thrombin, from human plasma

Product Number : T1063
Brand : Sigma
Index-No. : 647-014-00-9

CAS-No. : 9002-04-4

1.2 Relevant identified uses of the substance or mixture and uses advised against

Identified uses : Laboratory chemicals, Manufacture of substances

1.3 Details of the supplier of the safety data sheet

Company : Sigma-Aldrich
3050 Spruce Street
SAINT LOUIS MO 63103
USA

Telephone : +1 800-325-5832
Fax : +1 800-325-5052

1.4 Emergency telephone number

Emergency Phone # : (314) 776-6555

2. HAZARDS IDENTIFICATION

2.1 Classification of the substance or mixture

GHS Classification in accordance with 29 CFR 1910 (OSHA HCS)
Skin irritation (Category 2), H315
Eye irritation (Category 2A), H319
Respiratory sensitisation (Category 1), H334
Skin sensitisation (Category 1), H317
Specific target organ toxicity - single exposure (Category 3), Respiratory system, H335

For the full text of the H-Statements mentioned in this Section, see Section 16.

2.2 GHS Label elements, including precautionary statements

Pictogram

Signal word Danger

Hazard statement(s)
H315 Causes skin irritation.
H317 May cause an allergic skin reaction.
H319 Causes serious eye irritation.
H334 May cause allergy or asthma symptoms or breathing difficulties if inhaled.
H335 May cause respiratory irritation.

Precautionary statement(s)
P261 Avoid breathing dust/ fume/ gas/ mist/ vapours/ spray.
P264 Wash skin thoroughly after handling.
P271 Use only outdoors or in a well-ventilated area.

P272	Contaminated work clothing should not be allowed out of the workplace.
P280	Wear protective gloves/ eye protection/ face protection.
P285	In case of inadequate ventilation wear respiratory protection.
P302 + P352	IF ON SKIN: Wash with plenty of soap and water.
P304 + P340	IF INHALED: Remove victim to fresh air and keep at rest in a position comfortable for breathing.
P305 + P351 + P338	IF IN EYES: Rinse cautiously with water for several minutes. Remove contact lenses, if present and easy to do. Continue rinsing.
P321	Specific treatment (see supplemental first aid instructions on this label).
P333 + P313	If skin irritation or rash occurs: Get medical advice/ attention.
P337 + P313	If eye irritation persists: Get medical advice/ attention.
P342 + P311	If experiencing respiratory symptoms: Call a POISON CENTER or doctor/ physician.
P362	Take off contaminated clothing and wash before reuse.
P403 + P233	Store in a well-ventilated place. Keep container tightly closed.
P405	Store locked up.
P501	Dispose of contents/ container to an approved waste disposal plant.

2.3 Hazards not otherwise classified (HNOC) or not covered by GHS - none

3. COMPOSITION/INFORMATION ON INGREDIENTS

3.1 Substances

Synonyms : Factor IIa

CAS-No. : 9002-04-4
EC-No. : 232-648-7
Index-No. : 647-014-00-9

Hazardous components

Component	Classification	Concentration
thrombin		
	Skin Irrit. 2; Eye Irrit. 2A; Resp. Sens. 1; Skin Sens. 1; STOT SE 3; H315, H317, H319, H334, H335	-

For the full text of the H-Statements mentioned in this Section, see Section 16.

4. FIRST AID MEASURES

4.1 Description of first aid measures

General advice
Consult a physician. Show this safety data sheet to the doctor in attendance.Move out of dangerous area.

If inhaled
If breathed in, move person into fresh air. If not breathing, give artificial respiration. Consult a physician.

In case of skin contact
Wash off with soap and plenty of water. Consult a physician.

In case of eye contact
Rinse thoroughly with plenty of water for at least 15 minutes and consult a physician.

If swallowed
Never give anything by mouth to an unconscious person. Rinse mouth with water. Consult a physician.

4.2 Most important symptoms and effects, both acute and delayed
The most important known symptoms and effects are described in the labelling (see section 2.2) and/or in section 11

4.3 Indication of any immediate medical attention and special treatment needed
no data available

5. FIREFIGHTING MEASURES

5.1 Extinguishing media

Suitable extinguishing media
Use water spray, alcohol-resistant foam, dry chemical or carbon dioxide.

5.2 Special hazards arising from the substance or mixture
Nature of decomposition products not known.

5.3 Advice for firefighters
Wear self contained breathing apparatus for fire fighting if necessary.

5.4 Further information
no data available

6. ACCIDENTAL RELEASE MEASURES

6.1 Personal precautions, protective equipment and emergency procedures
Use personal protective equipment. Avoid dust formation. Avoid breathing vapours, mist or gas. Ensure adequate ventilation. Evacuate personnel to safe areas. Avoid breathing dust.
For personal protection see section 8.

6.2 Environmental precautions
Do not let product enter drains.

6.3 Methods and materials for containment and cleaning up
Pick up and arrange disposal without creating dust. Sweep up and shovel. Keep in suitable, closed containers for disposal.

6.4 Reference to other sections
For disposal see section 13.

7. HANDLING AND STORAGE

7.1 Precautions for safe handling
Avoid contact with skin and eyes. Avoid formation of dust and aerosols.
Provide appropriate exhaust ventilation at places where dust is formed.
For precautions see section 2.2.

7.2 Conditions for safe storage, including any incompatibilities
Keep container tightly closed in a dry and well-ventilated place.

Recommended storage temperature: -20 °C

Keep in a dry place.

7.3 Specific end use(s)
Apart from the uses mentioned in section 1.2 no other specific uses are stipulated

8. EXPOSURE CONTROLS/PERSONAL PROTECTION

8.1 Control parameters

Components with workplace control parameters
Contains no substances with occupational exposure limit values.

8.2 Exposure controls

Appropriate engineering controls
Handle in accordance with good industrial hygiene and safety practice. Wash hands before breaks and at the end of workday.

Personal protective equipment

Eye/face protection
Face shield and safety glasses Use equipment for eye protection tested and approved under appropriate government standards such as NIOSH (US) or EN 166(EU).

Skin protection
Handle with gloves. Gloves must be inspected prior to use. Use proper glove removal technique (without touching glove's outer surface) to avoid skin contact with this product. Dispose of contaminated gloves after use in accordance with applicable laws and good laboratory practices. Wash and dry hands.

Full contact
Material: Nitrile rubber
Minimum layer thickness: 0.11 mm
Break through time: 480 min
Material tested:Dermatril® (KCL 740 / Aldrich Z677272, Size M)

Splash contact
Material: Nitrile rubber
Minimum layer thickness: 0.11 mm
Break through time: 480 min
Material tested:Dermatril® (KCL 740 / Aldrich Z677272, Size M)

data source: KCL GmbH, D-36124 Eichenzell, phone +49 (0)6659 87300, e-mail sales@kcl.de, test method: EN374
If used in solution, or mixed with other substances, and under conditions which differ from EN 374, contact the supplier of the CE approved gloves. This recommendation is advisory only and must be evaluated by an industrial hygienist and safety officer familiar with the specific situation of anticipated use by our customers. It should not be construed as offering an approval for any specific use scenario.

Body Protection
Complete suit protecting against chemicals, The type of protective equipment must be selected according to the concentration and amount of the dangerous substance at the specific workplace.

Respiratory protection
For nuisance exposures use type P95 (US) or type P1 (EU EN 143) particle respirator.For higher level protection use type OV/AG/P99 (US) or type ABEK-P2 (EU EN 143) respirator cartridges. Use respirators and components tested and approved under appropriate government standards such as NIOSH (US) or CEN (EU).

Control of environmental exposure
Do not let product enter drains.

9. PHYSICAL AND CHEMICAL PROPERTIES

9.1 Information on basic physical and chemical properties

a)	Appearance	Form: powder, lyophilized Colour: white
b)	Odour	no data available
c)	Odour Threshold	no data available
d)	pH	no data available
e)	Melting point/freezing point	no data available
f)	Initial boiling point and boiling range	no data available
g)	Flash point	no data available
h)	Evapouration rate	no data available
i)	Flammability (solid, gas)	no data available
j)	Upper/lower flammability or explosive limits	no data available
k)	Vapour pressure	no data available
l)	Vapour density	no data available
m)	Relative density	no data available
n)	Water solubility	no data available

o)	Partition coefficient: n-octanol/water	no data available
p)	Auto-ignition temperature	no data available
q)	Decomposition temperature	no data available
r)	Viscosity	no data available
s)	Explosive properties	no data available
t)	Oxidizing properties	no data available

9.2 Other safety information
no data available

10. STABILITY AND REACTIVITY

10.1 Reactivity
no data available

10.2 Chemical stability
Stable under recommended storage conditions.

10.3 Possibility of hazardous reactions
no data available

10.4 Conditions to avoid
no data available

10.5 Incompatible materials
Strong oxidizing agents

10.6 Hazardous decomposition products
Other decomposition products - no data available
In the event of fire: see section 5

11. TOXICOLOGICAL INFORMATION

11.1 Information on toxicological effects

Acute toxicity
no data available

Inhalation: no data available

LD50 Dermal - mouse - > 3,000 mg/kg
Remarks: Behavioral:Somnolence (general depressed activity). Lungs, Thorax, or Respiration:Dyspnea. Skin and Appendages: Other: Hair.

no data available

Skin corrosion/irritation
no data available

Serious eye damage/eye irritation
no data available

Respiratory or skin sensitisation
no data available

Germ cell mutagenicity
mouse
fibroblast
Morphological transformation.

Chicken
Embryo
Unscheduled DNA synthesis

Carcinogenicity

IARC: No component of this product present at levels greater than or equal to 0.1% is identified as probable, possible or confirmed human carcinogen by IARC.

ACGIH: No component of this product present at levels greater than or equal to 0.1% is identified as a carcinogen or potential carcinogen by ACGIH.

NTP: No component of this product present at levels greater than or equal to 0.1% is identified as a known or anticipated carcinogen by NTP.

OSHA: No component of this product present at levels greater than or equal to 0.1% is identified as a carcinogen or potential carcinogen by OSHA.

Reproductive toxicity
no data available

no data available

Specific target organ toxicity - single exposure
no data available

Specific target organ toxicity - repeated exposure
no data available

Aspiration hazard
no data available

Additional Information
RTECS: Not available

Involved in clotting., To the best of our knowledge, the chemical, physical, and toxicological properties have not been thoroughly investigated.

12. ECOLOGICAL INFORMATION

12.1 Toxicity
no data available

12.2 Persistence and degradability
no data available

12.3 Bioaccumulative potential
no data available

12.4 Mobility in soil
no data available

12.5 Results of PBT and vPvB assessment
PBT/vPvB assessment not available as chemical safety assessment not required/not conducted

12.6 Other adverse effects

no data available

13. DISPOSAL CONSIDERATIONS

13.1 Waste treatment methods

Product
Offer surplus and non-recyclable solutions to a licensed disposal company. Contact a licensed professional waste disposal service to dispose of this material. Dissolve or mix the material with a combustible solvent and burn in a chemical incinerator equipped with an afterburner and scrubber.

Contaminated packaging
Dispose of as unused product.

14. TRANSPORT INFORMATION

DOT (US)
Not dangerous goods

IMDG
Not dangerous goods

IATA
Not dangerous goods

15. REGULATORY INFORMATION

SARA 302 Components
SARA 302: No chemicals in this material are subject to the reporting requirements of SARA Title III, Section 302.

SARA 313 Components
SARA 313: This material does not contain any chemical components with known CAS numbers that exceed the threshold (De Minimis) reporting levels established by SARA Title III, Section 313.

SARA 311/312 Hazards
Acute Health Hazard

Massachusetts Right To Know Components
No components are subject to the Massachusetts Right to Know Act.

Pennsylvania Right To Know Components

	CAS-No.	Revision Date
thrombin	9002-04-4	

New Jersey Right To Know Components

	CAS-No.	Revision Date
thrombin	9002-04-4	

California Prop. 65 Components
This product does not contain any chemicals known to State of California to cause cancer, birth defects, or any other reproductive harm.

16. OTHER INFORMATION

Full text of H-Statements referred to under sections 2 and 3.

Eye Irrit.	Eye irritation
H315	Causes skin irritation.
H317	May cause an allergic skin reaction.
H319	Causes serious eye irritation.
H334	May cause allergy or asthma symptoms or breathing difficulties if inhaled.
H335	May cause respiratory irritation.
Resp. Sens.	Respiratory sensitisation
Skin Irrit.	Skin irritation
Skin Sens.	Skin sensitisation

HMIS Rating

Health hazard:	2
Chronic Health Hazard:	*
Flammability:	0
Physical Hazard	0

NFPA Rating

Health hazard:	2
Fire Hazard:	0
Reactivity Hazard:	0

Further information

The above information is believed to be correct but does not purport to be all inclusive and shall be used only as a guide. The information in this document is based on the present state of our knowledge and is applicable to the product with regard to appropriate safety precautions. It does not represent any guarantee of the properties of the

product. Sigma-Aldrich Corporation and its Affiliates shall not be held liable for any damage resulting from handling or from contact with the above product. See www.sigma-aldrich.com and/or the reverse side of invoice or packing slip for additional terms and conditions of sale.

Preparation Information
Sigma-Aldrich Corporation
Product Safety – Americas Region
1-800-521-8956

Version: 4.5 Revision Date: 06/28/2014 Print Date: 04/13/2015

pneumatic scale ANGELUS

A Barry-Wehmiller Company

CARR Centritech Separation Systems

CARR® ViaFuge® Pilot

Key Features

- Gentle cell harvesting and supernatant recovery
- Simple operation
- Improved product processing
- Low-shear design
- Flexible optimization
- State-of-the-art manufacturing facility located in Clearwater, Florida.

CARR Centritech Separation Systems
CARR® ViaFuge® Pilot

PSA's unique CARR ViaFuge Pilot is designed for fast, gentle, small- to medium-scale cell harvesting and supernatant recovery. Capable of separating a wide variety of mammalian and insect cells with little to no damage, the ViaFuge Pilot offers intact cell recovery efficiencies in excess of 99% with non-detectable cell concentrations in clarified supernatant.

Simple Operation

Cells are concentrated at the bowl wall while clarified supernatant is continuously discharged throughout the separation process. Once the bowl fills with cell concentrate to a capacity of 1.3 L, a simple manifold system and concentrate pump is utilized to recover the cells without breaking containment. Subsequent cycles are performed for recovery of larger batch sizes.

Improved Product Processing

Cellular damage can result in release of intracellular material such as DNA, which may increase downstream processing and in some cases impact product purity. Because the ViaFuge Pilot is gentle to cells, damage is minimized from the start of the process. For supernatant recovery applications, filtration requirements downstream may be reduced. For cell harvesting applications, intact cell recovery will be increased.

Low-Shear Design

The ViaFuge Pilot's unique design minimizes shear forces on cells. Incoming feed is matched to the bowl hub's rotational velocity, allowing fast, efficient harvesting of even the most shear-sensitive cells without causing cell damage.

Flexible Optimization

Flexible operating conditions offer optimization for specific applications with a flow rate range of 0.1-4.0 L/min and a relative centrifugal force range of 500-10,000g. For mammalian cell culture, concentration to 2.5 ↔ 10^7 cells/ml can be achieved.

Machine Specifications

UTILITY REQUIREMENTS:

Power configurations: 120V, 15A, 1.0 Hp, 50/60Hz

CONSTRUCTION:

Process parts:	**316L SS/titanium alloy**
Non-wetted parts:	**316L SS**
Elastomers:	**EPDM**

DIMENSIONS & ORDER INFORMATION - 120V VERSION:

Centrifuge w/SIP:	**33.0 in Wx 39.5 in D x 42.5 in H**
	840 mm x 1000 mm x 1080 mm
Centrifuge w/o SIP:	**19.0 in Wx 33.5 in D x 35 in H**
	480 mm x 850 mm x 890 mm
Controller:	**13.0 in Wx 13.0 in D x 23.0 in H**
	330 mm x 330 mm x 580 mm
Weights:	
Centrifuge w/SIP:	**270 lbs (123 kg)**
Centrifuge w/o SIP:	**240 lbs (109 kg)**
Controller:	**38 lbs (17 kg)**

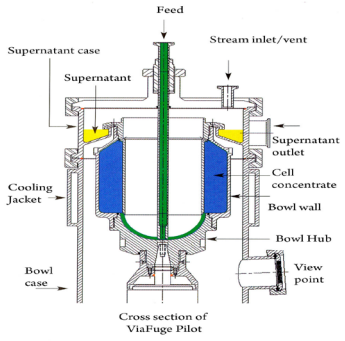
OPERATING SPECIFICATIONS:

Feed flow range:	**0.1 - 4 L/min***
Bowl capacity:	**1.3 Liters**
RCF range:	**500 - 10,000 x g**
RPM range:	**2,420 - 10,832 rpm**

Operating temp. range: 2º - 40º C (5º - 40º C-O(eversion)

Maximum temp. for SIP: 134º C

*** Actual capacity (throughput) is dependent on the characteristics of the fluids.**



Cross section of ViaFuge Pilot

pneumatic scale ANGELUS®
A Barry-Wehmiller Company

4485 Allen Road | Stow, OH 44224 | +1 (330) 923-0491
www.pneumaticscaleangelus.com | sales@psanglelus.com

pneumatic scale ANGELUS

A Barry-Wehmiller Company

CARR Centritech Separation Systems

CARR® Powerfuge® P18

Key Features

- Drier solids and clear liquids
- Sealed automatic operation
- Full CIP/SIP designs
- cGMP construction
- Designs available for ASME-rated
- boundary, hazardous locations and aseptic operations
- State-of-the-art manufacturing facility located in Clearwater, FL.

CARR Centritech Separation Systems

CARR® Powerfuge® P18

PSA's unique CARR P18 Powerfuge System provides continuous-flow two-phase separation of solids and liquids at rates up to 1,700 liters/hour for batches up to 10,000 liters. Using an innovative design, the feed is introduced through a stationary pipe and accelerated to full rotational speed before entering the titanium-alloy bowl. In this system, centrifugal forces as great as 20,000g permit separation of even sub-micron particles. Compressed solids are periodically removed with a fully-automated scraping cycle. After the solids have been discharged, automated CIP/SIP cycles can be performed via the PLC-controlled operating sequence.

The P18 is designed for ease of operation, with seal feed and drain lines allowing for aerosol-free operation. Similarly, no special tools are required to disassemble the system. Integrated turnkey systems incorporating feed delivery options, CIP and SIP skids, temperature control, and closed-loop centrate pumping under vacuum are available.* The P18 system meets cGMP and CE requirements and has been validated to meet chemical and pharmaceutical industry protocols. The P18 is engineered to optimize ease of operation while maximizing throughput; each step in the process can be readily automated so that time spent on routine maintenance can be minimized.

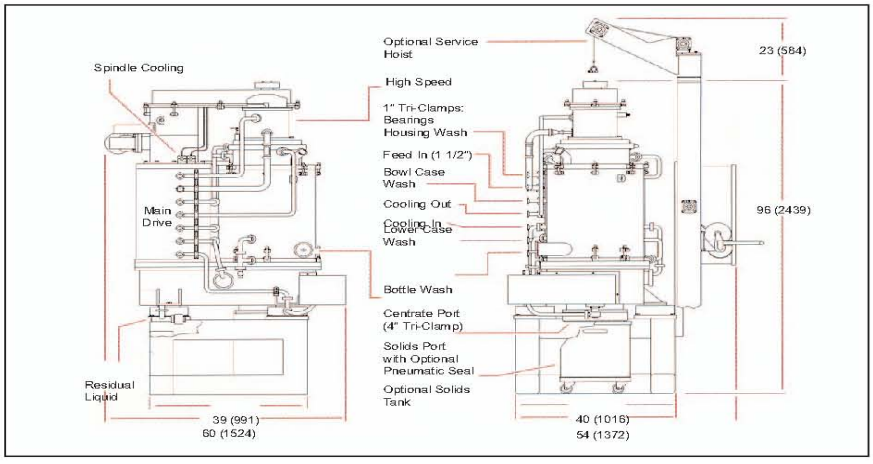
Machine Specifications

DATA -

Force (variable):	Up to 20,000g (ρ<1.5 kg/L) (Inquire for higher density solids)
Power (standard):	(20 or 30 HP), 480 VAC, 50/60 Hz, 3 Phase *(Other options available)*
Construction:	
Process Parts:	316L SS/Ti-6AL-4V
Non-wetted Parts:	316 and 304 SS
Dimensions:	60 in (1524 mm) L x 54 in (1372 mm) W x 96 in (2439 mm) H
Weight:	5,000 lb. (2272.7 kg)

*CAPACITY** -*

Flow Rate:	1,700 Liter/hour (nominal)
Bowl Volume:	36 Liters
Solids Space:	32 Liter (nominal)
Discharge (typical):	5 Minutes (adjustable)



* *Vessels designed for integration with the P18 for vacuum operation and solids handling are available.*

** *Actual capacity (throughput) is dependent on the characteristics of the fluids, amount and type of the solids and required degree of clarification. Practical capacities may differ substantially for your applications.*

Note: Dimensions are displayed in inches (millimeters).

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A Barry-Wehmiller Company

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AxiChrom™ columns

The AxiChrom column platform is a revolutionary concept in column chromatography that simplifies column handling at all scales from process development to full-scale production. AxiChrom columns (Fig 1) introduce three key features – Intelligent Packing, Intuitive handling, and Predictable scale-up – that together make process chromatography easier, safer, and more efficient.

Intelligent Packing: Verified, preprogrammed, axial compression packing methods save time and ensure accurate and reproducible packing results. This built-in experience reduces operator-dependence and facilitates faster product change-over.

Intuitive handling: Columns are simple to operate and service. Pivot or swing-out column tubes are safer and easier to handle. AxiChrom Master and UNICORN™ wizards guide users through key process steps to save time in method creation, set-up and maintenance.

Predictable scale-up: Straightforward scale-up and tech-transfer due to a liquid distribution system designed using the same analytical and computational fluid dynamic (CFD) modeling tools. Sanitizable columns support cleaning validation. Full technical and regulatory support promote fast, trouble-free start-up.

The entire AxiChrom column line, from 50 to 1000 mm, has been verified to give superior performance with new-generation, high-flow Capto™ and MabSelect™ media families as well as with other BioProcess™ Media.

Fig 1. The AxiChrom range has a novel design that promotes easy handling and operation. This includes a swing-out column tube in larger dimensions and a pivot design for the smaller column tubes. AxiChrom Master is used to control the larger columns.

Column description

General

AxiChrom columns are low-pressure, axial compression chromatography columns for the process development and manufacturing of biopharmaceutical products. Many configuration possibilities (diameters, bed heights, materials of construction, etc.) combined with packing and maintenance that both reduce change-over time plus a widely applicable plastic bed support make the range ideal for multipurpose facilities.

Axial compression enables more accurate and reproducible control of the packing compared to a traditional flow pack, for example.

After consolidation, the bed is compressed to the pre-determined and verified Packing Factor (PF)[1] for superior chromatographic performance. A range of column sizes is available. The smallest (50 to 200 mm i.d.) have a stand with a pivot design. In larger columns (300 mm i.d and above), the tube swings out.

[1] Packing Factor (PF) is defined as:

Consolidated bed height/Packed bed height compared to traditional Gravity-settled bed height/Packed bed height.

The distribution system for all column dimensions is based on a design developed using analytical methods and modern CFD-modeling tools. This gives predictable results over the entire range of scales by ensuring uniform plug flow through the bed, irrespective of size.

When packing small columns, slurry is introduced by hand and adapter movement is driven by internal hydraulics. In large columns, slurry is introduced via a media valve in the center of the bottom bed support and the adapter is driven by an electric servo-motor. Control of the media valve, adapter and Intelligent Packing is done via AxiChrom Master. Intelligent Packing with preprogrammed methods supports all column sizes. The main framework specifications of large and small AxiChrom columns are given on page 9.

Materials of construction

Materials of construction are recognized for use in biopharmaceutical manufacture and fulfill the ASME Bioprocessing Equipment Standard when required. Wetted polymeric materials and elastomers meet the requirements of USP Class VI as described in USP Biological Reactivity Tests *In Vivo* <88>, 21 CFR Part 177. They are free from animal-derived components or in compliance with (EMEA/410/01 Rev.2). Pressure-retaining and wetted parts are traceable to batch level. Columns with all non-metallic wetted flow-paths for potentially corrosive processes, for example, can also be supplied. A plastic bed support (Fig. 2) can be fitted for such a purpose, or as a low-cost, single-use bed support for multi-purpose facilities.

Fig 2. Single-use, low-cost plastic bed supports are ideal for processes that risk corroding metal column parts. Quick to fit, they also add extra convenience when changing to new campaigns in multi-purpose facilities.

Construction materials in AxiChrom columns (see page 8) are resistant to most chemical agents used in chromatography, including buffer solutions for adsorption, elution and washing, and to solutions effective in cleaning, sanitization and storage. Table 1 lists the general chemical resistance of AxiChrom columns.

Table 1. General guideline to chemical resistance for AxiChrom columns

Chemical[9]	Concentration[1]	Time/cycle restrictions
Acetic acid	25%	3 h
Acetone	2%	1 h
Ammonium sulfate	2 M[2]	5 h
Benzyl alcohol	2%	12 months
Ethanol	20%	12 months and max. 0.5 bar
Ethanol	70%[4]	3 h
Ethanol/acetic acid	20%/10%	3 h
Guanidine hydrochloride	6 M[2,3,7]	5 h
Hydrochloric acid	0.1 M[3] (pH=1)	1 h
Isopropanol	10%/30%[4]	1 h
Phosphoric acid	5%	8 h
Sodium chloride	0–3 M[2,3,6,8]	3 h
Sodium hydroxide	1 M (pH=14)	24 h, room temp. to 30°C
Sodium hydroxide	0.01 M[5] (pH=12)	12 months
Sodium sulfate	1 M[2]	3 h
Sodium hydroxide/Ethanol	1 M/20%	3 h
Urea	8 M[2]	5 h
Commonly used aqueous buffers for chromatographic use	10–250 mM, pH 3–10	24 h

[1] V/v when given as a percentage.

[2] Solution pH depends on the pH of the buffer, which can vary between 3-13.

[3] pH below 4 is not recommended for SS.

[4] Glass and stainless steel column.

[5] Not glass column.

[6] Max 1.0 M NaCl is recommended for columns containing wetted stainless steel components.

[7] Not for use in columns containing wetted stainless steel components.

[8] Rinse with at least five column volumes of water after NaCl exposure. Store columns in solutions free from chloride ions.

[9] The information in Table 1 has been collected from several published sources, not from individual tests on column components. It should be used only as a guide. Maximum exposure times vary. The effect of chemicals will generally be more severe at higher temperatures. Note also that the combined effects of agents have not been taken into account in this table. The applicable chemical resistance depends on the configuration of the column and the associated materials of construction. Always refer to User Manuals or contact GE Healthcare for detailed information.

Media and system compatibility

AxiChrom columns are developed for use with high-flow agarose media such as Capto and MabSelect. This type of column/medium combination can help the drive towards lean biomanufacturing and operational excellence, where improvements bring more speed and better economy to downstream processing. AxiChrom columns are also compatible with other BioProcess Media.

Depending on column size, ÄKTA™ avant, ÄKTAexplorer™, ÄKTApilot™ or ÄKTAprocess™ will be the chromatography system of choice. Full utilization of the Intelligent Packing strategy requires one of these systems running UNICORN™ control software. For ÄKTAexplorer and ÄKTApilot, the special strategy for Intelligent Packing is delivered with the column.

Intelligent Packing

Intelligent Packing comprises UNICORN software-controlled packing of AxiChrom columns using an ÄKTAexplorer, ÄKTApilot, or ÄKTAprocess system (Fig 3). Larger columns can also be packed directly from the AxiChrom Master. For preprogrammed BioProcess media, Intelligent Packing ensures optimally-packed beds and decreases dependence on the operator. In addition, UNICORN enables online monitoring of packing progress, automatic packed bed evaluation testing, and creates result files including dates, times, operator and data that can be used with batch records.

Fig 3. Intelligent Packing greatly simplifies the packing of AxiChrom columns used with ÄKTA™ systems.

With axial compression and the Intelligent Packing user interface, customized methods for media other than BioProcess can be developed. Operator-independence in scale and location also makes packing a 'non-critical' event in tech-transfer, even when this takes place at manufacturing sites in other locations.

The operational experience built into Intelligent Packing facilitates other important aspects of production planning. For example, more accurate forecasting of media consumption eliminates undue waste and reduces the amount of safety stocks needed to be held on site. In addition, the axial compression packing technique itself has a number of inherent benefits. It gives optimally compressed beds every time, is quick to complete, and requires just one operator.

Intelligent Packing in small columns

The packing method is built by entering values for the packing variables in a UNICORN Intelligent Packing wizard, which then calculates slurry volumes. Next, the column is connected to an ÄKTA system (column dimension dependent), primed, and filled with slurry according to the created UNICORN method. This method controls the flow of hydraulic fluid to drive the adapter and pack the column.

Figure 4 illustrates this procedure. Hydraulic liquid is pumped into the hydraulic chamber to move the adapter down. Packing liquid from the slurry is forced through the bottom bed support outlet and the bed consolidates. When the adapter meets the consolidated bed surface, the operator presses a button in a UNICORN dialog. This signals the adapter to continue its movement and compress the bed according to the predetermined Packing Factor. UNICORN then stops the flow. If selected in UNICORN wizard, Intelligent Packing will automatically run a packed bed evaluation test.

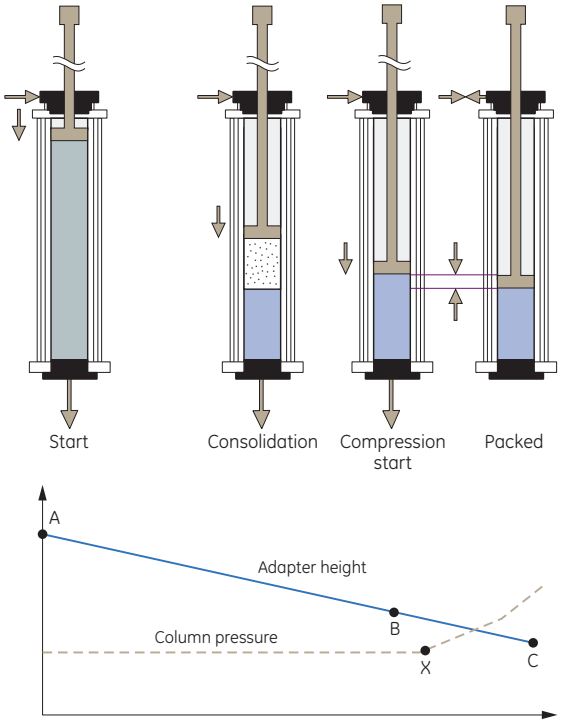


Fig 4. Intelligent Packing in small columns. **(Start)** The adapter moves down, forcing packing liquid out of the slurry. **(Consolidation)** The slurry forms a consolidated bed. **(Compression start)** When the adapter comes into contact with the consolidated bed surface, the operator initiates bed compression in the UNICORN wizard. Compression occurs according to a predetermined Packing Factor. **(Packed)** The target bed height is attained. Note: As the bed starts to compress (**B** in lower figure), an increase in pressure is seen at point **X** on the graph.

Unpacking small columns

Small AxiChrom columns are unpacked manually. The pivoting tube allows very convenient emptying. Slow upward flow is increased gradually so that the adapter rises and the packed bed successively breaks up. The flow rate is then slowed and the adapter finally stopped just below the upper flange. After removing the top plate and adapter, the column tube is tipped to empty the slurry into a container.

Intelligent Packing in larger columns

Large (300 mm and above) AxiChrom columns are controlled via AxiChrom Master, a separate unit that comprises a touch-screen operator interface (Fig 5) and a motor-drive. The same AxiChrom Master can be used for all diameters between 300 and 1000 mm. When connected to an ÄKTAprocess system, UNICORN is used as operator interface for priming, packing, and unpacking by using automated methods created with the Intelligent Packing wizard. Users only need to select the medium to pack, the slurry concentration of the medium, and the target bed height. Note that AxiChrom Master is not needed during chromatography operation, and that one unit can be used to control up to ten individual columns in the range of 300 to 1000 mm. See page 8 for more details.

Fig 5. AxiChrom Master controls the packing, unpacking and maintenance of large AxiChrom columns via a touch-screen interface.

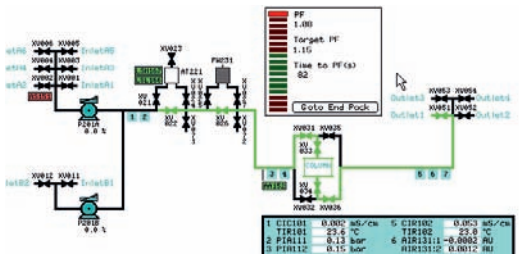
Large AxiChrom columns are equipped with a two-position media valve at the center of the bottom bed support. These two positions enable filling, packing, and unpacking without adjusting the assembled column.

Figure 4 also illustrates the general principles of the larger column packing procedure. The adapter rises from its lowest position and the column fills with slurry via the media valve, the volume of which is calculated automatically from the target bed height, slurry concentration and Packing Factor. Even the void volume of the hose connection between the column and slurry tank is taken into consideration. As an electric servo-motor controls the movement of the adapter, its position is monitored with millimeter accuracy.

When the correct slurry volume has been drawn into the column, the adapter starts to lower and packing buffer is forced out through the bottom bed support at a linear flow rate optimized for the medium being packed. Bed consolidation starts. The time to complete consolidation (i.e., when the adapter reaches the bed) is also automatically calculated, allowing the operator to carry out other tasks in the meantime.

The adapter hits the consolidated bed, an event monitored as a very distinct dip on the pressure curve. When this occurs, the operator confirms that the adapter has hit the bed and a graphical interface shows on the UNICORN control screen or AxiChrom Master. This graphical interface assists the operator in finishing the packing, giving a perfectly packed bed (see Fig 6 A and B). When the adapter symbol is within the range of optimal pack factors and bed height limits, the operator can end the packing. At this step, it is possible to prioritize exact Packing Factor or bed height.

A)



B)

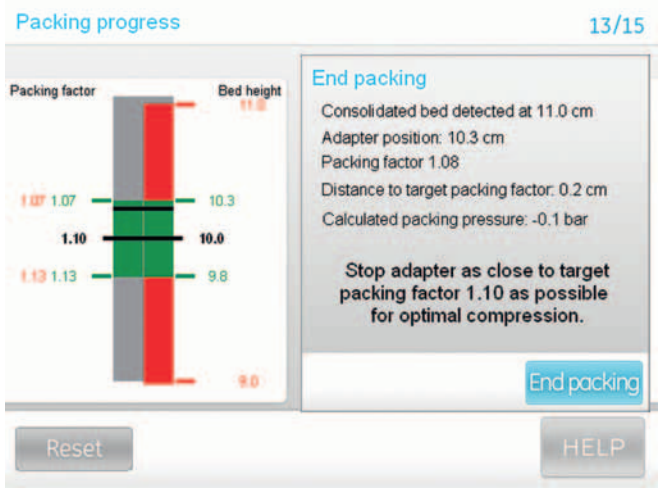


Fig 6. UNICORN (**A**) and AxiChrom Master (**B**) graphical interfaces at the end of the packing. When the compression of the bed has started, the accepted Packing Factors and bed height are shown. The area in which the criteria for packing factor and bed height overlap and where an approved packed bed can be achieved, is shown as green. The adapter, highlighted in the graphics, should be stopped as close to the target Packing Factor as possible.

Unpacking large columns

Large AxiChrom columns unpack easily at high slurry concentrations. This reduces the volume to handle and thereby the need for costly storage. Unpacking methods for preprogrammed media are available via the UNCORN wizard or AxiChrom Master.

Figure 7 summarizes the procedure. The motor lifts the adapter at the same time that upward flow is applied, causing the packed bed to rise (A). When a liquid space is created underneath the bed, and the flow is stopped, the bed eventually collapses and falls to the bottom (B). With flow back in the upward direction, the bottom media valve open, and the top mobile phase valve closed, the medium is kept resuspended while the adapter moves back down to its lowest position. Medium is pushed out of the column and collected in a slurry tank.

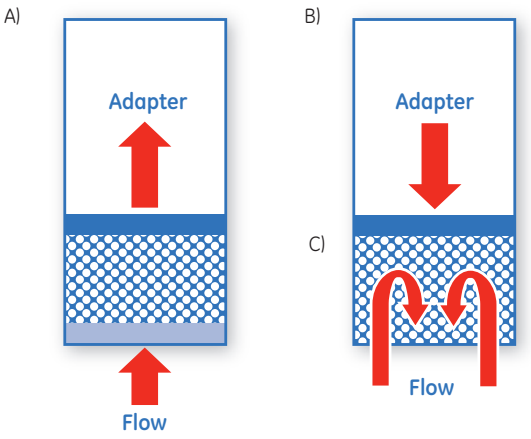


Fig 7. Unpacking large columns. **(A)** The adapter rises (motor driven) with the applied upward flow. **(B)** The adapter movement is stopped and the bed collapses and falls to the bottom. **(C)** Upward flow with an open media valve and a closed top mobile phase valve resuspends the medium and the adapter pushes it out through the bottom valve.

Intuitive handling

AxiChrom columns are easy to operate. Even the largest sizes can be handled safely by just a single operator. Step-by-step interfaces guide users through key packing, unpacking and maintenance steps. Previous experience or extensive training is not necessary, which makes it easy to quickly move columns between projects and/or locations. As well as helping avoid operator-error, these intuitive aids also reduce downtime and maximize column use.

Small columns feature a simple pivot design that eliminates lifting and promotes safer operation. Emptying is simple and accomplished without unnecessary waste of medium. Access to bed supports and O-rings is straightforward and most maintenance can be performed without disassembling the whole column.

The swing-out, hoist-free design of large AxiChrom columns (Fig 8) has many practical advantages. As there is no need to move it from the production site for maintenance, it requires less space than a conventional column, and as no hoists are needed, it provides a safer working environment as well. Furthermore, access to all relevant parts is easy. Together with clear and concise interactive instructions from AxiChrom Master, this reduces downtime to a minimum. For example, disassembly, changing all wetted parts, and reassembly takes about one hour.

AxiChrom columns are delivered with a comprehensive documentation package comprising spare parts and accessories lists, materials certificates, assembly drawings, User Manual, etc. The number of spare parts needed to be kept in stock is low compared to other column series.

Fig 8. AxiChrom column in swing-out mode provides easy access to bed supports and O-rings. In multi-purpose facilities, changing plastic bed supports for a new campaign is done very quickly.

Table 2. Verification of small and large diameter AxiChrom columns (50 to 1000 mm) with three commonly-used BioProcess Media platforms (Capto™, MabSelect™ and Sepharose™). Plate number and asymmetry results (average of three to five packings) are well within specifications, confirming the success of the column design

Medium	Column diameter (mm)	Bed height (cm)	Average (N/m)	Average (h)	Average (As)
Capto Q	50	20	6900	1.6	1.2
Capto Q	50	40	7100	1.6	1.0
Capto Q	70	20	6600	1.7	1.2
Capto Q	70	30	6200	1.8	1.3
Capto Q	100	20	7200	1.5	1.0
Capto Q	100	40	7300	1.5	1.1
Capto Q	140	20	6400	1.7	1.2
Capto Q	140	40	6700	1.7	1.0
Capto Q	200	20	7800	1.4	1.0
Capto Q	200	40	7600	1.5	1.0
Capto Q	400	20	7500	1.6	1.2
Capto Q	400	40	7200	1.6	1.1
Capto Q	1000	10	7500	1.6	1.3
Capto S	400	10	5300	2.1	1.3
Capto S	1000	15	7000	1.5	1.2
Capto DEAE	600	20	7200	1.6	1.2
Capto Adhere	600	20	8900	1.5	1.2
Capto Adhere	600	35	7700	1.5	1.1
Capto MMC	400	40	8300	1.2	1.2
Capto MMC	600	35	9500	1.4	1.1
Capto MMC	600	20	8800	1.5	1.3
Capto MMC	1000	20	7800	1.7	1.3
MabSelect	50	20	7900	1.5	1.1
MabSelect	100	20	8200	1.4	1.0
MabSelect	140	20	7900	1.5	1.2
MabSelect Xtra™	400	20	7400	1.7	1.2
MabSelect Xtra	600	20	8100	1.7	1.2
MabSelect SuRe™	400	20	8300	1.4	1.1
MabSelect SuRe	400	35	8200	1.4	1.1
MabSelect SuRe	600	20	8200	1.4	1.2
SP Sepharose Fast Flow	50	10	6600	1.7	1.3
SP Sepharose Fast Flow	70	10	7100	1.6	1.3
SP Sepharose Fast Flow	70	30	7200	1.5	1.0
SP Sepharose Fast Flow	100	10	7600	1.4	1.1
SP Sepharose Fast Flow	100	30	7700	1.4	1.0
SP Sepharose Fast Flow	140	10	6100	1.8	ND
SP Sepharose Fast Flow	140	30	6400	1.6	1.1
SP Sepharose Fast Flow	200	10	7000	1.5	1.2
SP Sepharose Fast Flow	200	30	7000	1.5	1.1
SP Sepharose™ High Performance	400	10	15900	1.9	1.4
SP Sepharose High Performance	600	10	12000	2.4	1.3
SP Sepharose High Performance	1000	10	16800	1.8	1.4
Sepharose Big Beads	1000	10	2700	1.9	1.3
Sepharose Big Beads	1000	30	3500	1.5	1.1
Phenyl Sepharose Fast Flow (high sub)	600	20	6700	1.7	1.3
SP Sepharose Fast Flow	400	10	5500	2.0	1.4
SP Sepharose Fast Flow	400	30	7100	1.6	1.2
SP Sepharose Fast Flow	1000	30	6000	1.9	1.2
SP Sepharose Fast Flow	1000	10	5500	2.0	1.3

Predictable scale-up

To secure scalable and predictable performance, an analytical method for computing the mathematical residence-time distribution of the liquid distribution system was applied during column design. CFD methods were then used to validate the analytical results, as well as for detailed studies analyzing more complicated geometries.

The impact of distributor design on separation efficiency was predicted as a function of media properties and packed bed dimensions. Efficiency loss caused by the distributor when increasing column diameter during scale-up was quantified. It was concluded that by selecting an appropriate distributor design with optimized dimensions, separations can be scaled up without any significant loss of chromatographic efficiency due to the distribution system. This design was then verified experimentally by HETP and asymmetry testing from small to large column diameters (Table 2).

The range of modeled mobile phase distribution systems ensures uniform plug flow through the bed, irrespective of size, thereby promoting reproducible results over the entire column range. Irrespective of experience or location, users can thus expect the same good separation efficiency when scaling up (or down). Together with Intelligent Packing, this promotes smooth and predictable tech-transfer between departments and sites or to CMOs (Fig 9). Model protein elution and HETP tests confirm this consistent chromatographic performance (Figs 10 and 11).

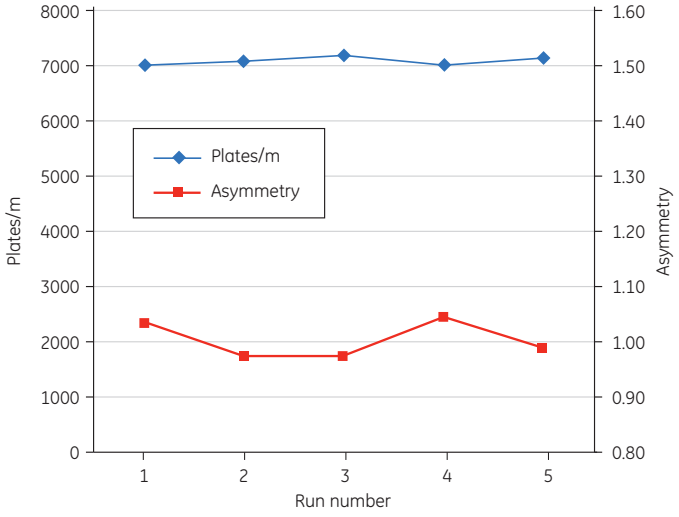


Fig 9. Minimizing operator influence greatly improves reproducibility. Repeated packings of Capto Q in AxiChrom 50 at 40 cm bed height show practically no variation in plate height plus asymmetries that only vary between 0.98 and 1.07.

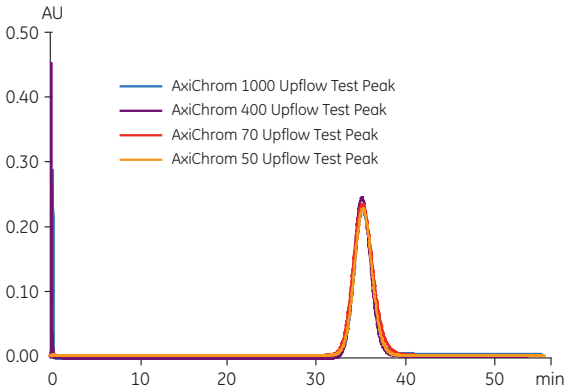


Fig 10. HETP tests on SP Sepharose Fast Flow packed to 20 cm bed heights in different AxiChrom column dimensions.

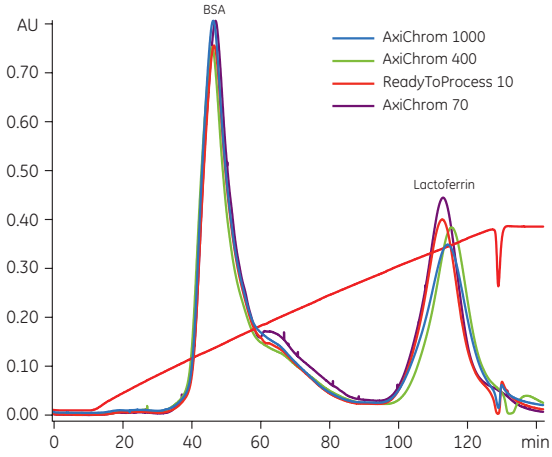


Fig 11. Separation of BSA and Lactoferrin on SP Sepharose Fast Flow in different AxiChrom and ReadyToProcess™ columns.

Documentation and traceability

Comprehensive documentation (including IQ/OQ documents) simplifies validation, thereby reducing start-up time. The same level of documentation is available for all column sizes. In addition, traceability to batch level for wetted polymeric materials and elastomers meets the requirements of USP Class VI, as well as 21 CFR Part 177. Both of these regulatory support measures speed up planning and implementing the cGMP production of biopharmaceuticals.

High standards of sanitary design

One key aspect of cGMP production is operation at hygienic standards. AxiChrom columns have been demonstrated to meet high standards of sanitary design, both for columns with stainless steel beds as well as plastic bed supports. For example, the efficiency of microbial sanitization and endotoxin clearance has been investigated by challenge testing. Columns packed with Sepharose™ Fast Flow media were challenged with *E. coli* and endotoxins and incubated for 16 to 20 h at room temperature before being treated with 1 M sodium hydroxide (NaOH) and then sampled.

The results of both studies fulfilled the set acceptance criteria proving sanitization with 1 M NaOH to be effective. Despite high levels of microbial contamination, no challenging organisms were found after treatment. In addition, 1 M NaOH gave a 6-log reduction of endotoxin concentration. The final level in the column flowthrough was less than 0.05 EU/ml, which is below the USP recommendation for water for injection (WFI).

Full study details are described in Application Note 'Sanitization and endotoxin clearance in AxiChrom columns' (28-9290-42).

Summary

AxiChrom columns help implement the philosophy of lean manufacturing in downstream processing by bringing new levels of simplicity, efficiency, and economy to process chromatography.

Cross-range features such as Intelligent Packing, intuitive handling and predictable scale-up save time and costs all the way from column preparation and packing through operation to unpacking and maintenance. AxiChrom makes column packing an operation that no longer needs to be regarded as an uncertain element on the 'critical' list of scale-up and tech-transfer tasks. Compatibility with new-generation, high-flow agarose separation media is excellent and materials of construction fulfill stringent regulatory requirements. A wide range of configurations also promotes flexibility. Finally, AxiChrom columns operate at the high standards of hygiene required by cGMP.

Materials of construction

Component	< 300 mm id	≥ 300 mm id
Column tube	Glass, borosilicate 3.3[1]	PMMA Cast cross-linked acrylic or stainless steel ASTM 316L
Seals	EPDM, FPM[3], and UHMWPE[3]	UHMWPE (adapter), FFPM (dynamic), and EPDM (static)[3]
Distributor	—	Polypropylene
Adapter	Stainless steel ASTM 316L[2] and Polypropylene	Stainless steel ASTM 316[5]
Bottom plate	Stainless steel ASTM 316L[2]	Stainless steel ASTM 316[5]
Top plate/top lid	Stainless steel ASTM 316L[2]	Stainless steel ASTM 316[5]
Connection tube material	—	Stainless steel ASTM 316L or Polypropylene
Media valve body	—	Polypropylene
Tubing	PVDF[3] or Polypropylene	—
Bed support ring	PEEK[3] or PTFE/PEEK	Stainless steel ASTM S32205 or UHMWPE
Bed support net	Stainless steel ASTM 316L[2], Polyethylene, or UHMWPE[6]	Stainless steel ASTM 316L, Polyethylene, or UHMWPE[6]
Stand	Stainless steel ASTM 316L[4] and POM-C[3]	Stainless steel ASTM 316
AxiChrom foot	PS[3]	—

[1] Glass according to EU standard EN 1595

[2] EN 1.4404, EN 1.4432 or 1.4435 may be used. All materials are to standard EN 10028-7 and EN 10272

[3] PEEK=PolyEtherEtherKetone, EPDM=Ethylene Propylene Diene Monomer rubber, FKM/FPM=FluoroCarbon rubber, UHMWPE=Ultra High Molecular Weight Polyethylene, PS=Polysterene, PVDF=PolyvinylideneDiFlouride, POM-C=PolyOxyMethylene, PMMA=Poly Methyl Meth Acrylat, FFPM=FullFlourinatedPolypropyleneMonomer

[4] EN 1.4404 or EN 1.4436 (316) may have been used

[5] Not wetted material

[6] Polyethylene for 20 µm and UHMWPE for 10 µm bed supports

Installation specifications

AxiChrom Master	
Height (mm)	1090
Footprint (mm)	670 x 590
Weight (kg)	75
Supply voltage (VAC)	380–400
Max voltage (North America)	480Y/277 VAC
Frequency (Hz)	50–60
Max power consumption (VA)	2400
Air supply (bar g)	5.5–7 (clean dry air)

Framework specifications

AxiChrom columns	50		70		100		140		200	
Inner column diameter (mm)	50		70		100		140		200	
Column type	50/300	50/500	70/300	70/500	100/300	100/500	140/300	140/500	200/300	200/500
Bed height (cm)	10–30	30–50	10–30	30–50	10–30	30–50	10–30	30–50	10–30	30–50
Weight, empty column[1] (kg)	6.5	7.5	10	11.5	16.3	19.3	28.5	31.5	41.5	45.5
Weight, column stand (kg)	7	7.5	7	7.5	7	7.5	23.5	25.0	23.5	25.0
Max. operating work height (mm)	1400	1700	1650	1800	1650	1800	2000	2100	2000	2100
Max. operating pressure (bar g)	10		8		8	8	6		5	
Max. packing pressure (bar g)	20		15		10	10	8		6	
Footprint, foot (mm × mm)	352 × 352									
Footprint stand (mm × mm)	350 × 360				350 × 360		615 × 550			
Operating temperature (°C)	2–30				2–30		2–30			
Adapter movement	Internal hydraulic				Internal hydraulic		Internal hydraulic			
Bed support (µm)	10, 20[2]				10, 20[2]		10, 20[2]			

[1] Weight includes stainless steel bed support
[2] 20 µm supports are standard; 10 µm can be special ordered

AxiChrom columns	300		400		450		600		800		1000	
Inner column diameter (mm)	300		400		450		600		800		1000	
Column type	300/300	300/500	400/300	400/500	450/300	450/500	600/300	600/500	800/300	800/500	1000/300	1000/500
Bed height (cm)	10–30	10–50	10–30	10–50	10-30	10-50	10–30	10–50	10–30	10–50	10–30	10–50
Weight, empty column[1] (kg)	420	440	460	480	710	760	835	900	2150	2240	2560	2680
Min height (mm)	1450	1710	1455	1715	1500	1760	1600	1860	1750	2010	1905	2165
Max. operating work height (mm)	2060	2580	2060	2580	2080	2600	2190	2710	2480	3000	2490	3010
Max. height for maintenance (mm)	2200	2720	2200	2720	2230	2750	2340	2860	2630	3150	2650	3170
Max. operating pressure (bar g)	4											
Footprint foot (mm x mm)	520 × 1110		600 × 1110		620 × 1110		780 × 1180		1080 × 1470		1300 × 1720	
Operating temperature (°C)	2–30											
Adapter movement	Servo motor											
Bed support (µm)	10, 20											

[1] Weights are for PMMA column tube and stainless steel bed support

AxiChrom columns	50			70			100			140			200		
Bed height (cm)	10	30	50	10	30	50	10	30	50	10	30	50	10	30	50
Column volume* (L)	0.2	0.6	1.0	0.4	1.2	1.9	0.8	2.4	3.9	1.5	4.6	7.7	3.1	9.4	15.7

AxiChrom columns	300			400			450			600			800			1000		
Bed height (cm)	10	30	50	10	30	50	10	30	50	10	30	50	10	30	50	10	30	50
Column volume* (L)	7	21	35	13	38	63	16	48	80	28	85	141	50	151	251	79	236	393

* Column volumes do not take medium compression into consideration

Ordering information

Columns	Code no.
AxiChrom 50/300/Glass/20SS	28-9018-31
AxiChrom 50/500/Glass/20SS	28-9018-41
AxiChrom 70/300/Glass/20SS	28-9018-40
AxiChrom 70/500/Glass/20SS	28-9018-47
AxiChrom 100/300/Glass/20SS	28-9032-74
AxiChrom 100/500/Glass/20SS	28-9032-76
AxiChrom 140/300/Glass/20SS	28-9077-02
AxiChrom 140/500/Glass/20SS	28-9439-27
AxiChrom 200/300/Glass/20SS	28-9077-03
AxiChrom 200/500/Glass/20SS	28-9439-28

AxiChrom 50, AxiChrom 70, and AxiChrom 100

Parts/Accessories	Quantity	Code no.
Pivot stand 50/70/100–300	1	28-4017-09
Pivot stand 50/70/100–500	1	28-4017-10
AxiChrom foot 70	1	28-4019-37
Mechanical locking 50	1	28-4018-39
Mechanical locking 70	1	28-4018-40
Mechanical locking 100	1	28-4018-41
Tool kit small AxiChrom	1	28-9361-36
Tool kit complete AxiChrom	1	28-9442-61
Torque wrench kit AxiChrom	1	28-9361-37
Torque driver kit	1	28-9361-39
Tubing kit AxiChrom 50 ÄKTAexplorer / desk	1	28-9055-41
Tubing kit AxiChrom 50 ÄKTAexplorer / floor	1	28-9056-03
Tubing kit AxiChrom 50 ÄKTApilot / desk	1	28-9056-76
Tubing kit AxiChrom 50 ÄKTApilot / floor	1	28-9136-13
Tubing kit AxiChrom 70 ÄKTApilot / floor	1	28-9136-14
Media stirrer (40 mm, for AxiChrom 50/70)	1	28-9231-80
Media stirrer (80 mm, for AxiChrom 100/140)	1	28-9191-03

AxiChrom 140 and AxiChrom 200

Parts/Accessories	Quantity	Code no.
Mechanical locking 140	1	28-9433-88
Mechanical locking 200	1	28-9433-53
Silicone tubing kit AxiChrom 140, i.d. 3.2 (ÄKTAprocess)	1	28-9429-86
Silicone tubing kit AxiChrom 140, i.d. 4.8 (ÄKTAprocess)	1	28-9429-93
Silicone tubing kit AxiChrom 140, i.d. 6.4 (ÄKTAprocess)	1	28-9430-20
TC 25 Clamp SS	5	28-4043-38
TC gasket 25/6.5	10	28-4034-13
TC end cap TC 25	1	28-4043-39
Media stirrer (80 mm)	1	28-9191-03
Media stirrer (150 mm)	1	28-9191-04
User Manual AxiChrom 140 and 200	1	28-9489-52
Tool kit small AxiChrom	1	28-9361-36
Tool kit large AxiChrom	1	28-9442-61
Torque wrench kit AxiChrom	1	28-9361-37
Torque driver kit AxiChrom	1	28-9361-39
Outlet tubing kit AxiChrom 140, 200	1	28-9430-41

Configurable, larger AxiChrom columns, parts, and accessories

Smaller columns without standard code numbers and all larger columns with diameters of 300 mm and larger, are configurable and ordered via a sales configurator. Columns can be tailored to requirements using this configurator. The configurator also creates an extensive documentation package including General Specification, Bill of Materials, Assembly Drawing, Spare Parts List, Site Preparation Guide, as well as a price quotation. Via the sales configurator, dynamic wizards for accessories and spare parts recommend a number of accessories and spare parts exactly matching the column and interface to a chromatography system. This facilitates easy, fast and correct selection, all fulfilling the same standards as the column.

Examples of accessories: tubings, T-junctions, reducers, gaskets and clamps, casters, safety valves, manual valves, tool kit, and media stirrer.

The sales configurator is also used to recommend upgrade kits for ÄKTAprocess systems that were delivered prior to Intelligent Packing being available. By entering the ÄKTAprocess system serial number, the applicable kit(s) for that system is given.

Please contact a GE Healthcare sales representative for assistance in configuring your column and system.

Related literature

	Code no.
Sanitization and endotoxin clearance in AxiChrom columns	28-9290-42
Column efficiency testing	28-9372-07
Handling of stainless steel column parts in sensitive environments	28-9433-77

For local office contact information please visit
www.gelifesciences.com/contact

www.gelifesciences.com/axichrom
www.gelifesciences.com

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28-9290-41 AJ 01/2011

GE Healthcare
Life Sciences

AxiChrom™ 300-1000 columns

Operating Instructions

Original instructions

Table of Contents

1 Introduction

Purpose of the Operating Instructions

The *Operating Instructions* provide you with the instructions needed to install, operate and maintain AxiChrom 300-1000 columns in a safe way.

Prerequisites

In order to operate the equipment in the way it is intended, the following prerequisites must be fulfilled:

- You must read and understand the safety instructions in the user documentation.
- You shall have a thorough knowledge of the entire system and process.
- All operation must be performed by qualified personnel who are adequately trained.

In this chapter

This chapter contains important user information, and a general description of the AxiChrom 300-1000 columns and their intended use.

1.1 Important user information

Read this before using AxiChrom columns

All users must read the entire AxiChrom 300-1000 columns *Operating Instructions* before installing, using, or maintaining the instrument. Always keep the Operating Instructions at hand when using AxiChrom 300-1000 columns.

Do not operate AxiChrom 300-1000 columns in any other way than described in the user documentation. If you do, you may be exposed to hazards that can lead to personal injury, and you may cause damage to the equipment.

Intended use

The AxiChrom family of process columns has been designed for low pressure chromatographic separation of biomolecules such as proteins, peptides and oligonucleotides in GMP-regulated environments. AxiChrom columns are intended for production use only and should not be used for diagnostic purposes in any clinical or *in vitro* procedures.

The columns are not suitable for operation in a potentially explosive atmosphere or for handling flammable liquids. If the columns are used for purposes other than those specified in the user documentation, safe operation and the protection provided by the system may be impaired.

Safety notices

This user documentation contains WARNINGS, CAUTIONS and NOTICES concerning the safe use of the product. See definitions below.

Warnings

WARNING

WARNING indicates a hazardous situation which, if not avoided, could result in death or serious injury. It is important not to proceed until all stated conditions are met and clearly understood.

Cautions

CAUTION

CAUTION indicates a hazardous situation which, if not avoided, could result in minor or moderate injury. It is important not to proceed until all stated conditions are met and clearly understood.

Notices

NOTICE

NOTICE indicates instructions that must be followed to avoid damage to the product or other equipment.

Notes and tips

Note: *A Note is used to indicate information that is important for trouble-free and optimal use of the product.*

Tip: *A tip contains useful information that can improve or optimize your procedures.*

Typographical conventions

Software items are identified in the text by ***bold italic*** text. A colon separates menu levels, thus ***File:Open*** refers to the ***Open*** command in the ***File*** menu. Hardware items are identified in the text by **bold** text (e.g., **Power** switch).

1.2 Regulatory information

This section describes the directives and standards that are fulfilled by the AxiChrom 300-1000 columns and AxiChrom Master.

Manufacturing information

Name of manufacturer	Address of manufacturer
GE Healthcare Bio-Sciences AB	GE Healthcare Bio-Sciences AB Björkgatan 30, SE-751 84 Uppsala, Sweden

Other regulatory information may be found in the Declaration of Conformity supplied with the product.

CE Conformity

This product complies with the European directives listed in the table, by fulfilling the corresponding harmonized standards. A copy of the Declaration of Conformity is supplied with the product.

Directive	Title
2006/42/EC	Machinery Directive (MD)
2006/95/EC	Low Voltage Directive (LVD)
2004/108/EC	ElectroMagnetic Compatibility (EMC) Directive
97/23/EC	Pressure Equipment Directive (PED)

International standards

This product is designed in accordance with the requirements of the following standards and regulations:

Standard	Description	Notes
EN 61010-1, IEC 61010-1, UL 61010-1, CAN/CSA C22.2 No 61010-1	Safety requirements for electrical equipment for measurement, control, and laboratory use	EN standard is harmonized with EU directive 2006/95/EC
EN 61326-1 (Emission according to CISPR 11, Group 1, class A)	EMC emissions and immunity requirements for electrical equipment for measurement, control and laboratory use	EN standard is harmonized with EU directive 2004/108/EC
EN ISO 12100	Safety of machinery, General principles for desgn, Risk assessment and risk reduction.	EN ISO standard is harmonized with EU directive 2006/42/EC
ASME BPVC VIII, div 1	Boiler and Pressure Vessel Code (BPVC)	Applies only to stainless steel columns
ASME BPE	Bioprocessing equipment	
UL 508a	UL standard for Safety for Industrial Control Panels	

Standard	Description	Notes
EMEA/410/01, CPMP Note	All wetted polymer and elastomeric parts are animal origin-free or comply with the conditions in the standard, and are also classified according to USP Class VI, 21 CFR Part 177	

CE Marking

The **CE** marking and the corresponding Declaration of Conformity is valid for the instrument when it is:

- used as a stand-alone unit, or
- connected to other CE-marked products recommended or described in the user documentation, and
- used in the same state as it was delivered from GE Healthcare, except for alterations described in the user documentation.

The Declaration of conformity is valid only for systems that are marked with the **CE**-marking.

CE

Regulatory compliance of connected equipment

Any equipment connected to the AxiChrom 300-1000 columns and AxiChrom Master should meet the safety requirements of IEC EN 61010-1/ IEC 61010-1 or relevant harmonized standards. Within EU, connected equipment must be CE marked.

1.3 The AxiChrom Column

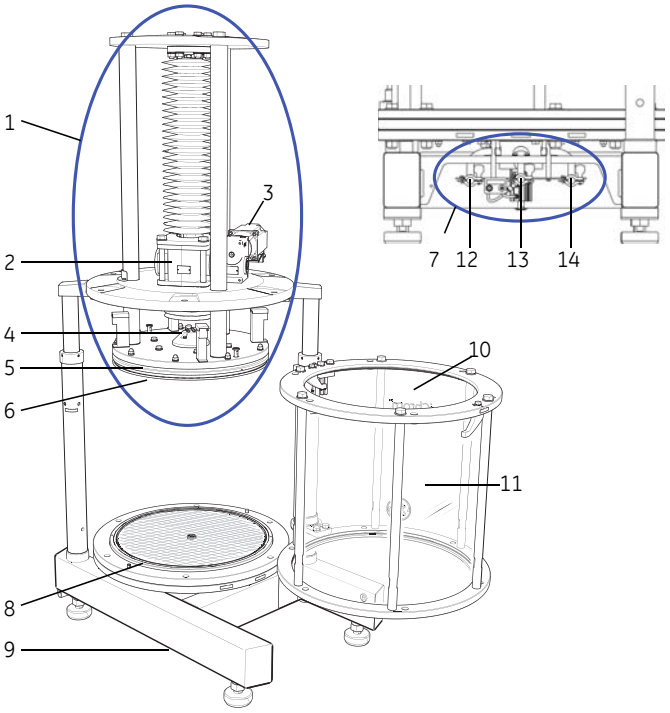
General description

The AxiChrom columns are available in two tube lengths for each size, for maximum bed heights of 30 and 50 cm respectively. The column tubes are made of acrylic plastic or stainless steel. The columns are operated from AxiChrom Master, either as a stand-alone unit or controlled in turn from an ÄKTAprocess™ instrument running UNICORN™ software.

Intelligent Packing

The columns are packed by motor controlled axial compression using an Intelligent Packing wizard. Intelligent Packing is performed and controlled by an ÄKTAprocess system or the AxiChrom Master.

Main parts



Part	Function	Part	Function
1	Top unit	8	Bottom bed support and distributor plate
2	Worm gear and bellows	9	Column stand
3	Servo motor	10	Process chamber
4	Top mobile phase inlet/outlet	11	Column tube
5	Adapter	12	Slurry inlet
6	Adapter bed support and distributor plate	13	Bottom mobile phase inlet/outlet
7	Media valve assembly	14	Rinse inlet

For information on column weights and dimensions, see *Appendix B Column and AxiChrom Master weights and dimensions, on page 125*.

1.4 AxiChrom Master

General description

AxiChrom Master is a self-contained operator console featuring interactive guides (wizards) for work procedures such as packing, unpacking and maintenance. The user interface is a touch screen panel. The operator has control over the workflow, and can use manual control to steer adapter movement and open or close the media valve.

One AxiChrom Master unit can be used to control several columns (one at a time).

Note: *Always use the same Master to control a given column. If you change to a different Master you will need to recalibrate the column with the new Master.*

For information on AxiChrom Master weight and dimensions, see *Appendix B Column and AxiChrom Master weights and dimensions, on page 125*.

1.5 User documentation

In addition to the *Operating Instructions* manual, the documentation package supplied with AxiChrom also includes product documentation binders containing detailed specifications and traceability documents.

The most important documents in the document package with regard to technical aspects of AxiChrom are:

System-specific documentation

User documentation	Content
AxiChrom 300-1000 columns Operating Instructions	All instructions needed to operate the instrument in a safe way, including brief system description, installation, and maintenance.
AxiChrom 300-1000 columns User Manual	Detailed system description. Comprehensive user instructions, method creation, operation, advanced maintenance and troubleshooting.
EC Declaration of Conformity for AxiChrom	Document whereby the manufacturer ensures that the product satisfies and is in conformity with the essential requirements of the applicable directives.

Software documentation

Together with each system, the following software documentation is supplied providing additional information that applies to AxiChrom 300-1000 columns, independent of the specific configuration:

Document	Purpose/Contents
UNICORN™ manual package	• The manuals contain detailed instructions on how to administer UNICORN, work with methods, perform runs and evaluate results. • The Online help contains dialog descriptions for UNICORN. The Online help is accessed from the ***Help*** menu.

Component documentation

Documentation for components produced both by GE Healthcare and by a third-party are, if existent, also included in the document package.

2 Safety instructions

2.1 Safety precautions

Introduction

Before installing, operating or maintaining the AxiChrom column, you must be aware of the hazards described in this manual. Follow the instructions provided to avoid personal injury or damage to the equipment.

The warnings and cautions in the user documentation shall in no way take precedence over more restrictive local regulations and policies.

For your personal safety it is important that you have a proper knowledge of the entire system that the column is part of. Study any complementary safety instructions and use appropriate personal protection equipment for the specific application and operation environment.

Risk assessment

AxiChrom columns have been designed and manufactured to provide a high level of personal safety. However, the residual risk is highly dependent on the application and environment in which the column is operated. In order to determine the safe operation of the equipment a risk assessment must be made. This risk assessment, in combination with local regulations and policies, will result in specific safety instructions for installation, operation and maintenance, use of proper personal protective equipment, or other arrangements that are needed to operate your process safely.

General precautions

WARNING

The customer must make sure that all installation, maintenance, operation and inspection is carried out by qualified personnel who are adequately trained, understand and adhere to local regulations and the operating instructions, and have a thorough knowledge of AxiChrom 300-1000 columns and the entire process.

WARNING

AxiChrom columns must NOT be used for any other purposes than chromatographic separations. They must not be used as:

- Storage tanks for chemicals etc.
- General pressure vessels
- Fermentation vessels
- Gas storage tanks

The column must never contain air or gas under pressure.

Using flammable liquids

WARNING

AxiChrom are not designed to handle flammable fluids. AxiChrom are not approved for work in a potentially explosive atmosphere, in areas classified as Zone 0 to Zone 2 according to IEC 60079-10 2002.

Personal protection

WARNING

Always use protective glasses and other personal protective equipment appropriate to the current application, to ensure personal safety during operation.

WARNING

Disconnection of pressurized air supply tubes can cause loud noises. Ear protection is recommended.

Note: *No ear protection is required during normal operation. The noise from AxiChrom is low (below 55 dB).*

Installing and moving the columns and Master

WARNING

Move transport crates. Make sure that the forklift has capacity to safely lift the crate weight. Make sure that the crate is properly balanced so that it will not accidentally tip when moved.

WARNING

Move column. Ensure that the column's center of gravity is well balanced over the forklift's lifting arms, otherwise the column may tip off the forklift.

WARNING

All electrical installations must be performed by authorized personnel only.

CAUTION

Make sure that all tubing, hoses and cables are placed so that the risk for tripping accidents is minimized.

NOTICE

Any computer used with the equipment shall comply with IEC 60950 and be installed and used according to the manufacturer's instructions.

NOTICE

Disconnect all tubing, hoses and cables before moving the column.

System operation

WARNING

The working pressure of the column should never exceed 4 bar, otherwise there is a risk of personal injury and damage to the column. Always use appropriate pressure alarms, pressure vents or rupture discs, and safety equipment.

WARNING

Do not block access to the power switch. The power switch must always be easy to access.

CAUTION

Do not touch the motor on the column during operation since the motor might be hot and there is a risk of burning injury.

CAUTION

Do not stand on the column base to reach the top parts of the column (e.g. top inlet/outlet). Always use proper equipment for climbing and standing when reaching the top parts of the column.

CAUTION

Remove any spillage on the floor immediately to minimize the risk of slipping accidents.

CAUTION

Use a pressure gauge, pressure relief valve, rupture disc or other pressure safety equipment to ensure that the maximum operating pressure of the column is not exceeded.

NOTICE

Do not operate the column at temperatures outside the operating temperature range.

NOTICE

Make sure that the column and the system are primed, that is, free from air, and that the inlet is open before the process run is started.

NOTICE

Do not use chemicals not listed in the Chemical Resistance information.

The wetted parts of AxiChrom may be damaged by chemicals not listed in the Chemical Resistance information. Contact your GE Healthcare representative before using chemicals that are not listed.

NOTICE

Ensure that any liquids used with the column is particle-free (down to 1 µm), as particles can block and damage the bed support.

NOTICE

Chlorides and low pH can cause corrosion on stainless steel. Rinse thoroughly with clean water after use.

Inspect the column regularly for signs of corrosive attacks, which may cause column damage if untreated. Note that the stainless steel bed supports are especially vulnerable to corrosion.

NOTICE

If there is air in the column, ensure that there is an unrestricted flow path for evacuation through an open valve before the adapter is moved or liquid is pumped into the column.

NOTICE

Ensure that the pressure does not exceed the operating pressure of the media packed in the column.

NOTICE

The acrylic column tube has limited resistance to organic solvents. Refer to the Chemical resistance section for more information.

Maintenance

WARNING

Follow all safety instructions displayed in the AxiChrom Master when performing maintenance on the column.

WARNING

Ensure that no body parts are caught between the column tube assembly and the column frame when using the swing out function for maintenance work on the column. Due to the weight of the column tube assembly, it is not advisable to try to stop the momentum of the assembly by hand when it is set in motion.

WARNING

There must not be any residues of harmful substances left in the column during maintenance. Make sure that the column is properly cleaned before maintenance, and that cleaning is documented in the Decontamination Report.

NOTICE

Lifting the top unit with incorrectly placed lock blocks may damage the column.

NOTICE

Inspect all connections and tubing before use and replace any defective parts. Also inspect the column tube thoroughly before use to verify that there are no cracks or other visible signs of damage.

NOTICE

Perform a leakage test whenever any of the wetted parts have been re-fitted or changed.

NOTICE

Always wear latex gloves (or gloves of other suitable material) when handling the bed support to prevent grease from unprotected fingers coming into contact with the bed support.

NOTICE

To avoid spillage, do not open the bottom valve while the column is filled with liquid, unless there are hoses connected to the outlets.

NOTICE

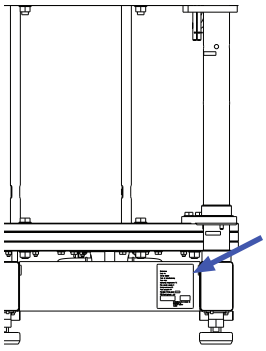
Handle stainless steel parts, especially the bed supports, with care. Damage to surfaces may lead to corrosion.

2.2 Labels

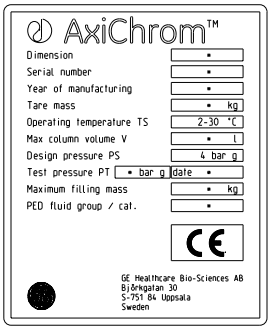
This section describes the identification labels, safety labels and labels concerning hazardous substances that are attached to the AxiChrom columns and AxiChrom Master.

Column label

Label placement



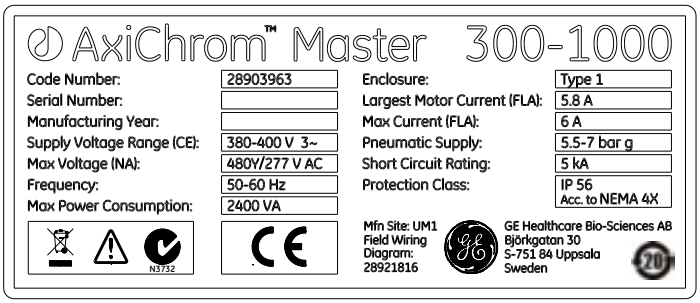
Example label



Label text	Meaning
Dimension	Dimensions of the column
Serial number	Serial number for the individual column
Year of manufacturing	Year when the column was manufactured
Tare mass	Weight of the empty column
Operating temperature TS	Operating temperature range
Max column volume V	Maximum column bed volume
Design pressure PS	Design pressure for the column
Test pressure PT	Pressure at which the column has been tested in manufacturing
Date	Date of test
Maximum filling mass	Maximum weight of column contents (media and eluent)
PED fluid group / cat.	Pressure Equipment Directive fluid group / category

AxiChrom Master label

The illustration below shows an example of an AxiChrom Master label.



Label text	Meaning
Code Number	Product code number for AxiChrom Master
Serial Number	Serial number for the individual AxiChrom Master
Manufacturing Year	Year when the AxiChrom Master was manufactured
Supply Voltage Range (CE)	Permissible supply voltage range (Europe)
Max Voltage (NA)	Maximum permissible supply voltage (North America)
Frequency	Supply voltage frequency
Max Power Consumption	Maximum power consumption
Enclosure	Enclosure rating according to EN 61326-1
Largest Motor Current (FLA)	Highest current used by the motor (Full Load Ampere)
Max Current	Highest current used by the AxiChrom Master
Pneumatic Supply	Required pressure for pressurized air supply
Short Circuit Rating	Maximum tolerated short circuit current
Protection Class	Protection class rating according to EN 60529

Symbols used in safety labels

Label	Meaning
	**Warning!** Read the user documentation before using the system. Do not open any covers or replace parts unless specifically stated in the user documentation.
	The system complies with the requirements for electromagnetic compliance (EMC) in Australia and New Zealand.
	The system complies with applicable European directives.

Labels concerning hazardous substances

Label	Meaning
	This symbol indicates that waste electrical and electronic equipment must not be disposed as unsorted municipal waste and must be collected separately. Please contact an authorized representative of the manufacturer for information concerning decommissioning of equipment.
	This symbol indicates that the product contains hazardous materials in excess of the limits established by the Chinese standard SJ/T11363-2006 Requirements for Concentration Limits for Certain Hazardous Substances in Electronics.

2.3 Emergency procedures

This section describes how to shut down the AxiChrom Master in an emergency. The section also describes the result in the event of power failure.

Emergency shutdown of AxiChrom Master

In an emergency situation, press the emergency stop button on the AxiChrom Master to stop adapter movement.

WARNING

The **EMERGENCY STOP** button will not shut off the electrical power to the motor of column. Use the **Power Switch** on the connector panel of AxiChrom Master to shut off the electrical power.

WARNING

Ensure that the **EMERGENCY STOP** button can always be reached while working with the column.

Emergency shutdown of the ÄKTAprocess system

In an emergency situation when the pumps have to be stopped, press any of the emergency stop buttons on the ÄKTAprocess system. There are two buttons on an ÄKTAprocess system, one on each side. Refer to the *ÄKTAprocess Safety Handbook* for more information about the emergency procedures for ÄKTAprocess.

Power failure

Power failure to...	will result in...
AxiChrom Master	Information about the ongoing procedure is lost. However, during maintenance mode the last static position is remembered so that the maintenance procedure can be resumed.
ÄKTAprocess	The pumps stop and the valves revert to the default position (closed). For further information, refer to ÄKTAprocess user documentation or contact your local GE Healthcare representative.

2.4 Recycling information

Decontamination

The equipment shall be decontaminated before decommissioning and all local regulations shall be followed with regard to scrapping of the equipment.

Disposal, general instructions

When taking the equipment out of service, different materials must be separated and recycled according to national and local environmental regulations.

3 Installation

3.1 Site requirements

Parameter	Requirement
Electrical power	380-400 VAC, 50-60 Hz
Ambient temperature	2°C to 30°C
Placement	Place the column on a level floor
Humidity	0% to 95%, non-condensing

For additional information please refer to *Site Preparation Guide*.

3.2 Transport

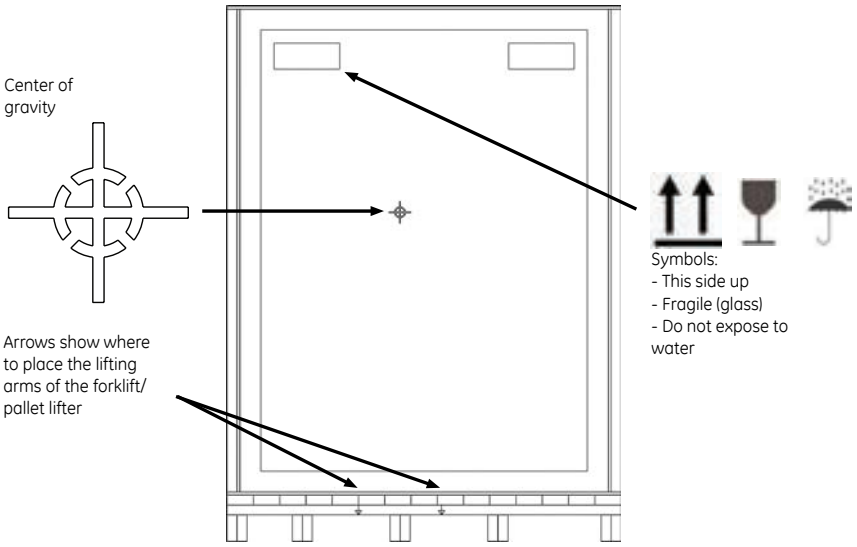
3.2.1 Transport the crates

WARNING

Move transport crates. Make sure that the forklift has capacity to safely lift the crate weight. Make sure that the crate is properly balanced so that it will not accidentally tip when moved.

For information on crate weights and dimensions, see *Appendix A Crate weights and dimensions, on page 124*.

The illustration below shows how the crate should be moved. Carefully read and follow the labels and symbols on the crate.



3.2.2 Transport the columns

WARNING

Move column. Ensure that the column's center of gravity is well balanced over the forklift's lifting arms, otherwise the column may tip off the forklift.

For information on column weights and dimensions, see *Appendix B Column and AxiChrom Master weights and dimensions, on page 125*.

The illustration below shows how the column should be moved. Carefully read and follow the labels and symbols on the column.

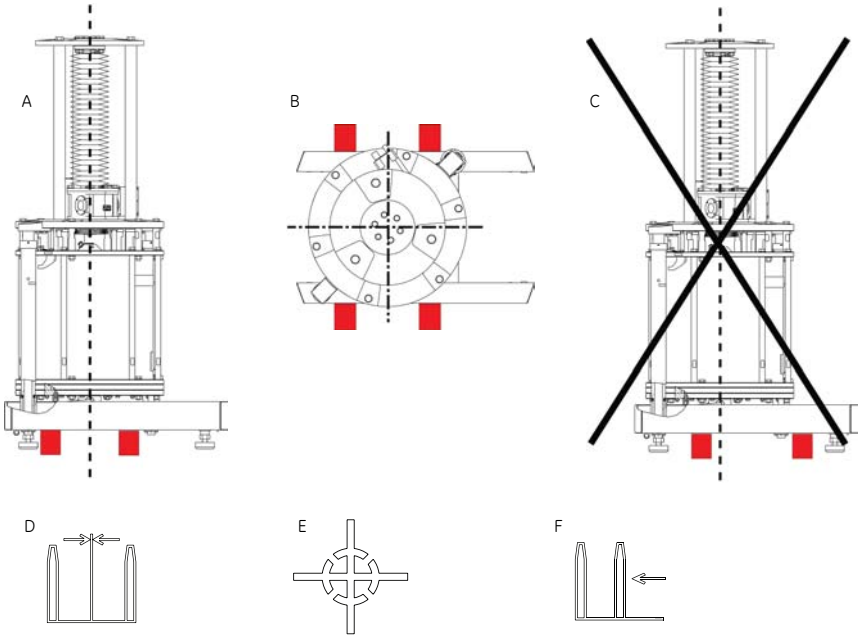


*Figure 3.1: **A + B**: The center of gravity should be centered over the forks on the forklift/ pallet lift. **C**: Shows where not to lift. **D + F**: The labels indicate how to place the forks. D: Centralized on sizes 450 to 1000. F: Shifted to the left on sizes 300 and 400. **E**: The label indicates the center of gravity.*

3.3 Unpacking

1 Unpack the crates according to instructions in the *AxiChrom 300-1000 columns Read Me First*, which is attached on the outside of the crates.

2 Inspect all AxiChrom components for any transportation damage.

3 If there is any damage, record the details on the receiving documents and inform your GE Healthcare representative.

3.4 Wheel kits

For complete instructions on how to use wheels, refer to the *User Manual*.

WARNING

Columns in swing-out or any kind of maintenance mode must not be moved. This may cause personal injury or damage to the column.

CAUTION

To avoid accidental collisions, use caution when moving columns equipped with wheels by hand. Two or more people may be required to move the column safely.

NOTICE

To avoid damage to the wheels and possible tipping when the column or AxiChrom Master is moved, ensure that the wheels do not run into objects (for example thresholds or tubing).

NOTICE

Columns equipped with casters must be levelled properly with the casters removed before the column is used.

Wheel kits on AxiChrom 300-600 columns

The wheels for 300-600 columns are delivered in a kit containing rear wheels, lever, trolley bar and trolley. Different column sizes use different wheel kits.

NOTICE

While transporting a 300-600 column, do not pull the handle upward, as the trolley knob may fall out of its position. Lifting the handle will not work as a brake.

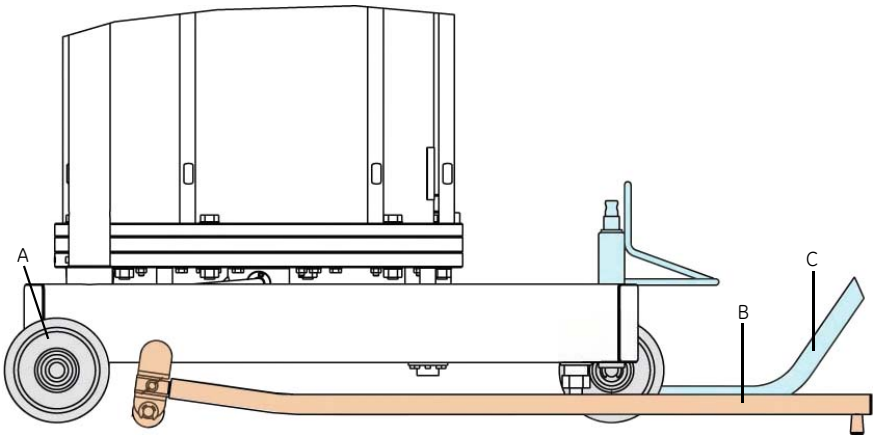


*Figure 3.2: To fit the rear wheels (**A**), lift the column back with the lever (**B**). The front is lifted with the trolley (**C**).*

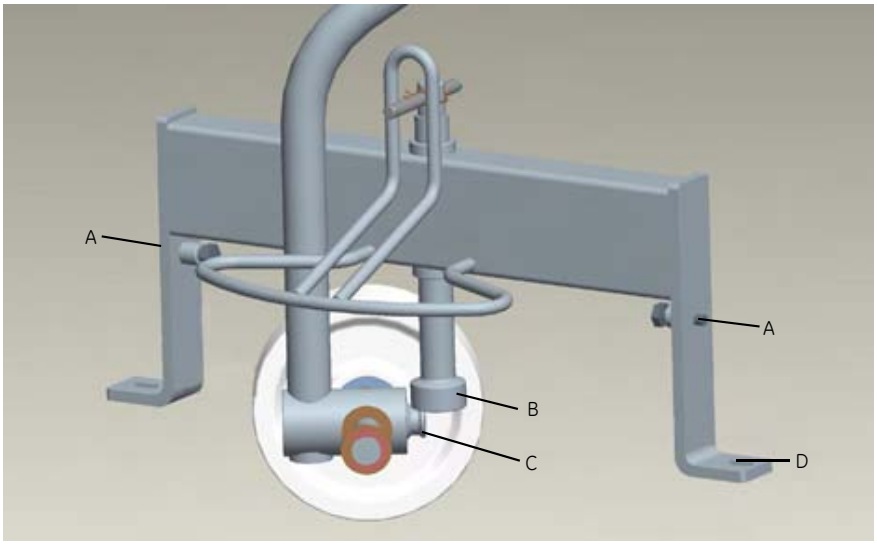


*Figure 3.3: Lifting the trolley bar with the trolley. **A**: Bolts on the trolley bar, **B**: Height adjusting screw, **C**: Trolley knob, **D**: Slots on trolley bar*

Wheel kits on AxiChrom 800 and 1000 columns

The wheels for 800 and 1000 columns are delivered in a kit containing a jack, trolley bar, bracket and tools. Different column sizes use different wheel kits. All equipment needed for fitting and removing the wheels and trolley bar is stored in the box on the trolley.

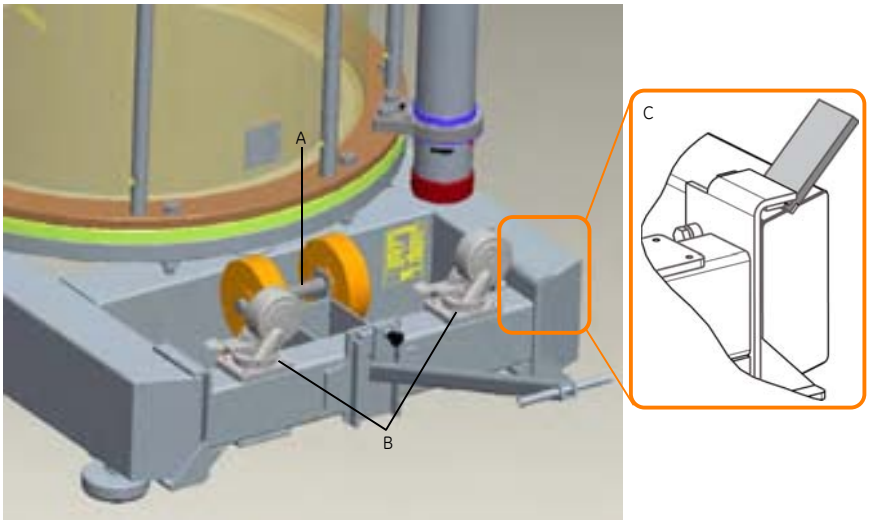
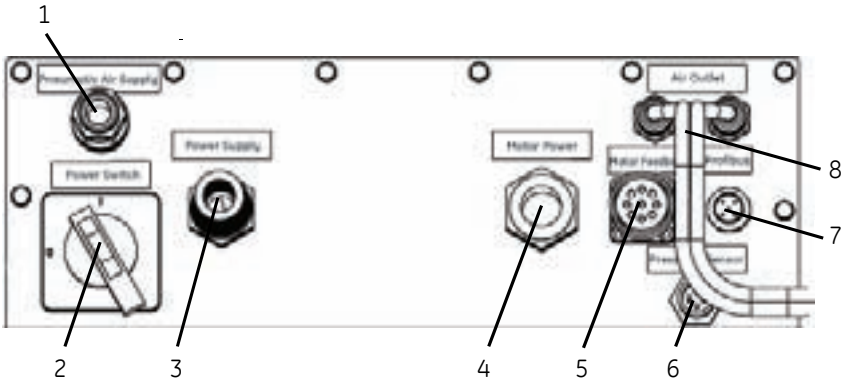


*Figure 3.4: Trolley bar attached to the column stand. Wheels have not been assembled yet. **A**: Rear wheels in storage positions, **B**: Trolley bar wheels in storage positions, **C**: Bracket used for lifting the trolley bar into position*

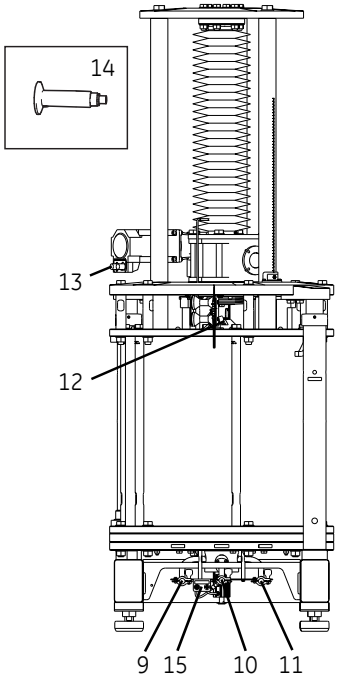
3.5 Connections

Connections on Master and column

The illustrations below show the AxiChrom Master connector panel and the connection points on a column.



Part	Description	Part	Description
1	Pneumatic air supply	5	Motor feedback
2	Power switch	6	Pressure sensor connector
3	Power supply cable	7	Profibus signal cable connector
4	Motor power cable	8	Two air outlet connectors



Part	Description
9	Slurry inlet
10	Bottom mobile phase inlet/outlet
11	Rinse inlet
12	Top mobile phase inlet/outlet
13	Motor power and motor feedback
14	Pressure sensor (PIS_119, mounted on hose to system)
15	Pneumatic inlets with 2 connectors

Connect column, Master, and external system

The table below shows how to connect the column, Master and an external system. Numbers in parentheses refer to the illustration *Connections on Master and column, on page 32*.

CAUTION

Use a pressure gauge, pressure relief valve, rupture disc or other pressure safety equipment to ensure that the maximum operating pressure of the column is not exceeded.

From	To
Pneumatic air supply (1) on the Master	**Wall socket air outlet** (5.5-7 bar)
Motor power cable (4) on the Master	**Motor power** (the right connector) on the column (13)
Motor feedback (5) on the Master	**Motor feedback** (the left connector) (13) on the column
Pressure sensor connector (6) on the Master	**Pressure sensor** mounted on system (14)
Profibus signal cable (7) on the Master	Profibus connection on an ÄKTAprocess system
Two air outlet connectors (8) on the Master	**Pneumatic inlets with 2 valves** (15) on the column
Slurry inlet (9) on the column	**Slurry tank**
Bottom mobile phase (10) on the column	**Bottom mobile phase** on a system (**Column1 bottom valve** on the ÄKTAprocess system)
Rinse inlet (11) on the column	A system (**CIP2 Inlet** on the ÄKTAprocess system)
Top mobile phase (12) on the column	**Mobile phase** on a system (**CIP1 Inlet** on the ÄKTAprocess system)
Protection ground cable on the column stand	**Ground** (See *Grounding the column, on page 38*)
Power supply cable (3) on the Master	**Power supply connector** (380-400 VAC, 50-60 Hz) with protective ground (The AxiChrom Master is delivered with CE or UL approved cables.)

Recommended mobile phase tubing inner diameters

Note:

- *All dimensions are given in millimeters.*
- *A dash (-) means that the combination is not compatible with Intelligent Packing.*

Table 3.1: Tubing inner diameters recommended for top and bottom mobile phase connections for different column inner diameters.

ÄKTAprocess dimension	300	400	450	600	800	1000
6 mm PP	6.4	6.4	6.4	-	-	-
	9.4	9.4	9.4			
3/8" SS	6.4	6.4	6.4	-	-	-
	9.4	9.4	9.4			
10 mm PP	6.4	6.4	6.4	9.4	-	-
	9.4	9.4	9.4	12.7		
	12.7	12.7	12.7	19.1		
1/2" SS	6.4	6.4	6.4	9.4	-	-
	9.4	9.4	9.4	12.7		
	12.7	12.7	12.7	19.1		
1" PP and SS	-	-	-	9.4	25.4	25.4
				12.7	34.7	34.7
				19.1		

Use narrower tubing for packing gel filtration or polishing media. Use the widest tubing compatible with the system for high flow media such as Capto.

Power requirements and connections

The general requirements are:

Requirement	Value
Supply voltage	380-400 VAC
Nominal current	10-15/16 A NTD (Non-Time Delay) (min. -max.)
Frequency	50 - 60 Hz
Max voltage (North America)	480 Y/277 VAC
Max current	6 A
Max power consumption	2400 VA
Short circuit rating	5 kA

Note: *Detailed requirements may vary for different column configurations. Refer to the column documentation for the applicable requirements for your specific column and AxiChrom Master.*

The power cables for both the AxiChrom Master and for the adapter control motor are delivered attached to the AxiChrom Master.

The system shall be connected to a 400 V supply voltage system or a 480 V supply voltage system with a maximum voltage of 277 V between phase and ground. A suitable connector has to be selected and assembled on the AxiChrom Master by the customer to comply with the supply voltage system and local regulations.

The **Motor Power** cable for the adapter control motor is permanently installed on the AxiChrom Master. The motor feedback communication cable is connected to **Motor Feedback**. Both these cables must be connected to the control motor before AxiChrom Master is connected to the power outlet.

Color coding of cable conductors

Conductor	Color
Protective ground (earth)	Green/yellow
Live 1	No 1 or Black
Live 2	No 2 or Brown
Live 3	No 3 or Grey

The black, brown and grey conductors may be connected to any of Live 1, 2 and 3. The phase connection is detected automatically.

WARNING

Ensure that the **EMERGENCY STOP** button can always be reached while working with the column.

WARNING

Electrical installations must be performed by authorized personnel only.

WARNING

Only authorized personnel are allowed to open the cabinet of AxiChrom Master. There are no user-serviceable parts inside the cabinet.

WARNING

Always connect AxiChrom Master to a power supply with protective grounding.

WARNING

Connection to wrong power supply voltage may cause injury to personnel and damage to the system.

WARNING

The power cables must be replaced only by cables of the same type or equivalent, fitted with the same type of connectors.

Power cables and connectors must be replaced or repaired by properly trained personnel, authorized by GE Healthcare.

WARNING

The power connection must be easily accessible to enable the user to disconnect the power in case of an emergency.

NOTICE

Connect the communication cable and power cable for the adapter control motor on the column to AxiChrom Master before AxiChrom Master is connected to power.

Note: *This is a class A product, input power >1 kW, intended for professional use. In a domestic environment it may cause radio interference, in which case the user might be required to take appropriate measures.*

Note: *This equipment complies with FCC part 15 (2004): Radio frequency device subpart B: Unintentional radiators, Class A. Operation is subject to the following two conditions:*

1 *This equipment may not cause harmful interference.*

2 *This equipment must accept any interference received, including interference that may cause undesired operation.*

Grounding the column

The column should always be connected to ground using a ground cable kit. Use the connection point on the inside of the column stand, to ground the column to a suitable grounding point.

The illustration below shows the connection point for protective ground cable on the column frame.

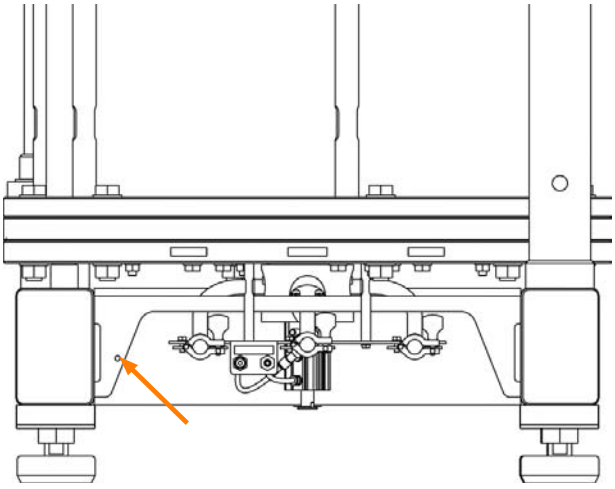


Figure 3.5: Connection point on the column frame for protective ground cable.

Compressed air requirements

It is important for personal safety and safe operation to use the correct pressure and quality of compressed air for the pneumatic valve control. The basic requirements are:

- Free of oil and particles
- -30°C dew point
- 5.5 to 7 bar

Note: *Pressure specifications in these Operating Instructions are given in bar. The pressure gauge is calibrated so that bar and bar g are equivalent.*

The pneumatic air supply connections on AxiChrom Master are illustrated in *Connections on Master and column, on page 32*.

3.6 Spare parts and accessories

Spare part list

A list of spare parts can be found in the product documentation for the column. The list can also be found online at www.gelifesciences.com/axichrom.

Spare parts recommended to keep on site

GE Healthcare recommends that spare parts used more often are kept on site. For example bed supports, snap rings, seals and o-rings are useful spare parts to have in stock.

4 Operation

4.1 Introduction

The AxiChrom column is operated from AxiChrom Master, either as a stand-alone unit or controlled in turn from an ÄKTAprocess™ instrument running UNICORN™ software. There are no manual controls available on the column.

4.2 Start Master and calibrate column

Step	Action
1	Turn the **Power Switch** on the Master control panel to the **I** position. *Result:* The Master starts and the start-up wizard opens.
2	Follow the instructions of the wizard to calibrate the column. More information about Master wizards can be found in the *User Manual*.

4.3 Cleaning the column

The cleaning should be performed before the bed is packed or when the column is new (that is, when the column is empty or filled with transportation/storage solution).

Cleaning procedure

Note: *Parts made from non-plastic materials may be autoclaved.*
For more information about cleaning methods, see the User Manual.

1 Clean the outside of the acrylic tube with for example water and/or 20% (v/v) ethanol to remove any surface residues from the packaging.

NOTICE

Do not use ethanol stronger than 20% (v/v) for cleaning the acrylic tube, since this may damage the column tube.

2 Steel surfaces can be cleaned with a wetted cloth and 70% (v/v) isopropanol or 70% (v/v) ethanol.

3 Ensure that the adapter seals and o-rings are clean from particles and waste, since these may damage the adapter and tube when the adapter is moving. If they are not clean, follow the cleaning instructions in Section 5.6 or Section 5.7 according to the type of bed support used in the column.

4 Perform a priming according to the instructions in the ***PRIMING*** wizard, in the AxiChrom Master ***MAIN MENU***. This procedure will clean the column and its tubes and remove any air from the column. More information about Master wizards can be found in the *User Manual*.

5 Ensure that the cleaning solution is completely flushed out and replaced by an appropriate storage solution after priming the column.

Result: The column is now primed and cleaned.

Cleaning the Master

Turn off the AxiChrom Master before it is cleaned with water and/or 20% (v/v) ethanol.

4.4 Leakage test

Perform a leakage test according to Section 5.9 when:

- the column is new,
- the column has been shipped,
- the o-rings have been replaced, or
- other parts that may cause leakage have been replaced
- maintenance has been performed.

4.5 Prepare slurry and buffer

Before packing the column, perform the following:

- Select an appropriate packing buffer
- Prepare slurry
- Determine the slurry concentration

Information about slurry preparation and recommendations on packing buffers can be found in the *User Manual*.

4.6 Priming the column

4.6.1 Wetting plastic bed supports

Follow the instructions below if the column is fitted with plastic bed supports.

Note: *Before priming the column, mount the bed supports dry and assemble the column as described in the AxiChrom 300-1000 Operating Instructions. Connect membrane valves on the column top and bottom mobile phases.*

Step	Action
1	Prime the column according to the AxiChrom Master priming instructions or a UNICORN priming method.
2	Perform a leakage test.
3	With the adapter at 1 cm from the bottom bed support, equilibrate the column with 20% v/v 1-propanol at 30 cm/h under a pressure of 1 bar for five column volumes.
4	Pause the flow. Use the membrane valves to seal the column mobile phases and incubate for 2 hours at 1 bar.
5	Carefully release the pressure on the membrane valves.
6	Flush the column with at least five column volumes of deionized water or packing buffer.
7	Pack the column according to the AxiChrom Master or a UNICORN packing method.

4.6.2 Using Master wizard

Before priming using the Master priming wizard, the media valve has to be primed manually.

Priming the media valve

1 Connect a pump to the rinse inlet.

2 Connect the slurry hose/tank to the slurry inlet.

3 Open the slurry hose/tank.

4 Close the Bottom mobile phase inlet and the Media valve.

5 Start a flow through the rinse inlet and further into the slurry hose/tank, at approximately

- 200 l/h for 300-600 columns, or
- 800 l/h for 800 and 1000 columns.

6

CAUTION

If the column is packed, do not open the media valve during the valve priming.

When the hoses are free from air: make sure the Top mobile phase inlet/outlet is open, and then open and close the Media valve from ***MANUAL CONTROL*** in the Master a couple of times. To make sure no more air comes from the Media valve, continue to pump liquid through the valve, filling the bottom of the column and covering the bottom bed support with liquid to a depth of about 1 cm.

7 When no more air comes up from the Media valve, close it.

8 Stop the pump and close the slurry tank.

Result: The Media valve has now been primed.

Priming the column

1 Select the ***PRIMING*** wizard in the ***Main menu*** in AxiChrom Master.

2 Follow the instructions in the wizard to prime the column.

Further information about Master wizards can be found in the *User Manual*.

4.6.3 Using UNICORN method

A priming method in UNICORN includes priming of both the media valve and the column.

1 In the UNICORN method wizard, choose to create a method for ***Priming***.

2 Follow the steps in the method wizard, make appropriate selections, and save the method.

3 Run the UNICORN method.

Further information about how to create and run UNICORN methods can be found in the *User Manual*.

4.7 Packing the column

Using Master wizard

1 Select the ***INTELLIGENT PACKING*** wizard in the ***Main menu*** in AxiChrom Master.

2 Follow the instructions in the wizard to pack the column.

Further information about Master wizards can be found in the *User Manual*.

Using UNICORN method

1 In the UNICORN method wizard, choose to create a method for ***Column Packing***, ***Packing Test***, or the two combined.

2 Follow the steps in the method wizard, make appropriate selections, and save the method.

3 Run the UNICORN method.

Further information about how to create and run UNICORN methods can be found in the *User Manual*.

4.8 Performance evaluation of the column

See the *User Manual* for how to evaluate the performance of the packed column.

4.9 Cleaning

CAUTION

Make sure that the piping system is completely leakage free before performing any Cleaning-In-Place (CIP) or Sanitation-In-Place (SIP) on the column.

Cleaning-In-Place (CIP)

Ensure that the media in the column withstands the chemicals used for CIP. For information about which chemicals to use for CIP, refer to *Section 6.2 Chemical resistance, on page 117*.

Sanitization-In-Place (SIP)

For recommendations on sanitization method, refer to the *User Manual*.

4.10 Unpacking the column

Using Master wizard

1 Select the ***UNPACKING*** wizard in the ***Main menu*** in AxiChrom Master.

2 Follow the instructions in the wizard to unpack the column.

Further information about Master wizards can be found in the *User Manual*.

Using UNICORN method

1 In the UNICORN method wizard, choose to create a method for ***Column Unpacking***.

2 Follow the steps in the method wizard, make appropriate selections, and save the method.

3 Run the UNICORN method.

Further information about how to create and run UNICORN methods can be found in the *User Manual*.

5 Maintenance and storage

5.1 General

5.1.1 Safety precautions

WARNING

Only trained personnel, or personnel with equivalent knowledge of similar equipment, are allowed to perform maintenance work on the column. Only authorized GE Healthcare personnel are allowed to perform service work on the column and AxiChrom Master.

WARNING

There must not be any residues of harmful substances left during maintenance. Make sure that the column is properly cleaned before maintenance. Cleaning should be documented in the Decontamination report (Appendix C).

WARNING

Do not remove any protection equipment from the column.

WARNING

Follow all safety instructions displayed in the AxiChrom Master when performing maintenance on the column.

WARNING

Do not perform any type of maintenance work on the column while the column is pressurized. Note that the column can be pressurized even when the system is closed down.

WARNING

Do not perform any type of maintenance work on the column while the column contains gel or liquids.

WARNING

Do not perform any type of maintenance work on the column while the adapter is in motion. Do not reach inside the column while moving the adapter. To avoid personal injury the adapter must be fully stopped and unable to move before work can be performed inside the column.

WARNING

Ensure that the power cable is disconnected or that the power is shut off at the outlet when changing connections to the AxiChrom Master (e.g. moving the Master from one column to another). There is still electrical voltage present in the AxiChrom Master when it is shut off using the **Power Switch**.

CAUTION

Limited amounts of cleaning solutions with high concentrations of alcohol may be used to wipe off and clean the surface of the column. Ensure that the area where the cleaning is performed is adequately ventilated and that all applicable local regulations are followed when handling the cleaning agent and when disposing of used cleaning materials.

NOTICE

Ensure that the product file is kept updated and together with the product documentation. The file should contain information about inspections, performed maintenance, exchanged spare parts and any other important information for safe operation.

NOTICE

Do not use metal implements that can scratch during maintenance and repairs, for example when removing o-rings.

5.1.2 Maintenance schedules

The table below provides recommendations for the frequency of regular maintenance procedures for columns in continuous use.

Procedure	Frequency
Change all O-rings	At least once every two years
Change liquid in flushing channels	Every 2 months and preferably before each packing
Check all seals for leakage	Regularly
Change O-rings and seals on moving parts (e.g. adapter and media valve)	Every 5-10 packings, more frequently if required
Clean stainless steel bed supports	Every 5-10 packings, more frequently if required
Replace plastic bed supports	Every packing

5.1.3 Cleaning before maintenance/service

Make sure that the column has been properly emptied, cleaned and rinsed to remove any infectious or aggressive fluids prior to performing any maintenance or service.

Cleaning before planned maintenance/service

To ensure the protection and safety of service personnel, all equipment and work areas must be clean and free of any hazardous contaminants before a Service Engineer starts maintenance work.

Please complete the checklist in the *On Site Service Health & Safety Declaration Form* or the *Health & Safety Declaration Form for Product Return or Servicing*, depending on whether the instrument is going to be serviced on site or returned for service, respectively. Copy the form you need from *Section 6.4 Health and Safety Declaration Form, on page 121* or print it from the PDF file available on the User Documentation CD.

WARNING

Make sure that the column is properly sanitized to avoid personnel being exposed to potentially contagious substances.

CAUTION

Make sure that the piping system is completely leakage free before performing any Cleaning-In-Place (CIP) or Sanitation-In-Place (SIP) on the column.

5.1.4 Weights of column parts

The column weights and specifications can be found on the rating plate and in *Appendix B Column and AxiChrom Master weights and dimensions, on page 125*. The table below states specific part weights. See the location of the main parts in Section 1.3.

Column	300	400	450	600	800	1000
Top unit [kg]						
• Short column tube	130	164	190	430	936	1390
• Long column tube	138	172	198	460	956	1420
Column tube [kg]						
• Short column tube	56	62	75	132	242	363
• Long column tube	69	75	93	162	288	433
Adapter bed support assembly [kg]						
• Stainless steel	3.2	4.7	5.7	8.7	14.4	22.3
• Plastic (including distributor)	2.4	4.5	5.8	10.5	20.9	32.9
Adapter distributor [kg]						
• Stainless steel	1.8	3.5	4.6	8.6	16.9	27.1
• Plastic	2.2	4.1	5.3	9.7	18.9	29.7
Bottom bed support assembly [kg]						
• Stainless steel	4.2	6.1	7.1	11.1	19.7	27.1
• Plastic	0.2	0.4	0.5	0.8	2.0	3.2
Bottom distributor						
• Stainless steel	4.5	6.4	7.9	13.7	27.8	43.4
• Plastic	5.0	7.1	8.6	14.6	29.6	45.5

Column	300	400	450	600	800	1000
Media valve assembly [kg]	1.3	1.3	1.3	1.3	2.3	2.3
Top mobile phase inlet/outlet	0.5	0.5	0.5	0.5	0.9	0.9
Locking pin	0.1	0.1	0.1	0.1	0.4	0.4
Lock block	0.4	0.4	0.4	0.4	1	1

5.1.5 Maintenance tools

This section describes the tools required for maintenance of AxiChrom.

NOTICE

Use appropriate tools and the correct tightening torque for bolts when working with the AxiChrom column and Master unit. Only the special toolkit provided by GE Healthcare for the AxiChrom column should be used.

Bed support tool

The bed support tool is used for removing and replacing the bed support screw. Engage the pins on the tool firmly in the screw when using the tool.

Figure 5.1: Bed support tool.

The threaded end of the tool is used with stainless steel bed supports to assist in centering the bed support on the distributor during assembly.

Removal tool

The removal tool is used for removing o-rings from their grooves and for similar tasks. The tool is made of plastic to avoid scratching o-ring fittings.

Figure 5.2: Using the removal tool to remove the snap ring.

Plastic mallet

The plastic mallet is used to tap the snap ring gently into position when fitting plastic bed supports. The groove on the mallet head may be used to lever the snap ring over the edge of the bed support if the fit is tight.

Figure 5.3: Using the groove on the mallet head to lever the snap ring into position.

Other required tools

Other tools required for disassembly, maintenance and assembly of the column are provided in the AxiChrom toolkit available from GE Healthcare.

All bolts and screws of size M8 and above are fitted with PTFE tape on the threads. In maintenance procedures that involve removal of bolts and screws with PTFE tape, remove the old tape from the bolts and apply new tape before refitting the nuts. Apply the tape in the same direction as the threads so that refitting the nuts draws the tape into the threads.

5.1.6 Power failure during maintenance

If there is a power failure during any column operation controlled via the Master, information about the ongoing procedure will be lost. However during maintenance mode the last static position is remembered so that the maintenance procedure can be resumed. After the Master has been restarted, start the same ***MAINTENANCE*** wizard again to carry on from the correct step. The column has to be re-calibrated if the power is lost during any adapter movement. If the wrong procedure is started, the on-going procedure will be reset and the column must be assembled or disassembled manually. If this becomes necessary, contact your GE Healthcare representative.

1 Restart the Master.

2 In the ***Select column*** dialog, select the name of the column that is used.

3 Verify the actual distance read from the level scale on the adapter rod. Enter the correct value in the ***Verify adapter position*** dialog.

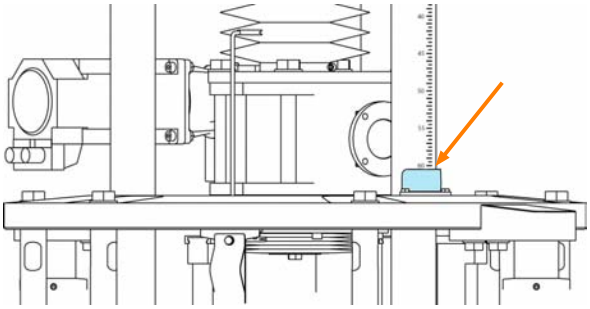


Figure 5.4: The adapter rod with its level scale. Note that the scale runs downward.

NOTICE

If the wrong adapter position is used, the result of future packings will be incorrect: in addition, maintenance positions will be incorrect and it may not be possible to complete the maintenance procedures. The level scale indicator is different for plastic and stainless steel bed supports: make sure that the correct indicator is fitted.

See Section 4.2 and *User Manual* for further information about calibration and restarting.

5.1.7 Pressure transmitter fault or screen shut-down

Symptom	Possible cause	Suggested action
Pressure transmitter fault	Transmitter not connected correctly, or faulty	Connect the cable, (< 4 mA) on the transmitter. If the problem still occurs contact your GE Healthcare service operator.
Pressure transmitter shows high pressure even though the column is depressurized	The TC gasket is too small or is stuck on the pressure transmitter membrane	Replace the gasket. Check the transmitter membrane for damage and replace the transmitter if necessary.
Master screen shut-down	One or more fuses in AxiChrom Master has defused	Press the **EMERGENCY STOP** button and contact your GE Healthcare service operator.

5.2 Putting the column in and out of maintenance mode

5.2.1 Introduction

The AxiChrom Master ***MAINTENANCE*** wizard is used for the disassembly and assembly of the column, for example to access the inside of the column to replace bed supports and o-rings.

The wizard contains step-by-step instructions for the disassembly and assembly procedures and also allows control of the necessary adapter movements. The wizard dialogs contain safety information, warnings and cautions which are displayed in connection to the process steps. Ensure that all locking pins and lock blocks are used as directed in the wizard screen.

The procedures for disassembly and assembly are described more detailed below. Refer to these instructions for an overview before starting the disassembly.

In general, the most severe risks for injury are during the disassembly and assembly procedures when the adapter is in motion outside the column tube.

Note: *If a **MAINTENANCE** wizard (**ASSEMBLE WIZARD** or **DISASSEMBLE WIZARD**) has been started, it is important to step through the whole procedure. If a **MAINTENANCE** wizard has for some reason been aborted, start the same wizard again and finalize the procedure. If the wrong procedure is started, the on-going procedure will be reset and the column must be assembled or disassembled manually. If this becomes necessary, contact your GE Healthcare representative.*

5.2.2 Safety information

WARNING

Follow all safety instructions displayed in the AxiChrom Master when performing maintenance on the column.

WARNING

Ensure that all locking pins and lock blocks are mounted in their proper, marked positions before proceeding with the next step in the procedure.

CAUTION

The air from damaged pneumatic tubes may cause eye injuries. Replace any damaged tubes.

NOTICE

The stand tubes will lock if the top unit is lifted above the permitted height. Please contact your GE Healthcare service operator for help to resolve this.

Risk areas

The illustration below shows the column areas where body parts may get caught when the adapter is lowered into the column tube and the suspended column tube is lowered onto the lower lid. Although the adapter movement is very slow, the force generated by the adapter control motor is substantial and any item that is caught between the moving adapter and other surfaces will be severely damaged.

The column tube swings out to offer access to the bed supports. The column tube must be locked in place using the designated locking pin when it is in its outer position.

WARNING

Ensure that no body parts are caught between the column tube assembly and the column frame when using the swing out function for maintenance work on the column. Due to the weight of the column tube assembly, it is not advisable to try to stop the momentum of the assembly by hand when it is set in motion.

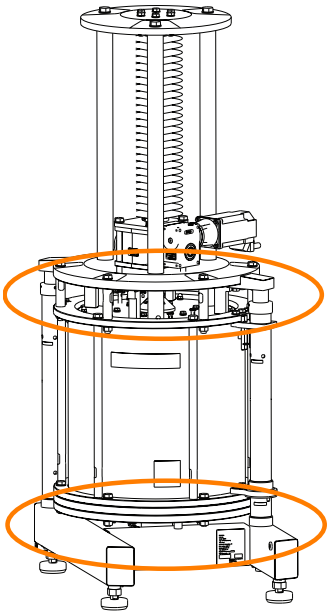
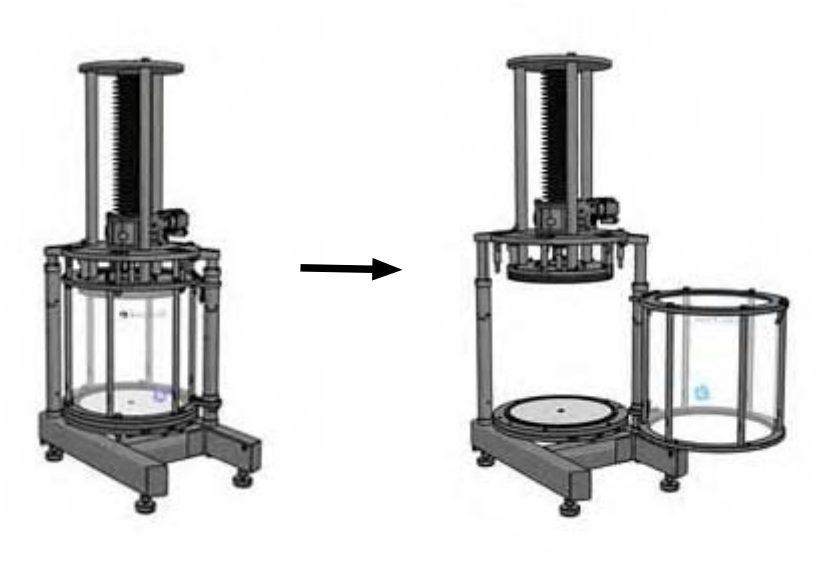


Figure 5.5: Areas where there is a risk that body parts may get caught during column and adapter movement.

5.2.3 Disassemble wizard



1 In the AxiChrom Master ***MAIN MENU***, press ***MAINTENANCE*** and then ***DISASSEMBLE WIZARD*** to open the wizard that sets the column into maintenance mode. This wizard is interactive and gives instructions of what to do and when.

CAUTION

A sudden release of pressure when disconnecting tubing may cause injury.

2 *Precheck:* Ensure that the inlet and outlet flowpaths are open and that the column is fully depressurized (for example by disconnecting the Top mobile phase hose). Press ***CONFIRM***.

3 *Precheck:* Verify that the 4 locking pins and lock blocks are in their storage positions as illustrated below (note that the number of blocks differs between column sizes). Press ***CONFIRM***.

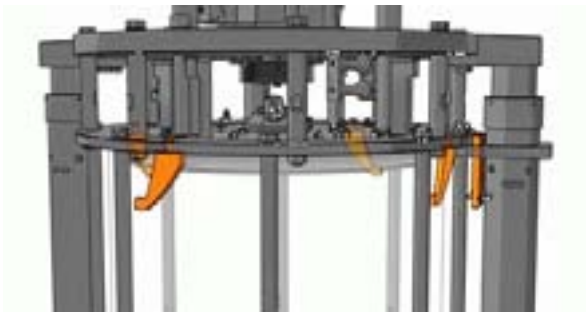


Figure 5.6: Lock blocks in their storage positions.

4 Unscrew and remove the nuts from the top column flange bolts as illustrated below (note that the number of bolts differs between column sizes). Press ***CONFIRM***.

Figure 5.7: Nuts on the top column flange bolts.

5 Verify that all top flange nuts are removed. Press ***CONFIRM*** to move the adapter to the top position.

Result: The adapter moves to its top position.

6 Remove the lock blocks from their storage positions. Fit the lock blocks in the lock positions as illustrated below (the illustration shows 4 blocks in lock positions **1A**, **1B**, **1C** and **1D**: the number of blocks differs between column sizes). Tighten the nuts securely to 45 Nm, using a torque wrench. Press ***CONFIRM***.

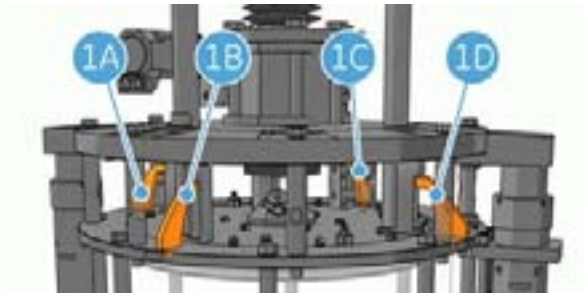


Figure 5.8: Lock blocks in the lock positions.

7 Verify that the lock blocks are securely fitted. Press ***CONFIRM*** to start lifting the top unit assembly.

Result: The top unit now moves upward.

NOTICE

Lifting the top unit with incorrectly placed lock blocks may damage the column.

NOTICE

If all nuts are not removed, the column may be damaged in later steps.

8 Insert and secure the locking pins in the lock hole positions **2A** and **2B**, as illustrated below.

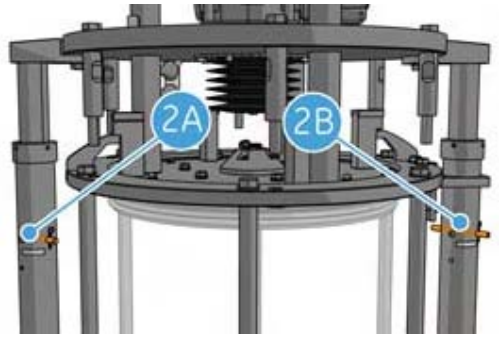


Figure 5.9: Locking pins inserted into the lock holes.

NOTICE

Moving the adapter with only one locking pin in place may damage the column.

If the locking pins cannot be inserted into the lock holes, the top unit may not be properly seated on the lock blocks (Figure 5.10 left). Shake the top unit gently by hand until the adapter is resting securely on the lock blocks (Figure 5.10 right).

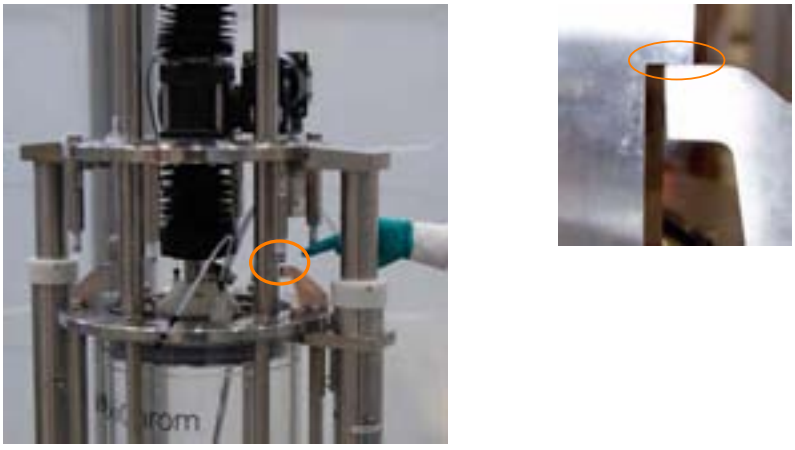


*Figure 5.10: **Left**: Top unit is not seated on the lock block. **Right**: Correct seating of top unit on lock block.*

9 Verify that the locking pins are secured in both positions. Press ***CONFIRM*** to move the adapter up to the chamfer, in the top of the column tube, to release the compression of the adapter seals.

Result: The adapter moves up to the chamfer.

10 Unscrew the nuts and remove the bottom flange bolts. Press ***CONFIRM***.

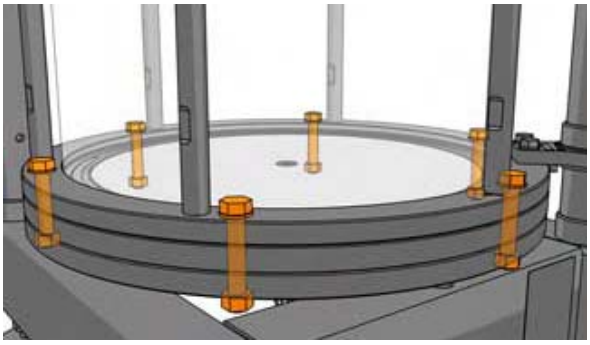


Figure 5.11: Bottom flange bolts.

NOTICE

Lifting the column tube with any bolts remaining in position may damage the column.

11 Verify that all bottom flange bolts are removed. Press ***CONFIRM*** to lift the column tube.

Result: The column tube now moves up.

12 Insert and secure a locking pin in the lock hole position **3**, as illustrated below. Press ***CONFIRM***.

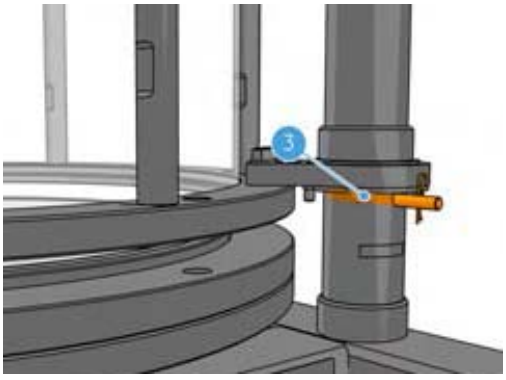


Figure 5.12: Locking pin inserted in the lock hole.

13 Verify that the locking pin is secured in position. Press ***CONFIRM*** to lower the adapter.

Result: The adapter moves down to release the weight from the lock blocks.

14 Remove the lock blocks from their lock positions and place the blocks in their storage positions as illustrated below (the illustration shows 4 blocks **1A**, **1B**, **1C** and **1D**: the number of blocks differs between column sizes). Press ***CONFIRM***.

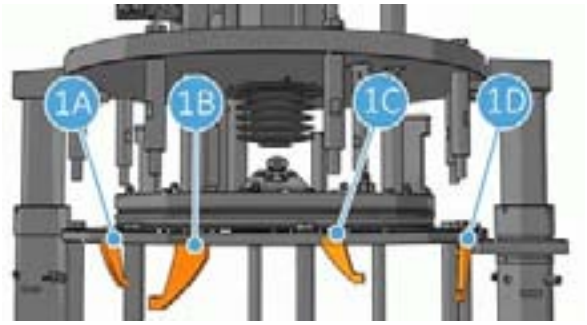


Figure 5.13: Lock blocks in their storage positions.

NOTICE

Moving the adapter with a lock block in the wrong position may damage the column.

15 Verify that all lock blocks are removed and in their storage positions. Press ***CONFIRM*** to move the adapter to the top position.

Result: The adapter now moves to its top position.

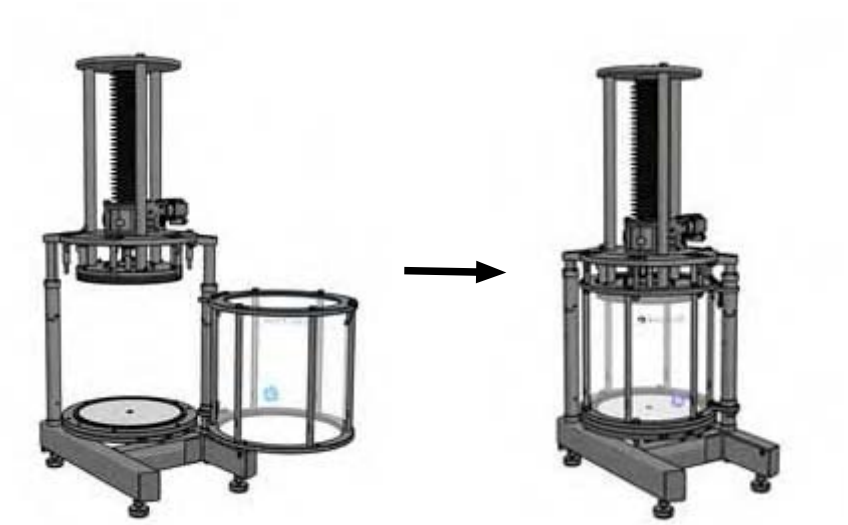
16 Swing out the column tube to perform the maintenance operations. Use the remaining locking pin to secure the column tube in the maintenance position.

Figure 5.14: Locking pin securing the column tube in the maintenance position.

CAUTION

Ensure that no body parts are caught when swinging out the column tube. The column tube must be locked in place during all maintenance work.

5.2.4 Assemble wizard



CAUTION

Make sure that no flow paths are blocked when you assemble the column. A dangerous build-up of pressure may be caused if the flow paths are blocked.

1 When the maintenance operations are completed, press the ***ASSEMBLE WIZARD*** button in AxiChrom Master. This wizard is interactive and gives instructions of what to do and when.

2 Press ***CONFIRM*** to move the adapter to the top position.

Result: The adapter now moves to the top position.

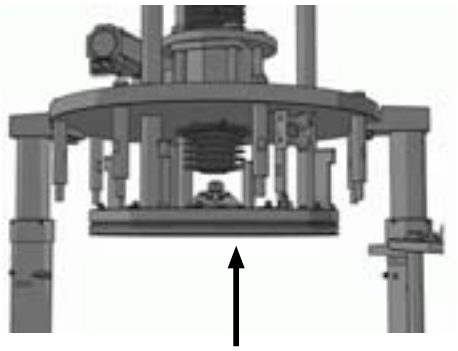


Figure 5.15: The adapter moves to the top position.

3 *Precheck:* Ensure that the inlet and outlet flowpaths are open. Press ***CONFIRM***.

4 Remove the locking pin **4**, that secures the column tube in maintenance position.

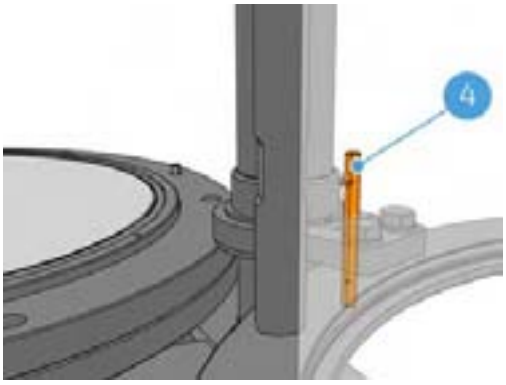


Figure 5.16: Locking pin securing the column tube in the maintenance position.

5 Verify that the lock blocks are in their storage positions as illustrated below (the illustration shows 4 blocks **1A**, **1B**, **1C** and **1D**: the number of blocks differs between column sizes). Press ***CONFIRM***.

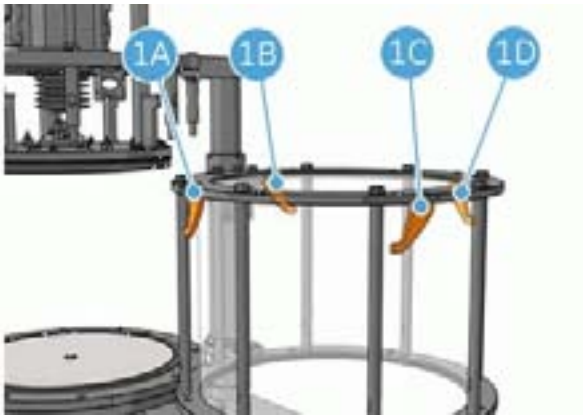


Figure 5.17: Lock blocks in their storage positions.

6 Swing the tube in position for operation. The tube must be aligned with the bolt holes. Press ***CONFIRM***.

Figure 5.18: Column tube in position for operation.

7 Insert bottom flange bolts to align the tube with the corresponding holes in the column bottom lid, as illustrated below. Do not refit the nuts yet. Press ***CONFIRM***.

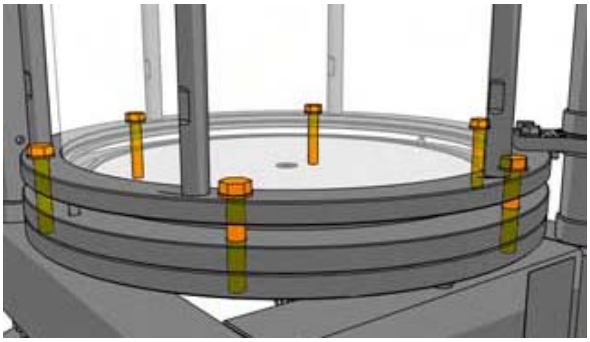


Figure 5.19: Bottom flange bolts in position.

NOTICE

Attempting to assemble a misaligned column will cause damage.

8 Verify that all bottom flange bolts are inserted and that the column tube is properly aligned. Press ***CONFIRM*** to move the adapter.

Result: The adapter moves down into position so that the lock blocks can be fitted.

9 Remove the lock blocks from their storage positions. Fit the lock blocks in the lock positions as illustrated below (the illustration shows 4 blocks in lock positions **1A**, **1B**, **1C** and **1D**: the number of blocks differs between column sizes). Tighten the nuts to 45 Nm using a torque wrench. Wet the scraper seals with 20% ethanol. Press ***CONFIRM***.

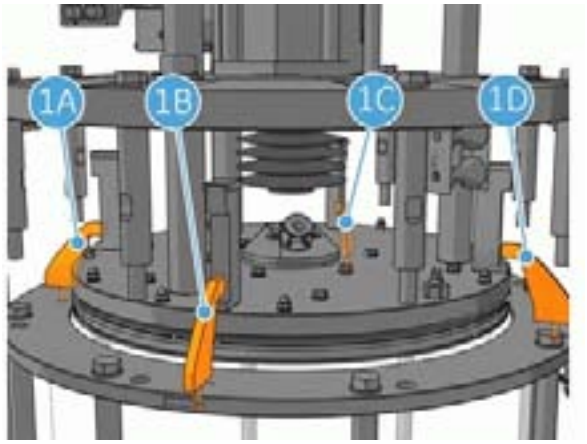


Figure 5.20: Lock blocks in the lock positions.

NOTICE

Lifting the column tube with incorrectly fitted lock blocks may damage the column.

10 Verify that the lock blocks are securely fitted. Press ***CONFIRM*** to start lifting the column tube.

Result: The column tube moves upward.

11 Remove the locking pin from lock hole position **3**. Place the locking pin in storage position. Press ***CONFIRM***.

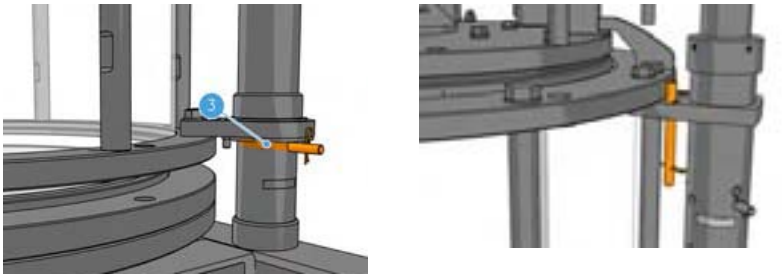


*Figure 5.21: **Left**: Locking pin in lock hole. **Right**: Locking pin replaced in storage position.*

NOTICE

Moving the column tube with a locking pin in the wrong place may damage the lock blocks.

12 Verify that the locking pin is removed and placed in storage position. Press ***CONFIRM*** to lower the column tube.

Result: The column tube moves downward.

13 Fit the bottom flange bolts, see illustration below. Tighten the nuts carefully by hand, only finger-tight.

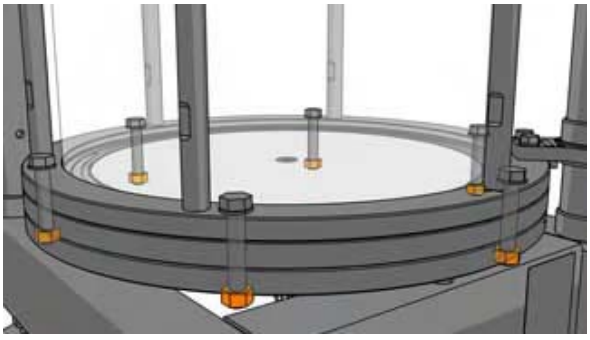


Figure 5.22: Nuts on the bottom flange bolts.

14 Verify that all bottom flange bolts are properly fitted. Press ***CONFIRM*** to lift the top unit assembly.

Result: The top unit moves upward.

15 Remove the locking pins from lock hole positions **2A** and **2B**. Place the locking pins in their storage positions (**1**, **2**, **3** and **4** in the right-hand illustration). Press ***CONFIRM***.

*Figure 5.23: **Left**: Locking pins in lock holes. **Right**: All locking pins replaced in storage position.*

If the locking pins are difficult to remove, the top unit may not be properly seated on the lock blocks (see Figure 5.10). Shake the top unit gently by hand until the adapter is resting securely on the lock blocks.

16 Verify that the locking pins are removed from both positions and placed in their storage positions. Press ***CONFIRM*** to lower the top unit.

Result: The top unit moves downward to position.

17 Remove the lock blocks from their lock positions and place the blocks in their storage positions under the top flange as illustrated below (the illustration shows 4 blocks **1A**, **1B**, **1C** and **1D**: the number of blocks differs between column sizes). Press ***CONFIRM***.

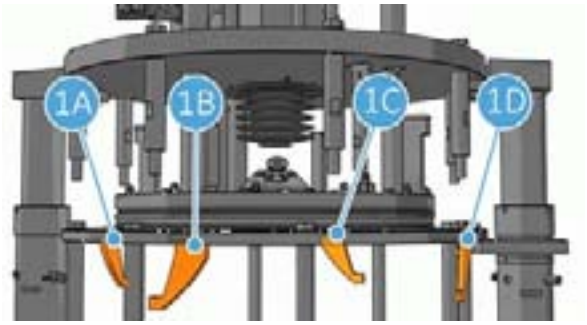


Figure 5.24: Lock blocks in their storage positions.

NOTICE

Moving the adapter with a lock block in the wrong place may damage the column.

18 Verify that both lock blocks are removed and in their storage positions. Press ***CONFIRM***.

19 Fit the top flange bolts as illustrated below. Tighten the nuts carefully by hand, only finger-tight.

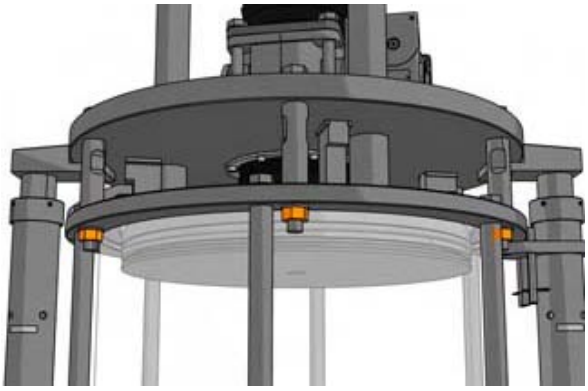


Figure 5.25: Nuts on the top flange bolts.

20 Verify that all top flange bolts are properly fitted. Press ***CONFIRM*** to lower the adapter.

Result: The adapter is pressing the column tube downward.

21 Using a torque wrench, tighten the bottom flange nuts with the correct tightening torque, see table below.

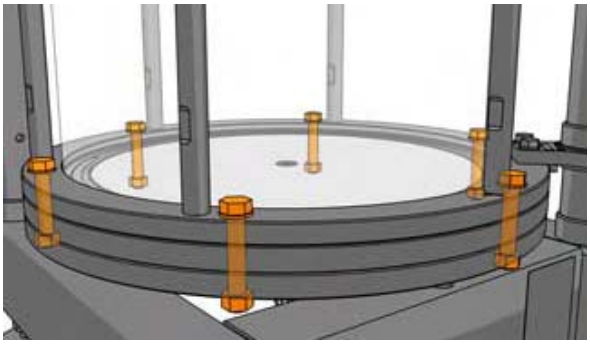


Figure 5.26: Bottom flange bolts.

Column size	Tightening torque [Nm]
300	80
400	80
450	80
600	100

Column size	Tightening torque [Nm]
800	140
1000	150

22 Verify that all bottom flange bolts are properly tightened. Press ***CONFIRM*** to lower the top unit.

Result: The adapter pulls the top unit downward.

23 Using a torque wrench, tighten the top flange nuts with the correct tightening torque, see table in step 21.

24 Verify that all top flange bolts are properly tightened. Press ***CONFIRM***.

25 The column is now assembled. Press ***CONFIRM*** to complete the AxiChrom ***MAINTENANCE*** wizard.

NOTICE

A leakage test must be performed after the assembly of the column. Refer to Section 5.9 for instructions on how to perform the leakage test.

5.3 Changing liquid in the flushing channels

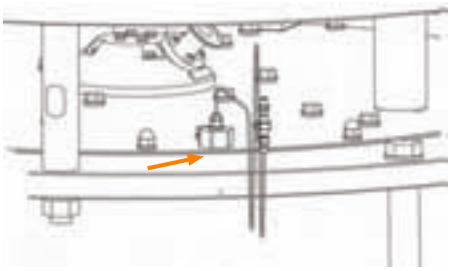
The flushing channels are filled with 20% (v/v) ethanol on delivery. The liquid should be changed every 2 months and preferably before each new packing.

1 Ensure that the tube on one of the flushing channels is open.

2 On the other flushing channel; connect a syringe filled with 20% (v/v) ethanol to the Luer connector (located on the tube).

3 Fill the channels with liquid until the old ethanol has been completely replaced.

5.4 Changing flushing connector o-rings



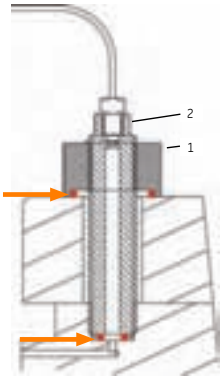


Figure 5.27: ***Left****: Flushing connector.* ***Right****: Cross-section showing (1) the flushing connector retaining nut, (2) the flushing connector, and the 2 o-rings indicated by arrows.*

There are 2 flushing connectors on the top of the adapter backing plate, one on each side. Inside each flushing connector are 2 o-rings, which should be changed at least once every two years. The o-rings should be checked regularly and cleaned if needed.

1 Unscrew the flushing connector retaining nut (1).

2 The flushing connector (2) is threaded into the adapter distributor. Unscrew the flushing connector so that the o-rings can be reached.

3 Remove the 2 o-rings from the flushing connector. Clean the o-rings with 20% ethanol or replace with new o-rings if necessary.

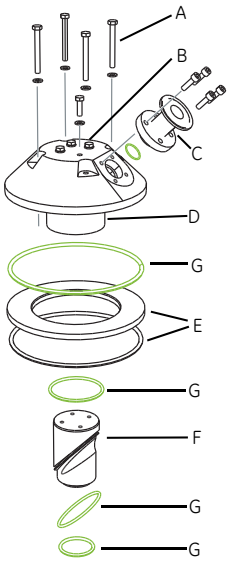
4 Refit the flushing connector (2) on the distributor plate and tighten finger-tight.

5 Refit the flushing connector retaining nut (1) and tighten finger-tight.

6 Repeat steps 1-5 on the other flushing connector.

5.5 Maintaining the adapter inlet/outlet

Adapter inlet/outlet maintenance is performed in connection with bed support maintenance (see Section 5.6 for columns with stainless steel bed supports and Section 5.7 for columns with plastic bed supports). This section describes how to change the o-rings in the inlet/outlet valve.



Part	Description
A	Outer countersunk bolts
B	Inner bolts
C	Connector
D	Valve outer body
E	Plastic spacer
F	Valve inner body
G	Valve body o-rings

Figure 5.28: Adapter inlet/outlet.

Disassembling the adapter inlet/outlet

1 Remove the connector (C) by removing the 4 bolts. Remove the o-ring from underneath the connector. Clean the o-ring with 20% ethanol or replace it with new o-ring if necessary.

2 Loosen the 4 bolts (B) on the top of the adapter inlet/outlet. Do not remove the bolts: make sure a few millimeters of the bolt remain screwed into the body of the inlet/outlet. Press the bolts against a flat surface so that the bolts push out the valve inner body, then unscrew the bolts completely and remove the valve inner body from the inlet/outlet assembly.

3 Remove the 4 o-rings (G) from the valve inner body and from underneath the inlet/outlet. Clean the o-rings with 20% ethanol or replace them with new o-rings if necessary.

Assembling the adapter inlet/outlet

4 Refit the diagonally placed o-ring on the valve inner body.

Note: *Stretch the o-ring when refitting it. Do* ***not*** *roll it into place.*

5 Refit the o-ring on top of the valve inner body.

6 Refit the valve inner body and tighten the 4 bolts (B) crosswise to 2.2 Nm.

7 Refit the connector o-ring and the connector (C). Tighten the 4 bolts crosswise to 2.2 Nm.

8 Refit the remaining o-rings.

5.6 Maintaining columns with stainless steel bed supports

Stainless steel bed supports should be cleaned at least every 5-10 column packings, or every time the column is packed for best performance.

Disassemble the bottom assembly first, so that components that may be dropped when working on the adapter assembly will not damage the fragile bed support. Similarly, assemble the adapter assembly before working on the the bottom assembly.

CAUTION

Some component assemblies on the larger column sizes weigh more than 20 kg and may need more than one person for safe lifting. See table on page 50 for component weights.

NOTICE

Do not tighten any nuts harder than 10 Nm for 300-600 columns and 15 Nm for 800 and 100 columns since this will damage the threads.

NOTICE

Handle the bed supports with care. The supports are very fragile.

Always use protective gloves when handling the bed supports to avoid contaminating the bed supports with skin grease.

Make sure the column is in maintenance mode before performing service operations. Follow the instructions in Section 5.2.3 to set the column in maintenance mode if required.

5.6.1 Disassembling the bottom assembly

1 Make sure the media valve is open. The media valve is open when the piston in the center of the bed support is lowered. If the media valve is closed, it can be opened in the ***MANUAL CONTROL*** wizard in AxiChrom Master.

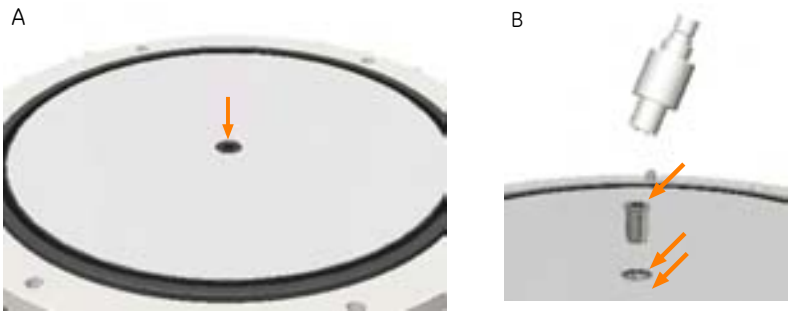


*Figure 5.29: **A**: Media valve is open when the piston is lowered. **B**: Bed support tool and center bed support screw. Arrows indicate o-rings (there are two o-rings in the centre of the bed support, one on each side).*

2 Use the bed support tool to remove the bed support screw in the center (see Figure 5.29 A).

NOTICE

Be careful not to slip with the bed support tool since this may damage the bed support screw.

3 Remove the o-ring on the bed support screw (see Figure 5.29 B). Clean the o-ring with 20% ethanol or replace it with a new o-ring if necessary.

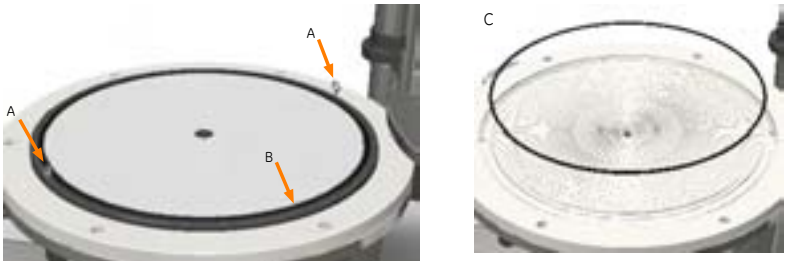


*Figure 5.30: **A**: Lifting the bed support with the eye bolts, **B**: O-ring on the bed support, **C**: Removing the o-ring from the distributor plate*

4 Unscrew the nuts underneath the bottom backing plate so that the bottom bed support can be lifted. Screw the 2 eye bolts (see Figure 5.30 A) delivered with the column into the holes and use them to lift the bed support.

5 Remove the large o-ring from the outer edge of the bed support. Clean the o-ring with 20% ethanol or replace it with a new o-ring if necessary (see Figure 5.30 B).

6 Remove the 2 small o-rings from centre of the bed support (see Figure 5.29 B). Clean the o-rings with 20% ethanol or replace them with new o-rings if necessary.

7 Remove the o-ring from the distributor plate. Clean the o-ring with 20% ethanol or replace it with a new o-ring if necessary (see Figure 5.30 C).

5.6.2 Disassembling the adapter

Note: *At least two persons are needed when disassembling the adapter assembly.*

Removing the bed support

1 Use the bed support tool to remove the bed support screw from the center of the bed support. Hold the bed support tool vertically when removing the bed support screw.

Figure 5.31: Removing the bed support screw.

NOTICE

Be careful not to slip with the bed support tool since this may damage the bed support screw.

2 With one or two persons (as required) supporting the weight of the bed support assembly, unscrew the dome nuts and remove the bed support assembly.

CAUTION

The bed support is heavy, particularly on larger columns. Make sure that the bed support does not fall when it is removed.

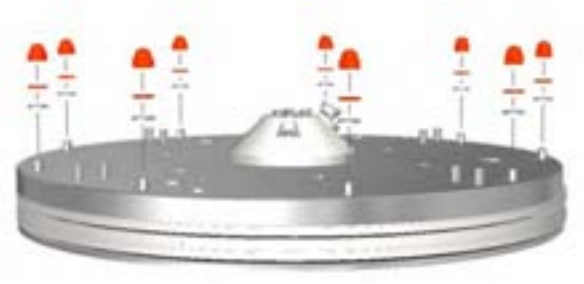


Figure 5.32: Remove the dome nuts.

Note: *The dome nuts should release from the fasteners, leaving the fasteners attached to the distributor plate. If any fastener releases from the distributor plate instead, refit the fastener and tighten to a torque of 20 Nm.*

3 Place the bed support on a clean and soft surface.

4 Remove the o-ring in the center of the top side of the bed support. Clean the o-ring with 20% ethanol or replace it with a new o-ring if necessary.

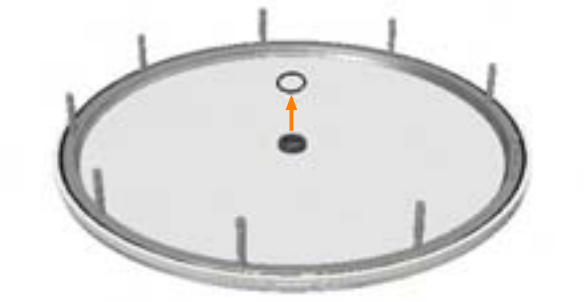


Figure 5.33: O-ring in the center of the bed support.

5 Remove the scraper seal and its underlying o-ring from the bed support. Remove the o-ring in the center of the bottom side of the bed support. Clean the scraper seal and o-rings with 20% ethanol or replace them with new seal and o-rings if necessary.

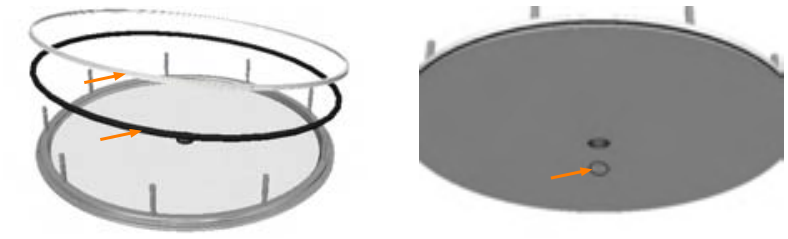


Figure 5.34: ***Left****: Scraper seal and underlying o-ring.* ***Right****: Center o-ring.*

6 Remove the o-ring from the distributor plate. Clean the o-ring with 20% ethanol or replace it with a new o-ring if necessary.

Figure 5.35: Distributor plate o-ring.

Removing the adapter inlet/outlet

7 Remove the adapter inlet/outlet from the column by unscrewing the 4 outer countersunk bolts.

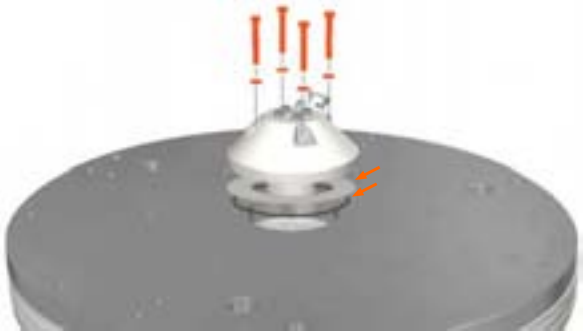


Figure 5.36: Removing the adapter inlet/outlet. Arrows indicate the plastic spacer and o-ring on 300, 400, 450 and 800 columns.

8 The 300, 400, 450, and 800 columns have a plastic spacer placed between the adapter inlet/outlet and the column. Remove this plastic spacer and the o-ring underneath. Clean the o-ring with 20% ethanol or replace it with new o-ring if necessary.

9 Replace the o-rings in the inlet/outlet valve if necessary (see Section 5.5).

Removing the distributor plate

10 Remove the 2 flushing connectors according to the instruction in Section 5.4. Clean their o-rings with 20% ethanol or replace them with new o-rings if necessary..

11 Remove the 4 bolts underneath the inlet/outlet.

Figure 5.37: Four bolts underneath the inlet/outlet.

12 With one or two persons (as required) supporting the weight of the distributor plate, unscrew the bolts and remove the distributor plate.

CAUTION

The distributor is heavy, particularly on larger columns. Make sure that the distributor does not fall when it is removed.

Figure 5.38: Bolts holding the distributor plate (the number of bolts varies with columns size).

13 Remove and clean the scraper seal and the large o-ring around the distributor plate. Clean the scraper seal and o-ring with 20% ethanol or replace them if necessary.

5.6.3 Cleaning stainless steel bed supports

Stainless steel bed supports may clog if not cleaned regularly. The supports should be cleaned at least after 5-10 packings, but preferably after each packing. If the supports can not be cleaned properly using the method below, contact your GE Healthcare service operator.

Note: *The compressed air that is used for cleaning bed supports must be completely free from lubricating oils and particles.*

1 Remove the bed support from the column.

2 Flush the bed support free from entrapped media using water.

3 Place a shut-off valve on a compressed air supply hose. Fit a 0.5-1 inch plastic Tri-clamp connector or similar to the valve.

4 Use a shallow basin to soak the bed support in 0.5 - 1 M NaCl solution for a maximum of 5 minutes.

5 Place the bed support with the coarse side up on a clean non-scratching (plastic) support, that allows air and media to flow through the bed support.

6 Open the valve and start blowing air though the bed support from a close distance. Make sure the whole surface of the bed support is properly blown and that special care is used at the outer rim and at the center.

7 Rinse the bed support thoroughly in water immediately after the above procedure is finished.

8 Repeat the procedure, this time using at least 20% ethanol solution. If 20% ethanol cannot be used, use water. Finish by carefully rinsing with water.

5.6.4 Assembling the adapter

Note: *At least two persons are needed when assembling the adapter.*

Refitting the distributor plate

1 Wet the large o-ring and scraper seal with 20% ethanol, then refit the o-ring on the distributor plate and place the scraper seal on top of the o-ring.

Figure 5.39: O-ring and scraper seal on the distributor plate.

2 Refit the distributor plate. Ensure that the holes in the distributor plate are aligned with the flushing connectors. First, refit all bolts finger-tight on the distributor plate. Then use a torque wrench to tighten the M12 bolts on the distributor plate to 15 Nm and the 4 bolts underneath the inlet/outlet assembly to 11 Nm.

Figure 5.40: Align the holes for the flushing connectors in the distributor plate with the corresponding holes in the backing plate.

3 Refit the 2 flushing connectors according to the instructions in Section 5.4.

Refitting the inlet/outlet

4 Refit the plastic spacer and o-ring (if used) on the inlet/outlet. The plastic spacer is used on the 300, 400, 450 and 800 columns, and not on the 600 and 1000 columns.

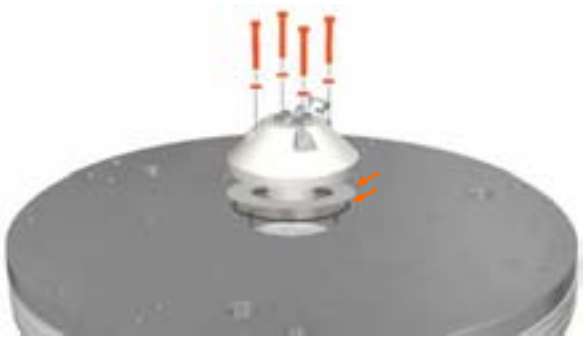


Figure 5.41: Fitting the adapter inlet/outlet. Arrows indicate the plastic spacer and o-ring on 300, 400, 450 and 800 columns.

5 Refit the adapter inlet/outlet to the column. Make sure that the o-rings are positioned correctly. Refit the inlet/outlet so that the tubing is closest to the tube roller assembly. Tighten the 4 bolts crosswise to 5 Nm.

NOTICE

When fitting an old inlet/outlet on a newer column, check if there are more than 4 threaded holes that the inlet/outlet can be fitted to on top of the adaptor. If so, remove the guide pin from the inlet/ outlet if it exists.

Refitting the bed support

6 Refit the 2 center o-rings, one on each side of the bed support.

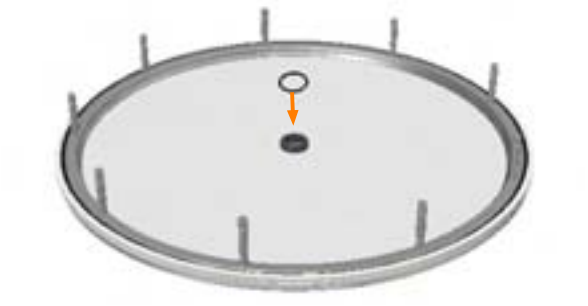


Figure 5.42: Refitting the center o-ring.

7 Refit the bed support o-ring and scraper seal.

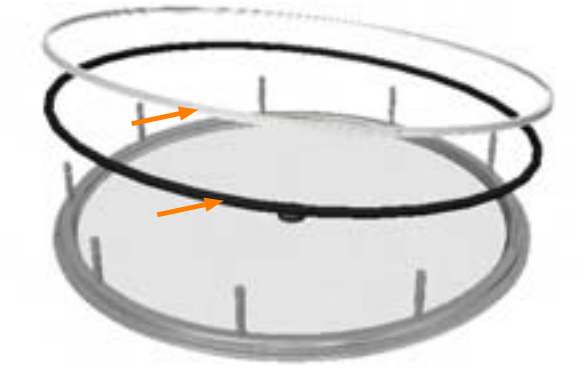


Figure 5.43: Bed support o-ring and scraper seal.

8 With one person holding the bed support in place, replace the dome nuts so that the bed support is retained. Do not tighten the dome nuts yet. Use the threaded side of the bed support tool to fit and center the bed support on the distributor plate. Ensure that the center of the bed support exactly fits into the corresponding countersink in the distributor plate, then remove the bed support tool.

9 Refit the bed support screw. Carefully start to tighten the bed support screw by hand making sure that the threads are not crossed. Finally tighten the bed support screw firmly using the bed support tool. Make sure the bed support is secured by the bed support screw.

Figure 5.44: Refitting the bed support screw.

NOTICE

Be careful not to damage the threads when refitting the bed support screw.

10 Tighten the dome nuts finger-tight, then use a torque wrench to tighten all dome nuts crosswise to 10 Nm for the 300-600 columns and 15 Nm for the 800 and 1000 columns.

5.6.5 Assembling the bottom assembly

1 Refit the o-ring on the distributor plate (see Figure 5.30 C).

2 Refit the o-ring on the bed support (see Figure 5.30 B).

3 Refit the 2 small o-rings on the center of the bed support, one on each side.

4 Refit the bed support on the distributor plate. Use the threaded side of the bed support tool to fit and center the bed support on the distributor plate. Ensure that the center of the bed support fits exactly into the corresponding countersink in the distributor plate.

5 Leave the bed support tool in place while you replace the nuts under the backing plate. Tighten the nuts crosswise with a torque wrench, to 10 Nm torque for the 300-600 columns and 15 Nm for the 800 and 1000 columns.

6 Remove the bed support tool.

7 Refit the bed support screw: Carefully start to tighten the bed support screw by hand making sure that the threads are not crossed. Finally tighten the bed support screw firmly using the bed support tool (Figure 5.29 B). Make sure the bed support is secured by the bed support screw.

NOTICE

Be careful not to damage the threads when refitting the bed support screw.

5.7 Maintaining columns with plastic bed supports

GE Healthcare recommends that the plastic bed supports and snap ring are replaced every time the column is packed.

NOTICE

Handle the bed supports with care. The supports are very fragile.

Disassemble the bottom assembly first, so that components that may be dropped when working on the adapter assembly will not damage the fragile bed support. Similarly, assemble the adapter assembly before working on the the bottom assembly.

CAUTION

Some component assemblies on the larger column sizes weigh more than 20 kg and may need more than one person for safe lifting. See table on page 50 for component weights.

NOTICE

Do not tighten any nuts harder than 4 Nm since this will damage the threads.

NOTICE

Handle the bed supports with care. The supports are very fragile.

Always use protective gloves when handling the bed supports to avoid contaminating the bed supports with skin grease.

Make sure the column is in maintenance mode before performing service operations. Follow the instructions in Section 5.2.3 to set the column in maintenance mode if required.

5.7.1 Disassembling the bottom assembly

1 Make sure the media valve is open. The media valve is open when the piston in the center of the bed support is lowered. If the media valve is closed, it can be opened in the ***MANUAL CONTROL*** wizard in AxiChrom Master.

*Figure 5.45: **A**: Media valve is open when the piston is lowered. **B**: Bed support tool and center bed support screw. Arrow indicates o-ring.*

2 Use the bed support tool to remove the bed support screw in the center (see Figure 5.45 A).

3 Remove the o-ring on the bed support screw (see Figure 5.45 B). Clean the o-ring with 20% ethanol or replace it with new o-ring if necessary.

4 Remove the bed support. If necessary, insert the removal tool between the edge of the bed support and the o-ring and gently prise the bed support out of its seating.

5 Remove the o-ring from the distributor plate. Clean the o-ring with 20% ethanol or replace it with a new o-ring if necessary.

5.7.2 Disassembling the adapter

Note: *At least two persons are needed when disassembling the distributor plate.*

Removing the adapter inlet/outlet

1 Remove the adapter inlet/outlet from the column by unscrewing the 4 outer countersunk bolts.

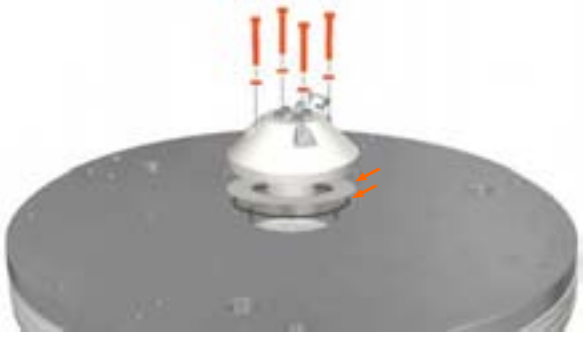


Figure 5.46: Removing the adapter inlet/outlet. Arrows indicate the plastic spacer and o-ring on 300, 400, 450 and 800 columns.

2 The 300, 400, 450, and 800 columns have a plastic spacer placed between the adapter inlet/outlet and the column. Remove this plastic spacer and the o-ring underneath. Clean the o-ring with 20% ethanol or replace it with new o-ring if necessary.

3 Replace the o-rings in the inlet/outlet valve if necessary (see Section 5.5).

Removing the bed support assembly

4 Remove the 2 flushing connectors according to the instruction in Section 5.4. Clean their o-rings with 20% ethanol or replace them with new o-rings if necessary..

5 Remove the 4 bolts underneath the inlet/outlet.

Figure 5.47: Four bolts underneath the inlet/outlet.

6 Remove the bolts on the top of the distributor plate.

Figure 5.48: Bolts holding the distributor plate (the number of bolts varies with columns size).

7 With one or two persons (as required) supporting the weight of the bed support assembly, unscrew the dome nuts and remove the bed support assembly.

CAUTION

The bed support assembly is heavy, particularly on larger columns. Make sure that the bed support assembly does not fall when it is removed.

Note: *The dome nuts should release from the fasteners, leaving the fasteners attached to the distributor plate. If any fastener releases from the distributor plate instead, refit the fastener and tighten to a torque of 2 Nm.*

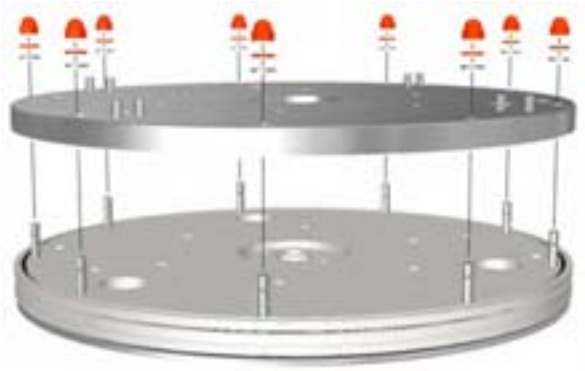


Figure 5.49: Remove the dome nuts.

8 Place the bed support and distributor assembly on a clean firm surface, allowing it to rest on the fasteners.

9 Use the bed support tool to remove the bed support screw from the center of the bed support. Hold the bed support tool vertically when removing the bed support screw.

Figure 5.50: Removing the bed support screw.

NOTICE

Be careful not to slip with the bed support tool since this may damage the bed support screw.

10 Remove the o-ring on the bed support screw. Clean the o-ring with 20% ethanol or replace with a new o-ring if necessary.

Disassembling the bed support assembly

11 Remove the snap ring using the removal tool.

Figure 5.51: Removing the snap ring.

12 Lift the bed support from the distributor.

13 Turn the distributor over so that the ribbed side faces downwards and place the distributor on a surface protected so as to avoid scratching the distributor channels.

14 Remove the upper scraper seal and o-ring. Clean the seal and o-ring with 20% ethanol or replace with new components if necessary.

Figure 5.52: Upper scraper seal and o-ring.

15 Remove the M8 hexagon socket screws holding the distributor ring using an Allen key.

Figure 5.53: Hexagon socket screws holding the distributor ring.

16 Remove the distributor ring from the distributor.

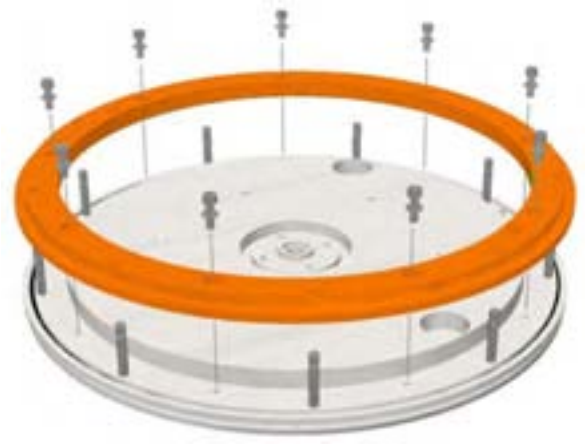


Figure 5.54: Distributor ring.

17 Remove the lower scraper seal and o-ring. Clean the seal and o-ring with 20% ethanol or replace with new components if necessary.

Figure 5.55: Lower scraper seal and o-ring.

5.7.3 Assembling the adapter

Note: *At least two persons are needed when assembling the adapter.*

Reassembling the bed support assembly

1 Wet the o-ring and lower scraper seal with 20% ethanol. With the ribbed side of the distributor facing downwards, refit the o-ring on the distributor plate and place the scraper seal on top of the o-ring.

Figure 5.56: Lower scraper seal and o-ring.

2 Place the distributor ring adapter on the distributor. The two steering pins ensure that the ring can only be placed in one orientation.

3 Refit the M8 hexagon socket screws to secure the distributor ring adapter. Tighten the screws with a torque wrench to 4 Nm.

Figure 5.57: Hexagon socket screws holding the distributor ring.

4 Wet the o-ring and upper scraper seal with 20% ethanol. Refit the o-ring on the distributor and place the scraper seal on top of the o-ring.

Figure 5.58: Upper scraper seal and o-ring.

5 Turn the distributor over so that it rests on the fasteners. Make sure that the scraper seal and o-ring remain in place.

6 Place the new bed support on the distributor. The smoother side of the bed support shall face the interior of the column.

7 Refit the o-ring in the bed support screw, then wet the o-ring and screw with 20% ethanol. Use the removal tool to help fit the o-ring if necessary.

Figure 5.59: Bed support screw and o-ring.

8 Refit the bed support screw. Carefully start to tighten the bed support screw by hand making sure that the threads are not crossed. Finally tighten the bed support screw more firmly using the bed support tool. Make sure the bed support is secured by the bed support screw.

NOTICE

Be careful not to damage the threads when refitting the bed support screw.

9 Refit the snap ring, tapping gently with the plastic mallet if necessary. Use the groove on the mallet head to lever the snap ring over the edge of the bed support if the fit is tight.

Note: *Check that the snap ring is correctly and evenly mounted around the whole circumference of the bed support.*

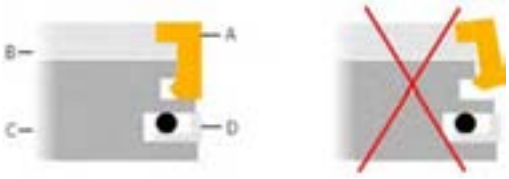


Figure 5.60: Cross-section of the bed support edge with the snap ring mounted correctly (left) and incorrectly (right). ***A****: Snap ring.* ***B****: Bed support.* ***C****: Distributor.* ***D****: Scraper seal.*

Figure 5.61: Use the groove on the plastic mallet if the snap ring is difficult to fit.

Refitting the bed support assembly

10 With one or two persons (as required) supporting the bed support and distributor assembly, refit the assembly on the backing plate. Position the assembly so that the holes in the assembly and backing plate are aligned (the assembly can only be mounted in one orientation on the backing plate). Fit both stainless steel and plastic washers on each screw, with the plastic washer innermost. Tighten all dome nuts finger-tight, then use a torque wrench to tighten all dome nuts crosswise to 4 Nm.

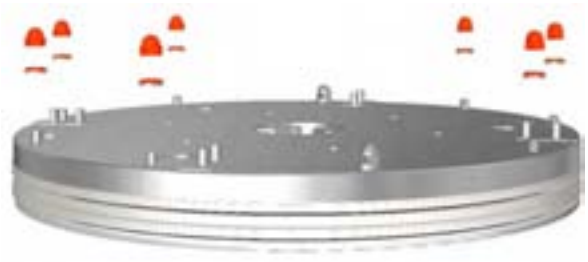


*Figure 5.62: Dome nuts holding the bed support and distributor assembly on the backing plate. **A**: Stainless steel washer. **B**: Plastic washer.*

11 Refit the bolts on top of the distributor plate. Fit both stainless steel and plastic washers on each screw, with the plastic washer innermost. Tighten the bolts to 15 Nm.

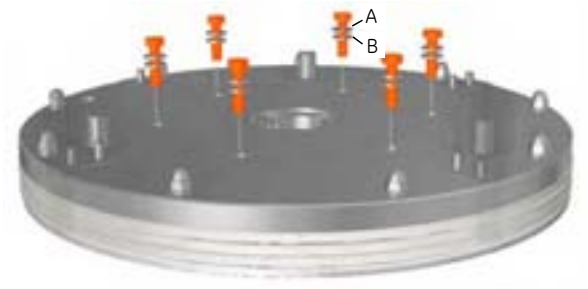


*Figure 5.63: Bolts holding the distributor plate. **A**: Stainless steel washer. **B**: Plastic washer.*

12 Refit the 4 bolts underneath the inlet/outlet assembly and tighten to 11 Nm.

Figure 5.64: Four bolts underneath the inlet/outlet.

13 Refit the 2 flushing connectors according to the assembly instructions in Section 5.4.

Refitting the adapter inlet/outlet

14 Refit the plastic spacer and o-ring (if used) on the inlet/outlet. The plastic spacer is used on the 300, 400, 450 and 800 columns, and not on the 600 and 1000 columns.

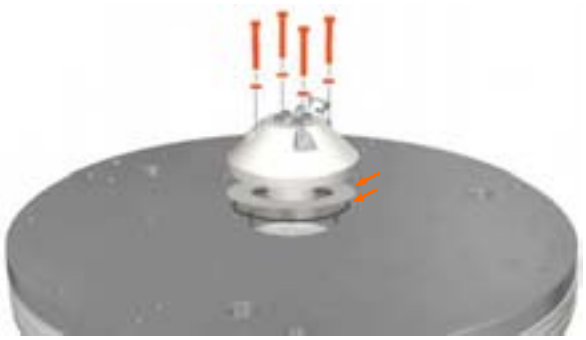


Figure 5.65: Fitting the adapter inlet/outlet. Arrows indicate the plastic spacer and o-ring on 300, 400, 450 and 800 columns.

15 Refit the adapter inlet/outlet to the column. Make sure that the o-rings are positioned correctly. Refit the inlet/outlet so that the tubing is closest to the tube roller assembly. Tighten the 4 bolts (A) cross-wise to 5 Nm.

NOTICE

When fitting an old inlet/outlet on a newer column, check if there are more than 4 threaded holes that the inlet/outlet can be fitted to on top of the adaptor. If so, remove the guide pin from the inlet/outlet if it exists.

5.7.4 Assembling the bottom assembly

1 Fit a new bed support on the distributor. The smoother side of the bed support shall face the interior of the column.

2 Refit the o-ring on the bed support screw, then wet the o-ring with 20% ethanol.

3 Refit the bed support screw. Carefully start to tighten the bed support screw by hand making sure that the threads match. Finally tighten the bed support screw until it reaches a stop. Make sure the bed support is secured by the bed support screw.

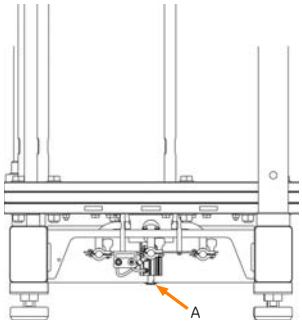
NOTICE

Be careful not to damage the threads when refitting the bed support screw.

4 Refit the o-ring on the bed support.

5.8 Media valve maintenance

5.8.1 Media valve - troubleshooting



In rare cases the media valve may get stuck in closed position. First, check that the following conditions are met:

- The compressed air requirements are fulfilled. The pressure should be between 5.5 and 7 bar, see *Compressed air requirements, on page 39*.
- The pneumatic air or other tubes are correctly connected, see *Connections on Master and column, on page 32*.
- The media valve is primed before operation, see *Section 4.6 Priming the column, on page 42*.

If the media valve cannot be opened when the above conditions have been met, the o-ring in the media valve may have stuck to the piston. This may have happened if the column has been unused for a while. Try the following:

1 Check that the compressed air and AxiChrom Master are connected to the column and the media valve mode in the ***MANUAL CONTROL*** wizard is set to Open. Even though nothing happens visually when the media valve is opened, this will release a lock in the pneumatic cylinder.

2 Place a screwdriver on top of the washer at the end of the piston of the pneumatic cylinder. Carefully lever against the bottom end of the pneumatic cylinder until the media valve opens, see A for where to apply leverage.

3 If this does not work, contact a GE Healthcare service operator.

5.8.2 Disassembling the media valve

Make sure the column is empty before disassembling the media valve.

Note: *It is not necessary to put the column into maintenance mode when disassembling the media valve.*

O-rings that form stationary seals in the media valve should be replaced at least once every two years. O-rings on moving parts should be replaced after every 5-10 packings or more frequently if necessary.

1 Set the media valve to Open in the ***MANUAL CONTROL*** wizard in AxiChrom Master.

Close the air supply to the column.

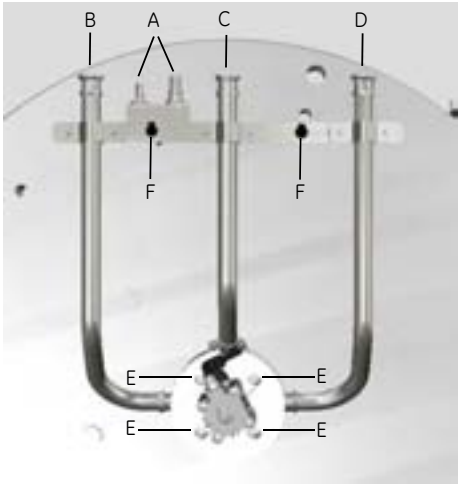


*Figure 5.66: **A**: 2 valve pneumatic inlets **B**: Slurry inlet, **C**: Bottom mobile phase inlet/outlet, **D**: Rinse inlet, **E**: Media valve bolts screwed into the bottom backing plate, **F**: Locking screws on the tube holder bolts.*

Disconnect the air supply tubes from the two valve pneumatic inlets (see Figure 5.66 A) on the media valve.

Disconnect the hoses (see Figure 5.66) to the:

- Slurry inlet (B),
- Bottom mobile phase inlet/outlet (C), and

- Rinse inlet (D)

2 Hold the media valve in position while removing the 4 bolts screwed into the valve from underneath the column (see Figure 5.66 E).

3 Continue to hold the media valve in place while loosening the 2 locking screws on the tube holder bolts (see Figure 5.66 F).

4 The media valve and tube holder can now be removed downwards from the column. Let the tube holder slide off its fastener. The following steps on the media valve can be performed on a table.

5 Firmly press the release washer and hold it into the connector while removing the pneumatic tube from pneumatic cylinder (see Figure 5.67 A). Repeat the procedure to disconnect the other pneumatic tube (B).

*Figure 5.67: Pneumatic tubes **A** and **B**, the connection between the pneumatic cylinder and the tube holder.*

6 Unscrew and remove the tube holder brackets (see Figure 5.68 B) from the:

- Slurry inlet tube,
- Bottom mobile phase tube, and
- Rinse inlet tube.

Let the pneumatic tubes stay connected to the tube holder.

*Figure 5.68: **A**: Tube holder, **B**: Tube holder brackets*

Remove the tube holder and pneumatic tubes from the media valve (see Figure 5.68 A).

7 Remove the 3 tubes and their o-rings from the media valve body (see Figure 5.69):

- Slurry inlet (A),
- Bottom mobile phase inlet/outlet (B),
- Rinse inlet (C).

Clean o-rings with 20% ethanol. Replace with new o-rings if necessary.

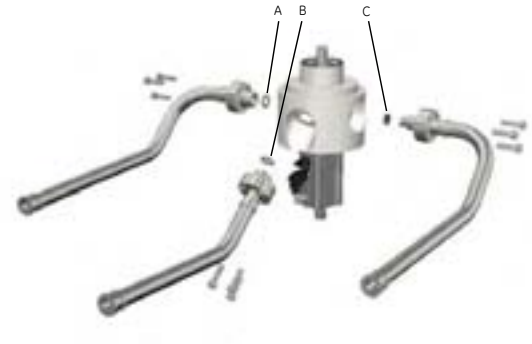


*Figure 5.69: **A**: Slurry inlet o-ring, **B**: Bottom mobile phase inlet/outlet o-ring, **C**: Rinse inlet o-ring*

For 300-600 columns equipped with plastic tubes, the rinse inlet has an inner connector and additional o-ring (see Figure 5.70).

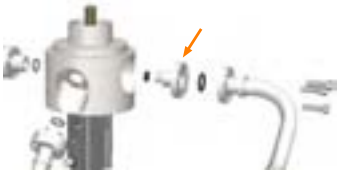


Figure 5.70: Inner connector on the rinse inlet for 300-600 columns equipped with plastic tubes.

8 Unscrew the 4 bolts to remove the pneumatic cylinder and its piston from the media valve outer body.

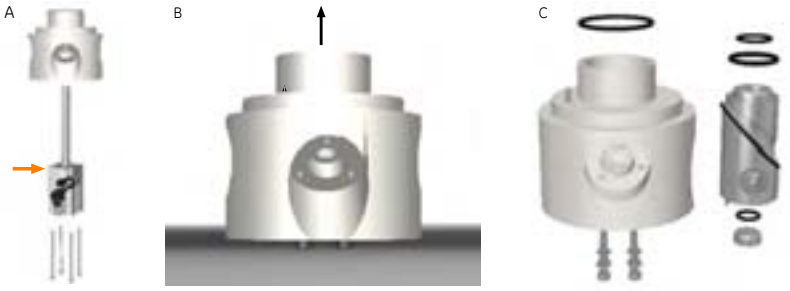


*Figure 5.71: **A**: Pneumatic cylinder and piston, **B**: Media valve outer body, press against a flat surface to push out the valve inner body, **C**: O-rings on the valve inner body*

On AxiChrom 300-600 columns: When removing the piston, hold the upper part (marked in Figure 5.71 A) of the pneumatic cylinder, to prevent the cylinder from falling apart.

9 Loosen the 4 bolts on the bottom of the media valve outer body. Do not remove the bolts: make sure a few millimeters of the bolt remain screwed into the media valve. Press the bolts against a flat surface so that the bolts push out the valve inner body, then remove the valve inner body (see Figure 5.71 B).

10 Remove and clean the o-ring from the valve outer body with 20% ethanol, or replace with a new o-ring if necessary (see Figure 5.71 C).

11 Remove and clean the 4 o-rings from the valve inner body with 20% ethanol, or replace with new o-rings if necessary (see Figure 5.71 C).

5.8.3 Assembling the media valve

1 Refit all o-rings and the o-ring holder on the valve inner body (see Figure 5.71 C). When refitting the diagonal o-ring on the valve inner body, make sure that you stretch it when putting it back in place. It must not be rolled into place.

2 Wet the diagonal o-ring with 20% ethanol, then assemble the media valve inner body into the valve outer body. Make sure that the media valve inner body pin fits inside the hole on the bottom of the valve outer body. Tighten the bolts (crosswise) in steps up to 2.2 Nm.

3 Refit the pneumatic cylinder into the media valve outer body (see Figure 5.71 A). Ensure that the alignment of the pneumatic cylinder corresponds to Figure 5.74. Tighten the bolts (crosswise) in steps to 1.7 Nm.

4 Reposition the slurry inlet, rinse inlet and bottom mobile phase inlet/outlet tubes on the media valve. Tighten the bolts in steps up to 2.2 Nm (see Figure 5.72).

CAUTION

The air from damaged pneumatic tubes may cause eye injuries. Replace any damaged tubes.

Figure 5.72: Bolts connecting the tubes to the media valve body.

Note: *For 300-600 columns equipped with plastic tubes, fit the inner connector and o-ring on the rinse inlet, see Figure 5.70.*

5 Place the media valve so that the mobile phase tube rests in the correct position in the tube holder. Refit the tube holder bracket on the mobile phase tube and tighten the bolts slightly, so that the tube can still slide under the bracket (see Figure 5.73), to allow for adjustments in position when the tube holder is refitted to the bottom backing plate.

*Figure 5.73: **A**: Tube holder, **B**: Tube holder brackets*

6 To ensure that the Slurry inlet tube and the Rinse inlet tube are placed in their correct angle when refitted, assemble the tube holder brackets. Tighten the bolts only slightly, so that the tubes can still slide under the brackets.

7 Reposition the Slurry inlet tube and Rinse inlet tube to the media valve body and tighten the tube bolts, in steps up to 2.2 Nm (see Figure 5.72 A and C).

8 Refit the two pneumatic tubes on the pneumatic cylinder according to Figure 5.74. Ensure that the 2 tubes are connected to the correct connectors.

*Figure 5.74: Pneumatic tubes **A** and **B**, the connection between the pneumatic cylinder and the tube holder.*

9 Re-assemble the media valve and tube holder under the column.

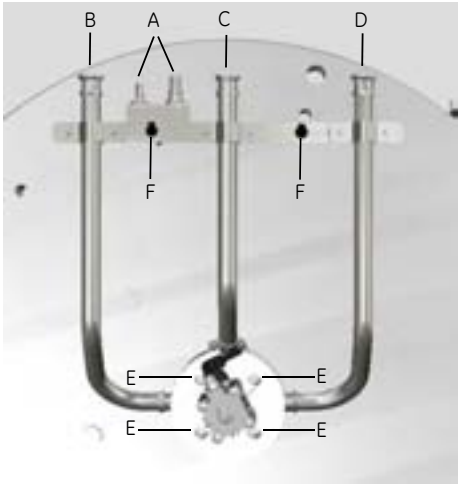


*Figure 5.75: **A**: 2 valve pneumatic inlets **B**: Slurry inlet, **C**: Bottom mobile phase inlet/outlet, **D**: Rinse inlet, **E**: Media valve bolts screwed into the bottom backing plate, **F**: Locking screws on the tube holder bolts.*

a Assemble the 4 media valve bolts into the bottom backing plate (see Figure 5.75 E). Tighten the bolts (crosswise) in steps up to 5 Nm.

b Fit the tube holder bolts in their holes in the bracket.

c Tighten the bolts on the tube holder brackets (see Figure 5.73 B). The bolts should be tightened evenly and not to hard, to avoid any damage on the tubes.

d For media valves equipped with plastic tubes, make sure the tubes are at a slight angle to the horizontal so that liquid in the tubes drains away from the media valve.

e Tightening the locking screws on the tube holder bolts in steps up to 10 Nm (see Figure 5.75 F).

10 Connect the air supply tubes to the two valve pneumatic inlets on the tube holder (see Figure 5.75 A). Open the air supply to the column.

11 Connect the hoses to the Slurry inlet (see 5.75 B), Bottom mobile phase inlet/outlet (C), and Rinse inlet (D). See *Section 3.5 Connections, on page 32* for more information.

5.9 Performing a leakage test

Perform a leakage test when:

- the column is new,
- the column has been shipped,
- the o-rings have been replaced, or

- other parts that may cause leakage have been replaced.

Note: *Read the whole procedure before starting the test.*

CAUTION

Only liquid should be used in the column during the leakage test. Do not perform a leakage test on a column containing media.

Material

- Reference pressure gauge (calibrated, range: 0-10 bar)
- External pump with capacity up to 400 cm/h and 4 bar
- Three valves (and a Check valve if not included in the pump outlet)
- Water tank
- Pipes and bows to connect the pump, water tank, valves and pressure gauge
- End caps

Procedure

1 Fill the water tank with water and let it reach room temperature before continuing.

Note: *To be able to perform the test correctly both the AxiChrom column and test liquid have to be equilibrated at room temperature during the whole test.*

2 Connect the column and the Master to the water tank.

3 Start the Master.

4 Open the bottom valve using the Master ***MANUAL CONTROL*** wizard.

5 Set up the test with the AxiChrom column as illustrated below:

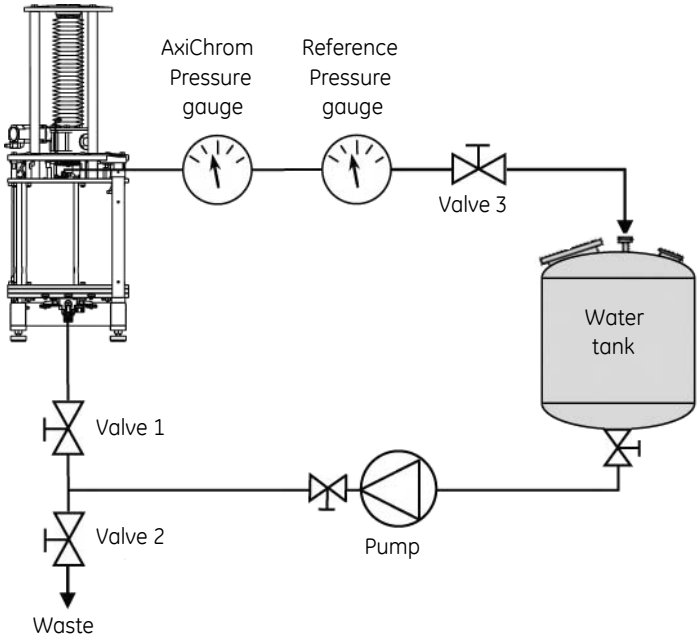


Figure 5.76: Flow system setup for leakage test.

a Connect the water tank to the Pump inlet.

b Connect **Valve 1** to the **Bottom mobile phase** inlet/outlet on the AxiChrom column and seal the other two connections with end caps.

c Connect a t-connector to:

- **Valve 1**
- the Pump outlet, and
- **Valve 2** with a hose leading to waste

Note: *Put a plastic block underneath the tubing to relieve any strain on the Bottom mobile phase inlet/outlet*.

d Connect the AxiChrom Pressure gauge for the Master, a Reference pressure gauge and shut-off **Valve 3** to the Top mobile phase.

e Connect a hose to **Valve 3** that leads the water back to the tank.

f Open **Valve 3** fully.

6 Move the adapter so that the lower adapter scraper seal is positioned in the middle of the priming groove, creating a clear passage to the flushing channels. and so that the filling water can pass out through the flushing connector in later steps.

7 Fill the column gently by starting the pump in a low flow (below 400 cm/h) and opening **Valve 1** completely (**Valve 2** should be closed).

8 Continue filling water until it seeps out from the flushing connectors, and then move the adapter below the priming groove.

9 Press out the remaining air in the column and hoses with the pump at a speed of below 400 cm/h.

10 Stop the pump when there is no air left.

11 Move the adapter to its maximum bed height (30 cm for a short column tube, or 50 cm for a long column tube) and make sure that all air is evacuated from the column.

Note: *The process chamber under the adaptor must be completely filled with liquid.*

12 Close shut-off **Valve 3** completely.

13 Use the pump to gently pressurize the column to the intended test pressure and allow the pressure to stabilize. The test pressure shuld be the same as the design pressure for the AxiChrom column.

Note: *It might take several minutes to adjust the pressure until it is stable.*

14 When a stable pressure has been achieved, close the shut-off **Valve 1** and note the pressure and start time.

15 Monitor the pressure and let the column remain pressurized for 30 ±5 minutes.

16 When the test period is completed, record the pressure and evaluate the result. The pressure drop should not exceed 0.20 bar during the test period (30 minutes).

If the pressure has dropped more and continues to drop when the 30 minutes have passed, there is a substantial risk that the column is leaking.

Note: *If no leak is found and there is a doubt about if the AxiChrom column is really leaking, redo the test before releasing the pressure. (There might be a test valve that leaks.)*

17 Before releasing the pressure, check for liquid leakage, especially around the o-rings.

18 Release the pressure slowly, by slowly opening the **Valve 1** and then slowly opening **Valve 3**.

Note: *If the pressure is released too fast, there is a slight risk that any remaining air will expand and damage the column when depressurized.*

19 Empty the column by opening **Valve 2** and moving the adapter downward.

5.10 Master firmware installation

The Master firmware has to be updated if the column delivered is not available in the existing firmware, or if new functionality has been implemented.

Compare the functionality and compatibility of your Master firmware with the Capability Matrix supplied in the AxiChrom Master firmware upgrade kit to see if the Master firmware needs to be updated.

Safety precautions

WARNING

The end user must ensure that all installation, maintenance, operation and inspection is carried out by qualified personnel who are adequately trained, understand and adhere to local regulations and the operating instructions, and have a thorough knowledge of the entire system and process.

WARNING

High voltage inside the Master. Never open the door before the Master has been turned off, the Master power switch has been switched off, and the Master power cable has been disconnected or external electric switch has been switched off.

CAUTION

Make sure that no liquid gets into the Master. Do not handle any liquid in the area around the Master when the Master door is open.

Installing Master firmware

5.10.1 Pre-requisites

If any columns are saved in the Master column list, write down all the column data. After the update, this information has to be reentered in the Master column list.

5.10.2 Instruction

Shut down the Master

1 In the ***Main menu*** of AxiChrom Master, press ***POWER OFF*** to turn off the Master.

2 When the text ***IT IS NOW SAFE TO POWER OFF*** is displayed, use the **Power Switch** on the Master connector panel to turn off the power.

3 Disconnect the Master power cord, or switch off external electric switch.

Install the Compact Flash memory card and the USB memory stick

4 Open the door on the Master.

5 Unscrew the two screws holding the plastic cover and pull off the plastic cover.

6 Pull the Compact Flash memory card out from its holder.

7 Insert the new Compact Flash memory card.

8 Connect the USB memory stick to the USB extender located inside the Master. Leave the USB memory stick connected.

9 Put the plastic cover back in position, and replace the two screws.

10 Close the door on the Master.

Start the Master

11 Connect the Master power cord.

12 Turn on the Master using the **Power Switch** on the Master connector panel. The Master firmware is automatically updated.

Check the update

13	On the Master touch screen panel, press ***CONFIGURATION***.
14	In the ***Configuration*** dialog, press ***SYSTEM INFO***.
15	In the ***System info*** dialog, check that: • the ***Application rev.*** under ***DriveLogix*** is the same as the one stated on the packing list. • the ***Application rev.*** under ***Operator panel*** is the same as the one stated on the packing list.

Prepare for use of column

16	On the Master touch screen panel, press ***CONTINUE*** and then ***BACK*** to enter the ***Select column*** dialog.
17	In the ***Select column*** dialog, press ***ADD*** to add the column information written down from the Master before the update, or to add new columns to the column list. For further information refer to *AxiChrom 300-1000 columns User Manual*.
18	Calibrate the column before use, see *AxiChrom 300-1000 columns User Manual*.

5.10.3 Remove the USB memory stick

When the update is completed, remove the USB memory stick from the USB extender inside the Master.

1 Repeat steps 1 through 4 in the instruction above.

2 Remove the USB memory stick from the USB extender.

3 Repeat steps 10 through 12 in the instruction above.

5.11 Service

Please contact your local GE Healthcare representative for information about service of the column.

5.12 Storage

Before storage

The following procedure is recommended before long-term storage of the column:

1 Perform a cleaning in place according to your normal cleaning procedures (for example using 0.5 to 1.0 M sodium hydroxide for 1 to 4 hours).

2 If the column is to be primed using 20% (v/v) ethanol (see step 4), the column should be rinsed with a suitable buffer that neutralizes the pH. The buffer can not contain any chlorides, since these may cause corrosion attacks on the column.

3 Move the column adapter down to 2 cm above the bottom bed support, leaving the space between the adapter and bottom bed support completely filled with the storage solution.

4 Prime the column using a suitable storage solution (for example 0.01 M sodium hydroxide or 20% (v/v) ethanol solution) with an amount of storage solution corresponding to 5 times the present column volume.

5 Close all valves and fit tri-clamp blind caps on all inlets/outlets of the media valve.

6 Disconnect all tubes connected to the top inlet. If the tubes are not disconnected there may be a buildup of vacuum in the next step.

7 Fit a tri-clamp blind cap on the top inlet.

CAUTION

The storage solution may evaporate over time when the column is stored. This may create an increase in pressure in the column. Ensure that all valves are closed before removing the TC-blind caps from the bottom slurry inlet and carefully open the valve to release the pressure.

Storage conditions

The following conditions shall be maintained while the column is in storage:

- The column must be stored indoors.
- Temperature 2°C to 30°C (preferably room temperature).
- Relative humidity 0% to 95%, non-condensing (preferably low humidity).
- The column must not be exposed to chlorides.
- If the column should be stored over a longer period of time, it is recommended to change the storage solution regularly.

5.13 Decommissioning and recycling

Recycling should be done according to current local rules and regulations.

6 Reference information

6.1 Specifications

Parameter	Value
Protection class	IP 56, NEMA 4X
Supply voltage	380-400 VAC, 50-60 Hz with protective ground
Max voltage (North America)	480 Y/277 VAC
Max power consumption	2400 VA
Dimensions	See *Appendix B Column and AxiChrom Master weights and dimensions, on page 125*
Weights	See *Appendix B Column and AxiChrom Master weights and dimensions, on page 125*
Ambient temperature	+2°C to +30°C
Operating temperature	+2°C to +30°C
Relative humidity	0% to 95%, non-condensing

6.2 Chemical resistance

AxiChrom columns are resistant to chemical agents used in protein recovery, including buffer solutions for adsorption, elution and washing, and to solutions effective in cleaning, sanitization and storage. *Table* lists chemicals that may or may not be used with AxiChrom columns. The concentrations listed are not normally exceeded during an operating cycle.

CAUTION

Do not use chemicals with temperatures above the specified limits.

NOTICE

Chlorides and low pH can cause corrosion on stainless steel. Rinse thoroughly with clean water after use.

Inspect the column regularly for signs of corrosive attacks, which may cause column damage if untreated. Note that the stainless steel bed supports are especially vulnerable to corrosion.

Note: *The information in Table has been collected from several published sources, not from individual tests on column components. It should be used only as a guide. The effect of chemicals will generally be more severe at higher temperatures. Note also that the combined effects of agents have not been taken into account in this table. The applicable chemical resistance depends on the configuration of the column and the associated materials of construction.*

Chemical	Concentration [1]	Time/cycle restrictions	Comments	Operating temperature	CAS no. [2]
Acetic acid	25%	3 h	Cleaning-In-Place (CIP)	2°C to 30°C	64-19-7
Acetone	2%	1 h	Efficiency test	2°C to 30°C	67-64-1
Ammonium sulphate	2 M [3]	5 h	Adsorption	2°C to 30°C	7783-20-2
Benzyl alcohol	2%	12 months	Storage	2°C to 30°C	100-51-6
Ethanol	20%	12 months and max. 0.5 bar	Storage	2°C to 30°C	64-17-5
Ethanol	70% [4]	3 h	CIP	2°C to 30°C	64-17-5
Ethanol/ acetic acid	20%/ 10%	3 h	CIP	2°C to 30°C	64-17-5/ 64-19-7
Guanidinium hydrochloride	6 M [5]	5 h	CIP	2°C to 30°C	50-01-1
Hydrochloric acid	0.1 M (pH = 1) [6]	1 h	CIP	2°C to 30°C	7647-01-0
Isopropanol	30% [7]	1 h	CIP	2°C to 30°C	67-63-0

Chemical	Concentration [1]	Time/cycle restrictions	Comments	Operating temperature	CAS no. [2]
Phosphoric acid	5%	8 h	For passivation of stainless steel bed supports	2°C to 30°C	7664-38-2
Sodium chloride	0 to 3 M [3, 6, 8]	3 h	Purification, CIP	2°C to 30°C	7647-14-5
Sodium hydroxide	1 M (pH = 14)	24 h, room temp. to 30°C	CIP	2°C to 30°C	1310-73-2
Sodium hydroxide	0.01 M (pH = 12)	12 months	Storage	2°C to 30°C	1310-73-2
Sodium hydroxide/ ethanol	1 M/ 20%	3 h	CIP	2°C to 30°C	1310-73-2/ 64-17-5
Sodium sulphate	1 M [3]	3 h	Adsorption	2°C to 30°C	7757-82-6
Urea	8 M [3]	5 h	Purification, CIP	2°C to 30°C	57-13-6
Commonly used aqueous buffers for chromatographic use	10 to 250 mM, pH 2 to 10	24 h	Equilibration, adsorption, elution	2°C to 30°C	

1 When a concentration is given as a percentage, this is v/v.

2 CAS no.: Registration number assigned by the Chemical Abstract Services (CAS), American Chemical Society.

3 pH in these solutions depends on the pH of the buffer, which can vary between 3 and 13.

4 On stainless steel column parts only. Exposure of other column parts to ethanol at higher concentrations than 20% can damage the column.

5 Not for use with columns contaning wetted components of stainless steel.

6 pH below 4 for stainless steel is not recommended.

7 Applies only to acrylic column tubes.

8 For columns containing wetted stainless steel components max 1.0 M NaCl is recommended. For additional important information, see *Section 6.2.1 Resistance to sodium chloride, on page 120*.

Avoid using the following chemicals in AxiChrom columns:

- Extreme oxidizers
- Fluorine and halogenated compounds
- Chlorinated solvents (such as methylene chloride)
- Esters
- Aromatic hydrocarbons (such as toluene)
- Alcohols at concentrations higher than those specified in the table above
- Salt in combination with pH below 4. Always wash the column with at least five column volumes of pH-neutral solution (water) between and after use of salt and low pH buffers.

6.2.1 Resistance to sodium chloride

Depending on configuration, AxiChrom columns can be equipped with wetted components of stainless steel and must therefore be appropriately maintained when exposed to sodium chloride (NaCl) during chromatographic processes. While the stainless steel bed supports have a high degree of resistance to corrosion, they may corrode on extended exposure to NaCl. The degree of susceptibility varies according to conditions of use. Low pH in combination with NaCl, high temperature and damage to the steel surface all increase the risk of corrosion.

If a stainless steel surface is damaged (scratches, impact marks etc.) it has to be cleaned and passivated prior to taken into operation. Your GE Healthcare representative can provide guidance on suitable cleaning and passivation procedures if required.

It is recommended that a water rinse of at least five column volumes is used to remove NaCl from stainless steel surfaces. Water is the preferred rinse solution because of the solubility properties of sodium chloride in water.

Columns should be stored with solutions free from chloride ions.

6.3 System recommendations

Refer to UNICORN user documentation supplied, or contact your local GE Healthcare representative for the most current information.

6.4 Health and Safety Declaration Form

On site service

GE Services

DOC1149542

On Site Service Health & Safety Declaration Form

Service Ticket #: .....

To ensure the mutual protection and safety of GE Healthcare service personnel and our customers, all equipment and work areas must be clean and free of any hazardous contaminants before a Service Engineer starts a repair. To avoid delays in the servicing of your equipment, please complete this checklist and present it to the Service Engineer upon arrival. Equipment and/or work areas not sufficiently cleaned, accessible and safe for an engineer may lead to delays in servicing the equipment and could be subject to additional charges.

Yes	No	Please review the actions below and answer "Yes" or "No". Provide explanation for any "No" answers in box below.
		Instrument has been cleaned of hazardous substances. Please rinse tubing or piping, wipe down scanner surfaces, or otherwise ensure removal of any dangerous residue. Ensure the area around the instrument is clean. If radioactivity has been used, please perform a wipe test or other suitable survey.
○	○	**Adequate space and clearance is provided to allow safe access for instrument service, repair or installation.** In some cases this may require customer to move equipment from normal operating location prior to GE arrival.
		Consumables, such as columns or gels, have been removed or isolated from the instrument and from any area that may impede access to the instrument.
○	○	**All buffer / waste vessels are labeled. Excess containers have been removed from the area to provide access.**
Provide explanation for any "No" answers here:		

Equipment type / Product No: ..... **Serial No:** .....

I hereby confirm that the equipment specified above has been cleaned to remove any hazardous substances and that the area has been made safe and accessible.

Name in Capital letters: .....

Company or institution: .....

Position or job title: ..... **Date (Year/month/date):** ..... 20 ..... / ..... / .....

Signed: .....

28-9800-26 AB 05/2012

Product return

GE Services

DOC1149544

Health & Safety Declaration Form for Product Return or Servicing

Return authorization number: ..... **and/or Service Ticket/Request:** .....

To ensure the mutual protection and safety of GE Healthcare personnel, our customers, transportation personnel and our environment, all equipment must be clean and free of any hazardous contaminants before shipping to GE Healthcare. To avoid delays in the processing of your equipment, please complete this checklist and include it with your return.

1. **Please note that items will NOT be accepted for servicing or return without this form**
2. Equipment which is not sufficiently cleaned prior to return to GE Healthcare may lead to delays in servicing the equipment and could be subject to additional charges
3. Visible contamination will be assumed hazardous and additional cleaning and decontamination charges will be applied

Please specify if the equipment has been in contact with any of the following:

Yes **No** Radioactivity (please specify): .....

Yes **No** Infectious or hazardous biological substances (please specify) .....

Yes **No** Other Hazardous Chemicals (please specify) .....

Equipment must be decontaminated prior to service / return. Please provide a telephone number where GE Healthcare can contact you for additional information concerning the system / equipment.

Telephone No: .....

Liquid and/or gas in equipment is: **Water** **Ethanol** **None, empty** **Argon, Helium, Nitrogen**

Liquid Nitrogen **Other, please specify:** .....

Equipment type / Product No: ..... **Serial No:** .....

I hereby confirm that the equipment specified above has been cleaned to remove any hazardous substances and that the area has been made safe and accessible.

Name in Capital letters: .....

Company or institution: .....

Position or job title: ..... **Date (Year/month/date):** .....20...../...../.....

Signed: .....

To receive a return authorization number or service number, please call local technical support or customer service.

28-9800-27 AB 05/2012

6.5 Ordering information

For ordering information visit www.gelifesciences.com/axichrom.

Appendix A Crate weights and dimensions

Typical weights and dimensions for the different crate sizes are listed in the table below.

Column diameter [mm]	Column bed heights [mm]	Crate height [mm]	Crate length [mm]	Crate width [mm]	Empty crate weight [kg]	Total weight (crate+column)[1] [kg]
300	100 to 300	1920	970	1495	160	574/580
300	100 to 500	2180	970	1495	165	599/605
400	100 to 300	1920	970	1495	160	611/620
400	100 to 500	2180	970	1495	165	636/645
450	100 to 300	1920	1090	1480	180	879/890
450	100 to 500	2180	1090	1480	185	934/945
600	100 to 300	1875	1100	1395	195	1013/1030
600	100 to 500	2135	1100	1395	205	1088/1105
800	100 to 300	2190	1440	1800	350	2472/2500
800	100 to 500	2450	1440	1800	360	2572/2600
1000	100 to 300	2240	1650	2040	440	2957/3000
1000	100 to 500	2500	1650	2040	450	3087/3130
Master		1300	770	700	65	140

1 Weights are given for columns with plastic bed support/stainless steel bed support

Note: *Some crate weights are estimates.*

Appendix B Column and AxiChrom Master weights and dimensions

The actual weight and dimensions for the individual column is given in the documentation. Typical weights and dimensions for the different column sizes are listed in the table below. The min. and max. heights refer to the height of the column with the adapter in its lowest position for transportation, and with the adapter in its highest position, for example for maintenance work.

Column weights and dimensions (acrylic column tube)

Column diameter [mm]	Column bed heights [mm]	Footprint (length × width) [mm]	Min. height [mm]	Max. height [mm]	Weight of empty column [1] [kg]
300	100 to 300	1110 × 520	1450	2220	414/420
300	100 to 500	1110 × 520	1710	2720	434/440
400	100 to 300	1110 × 600	1425	2220	451/460
400	100 to 500	1110 × 600	1685	2720	471/480
450	100 to 300	1110 × 620	1470	2330	699/710
450	100 to 500	1110 × 620	1730	2750	749/760
600	100 to 300	1180 × 780	1570	2340	818/835
600	100 to 500	1180 × 780	1830	2860	883/900
800	100 to 300	1470 × 1080	1720	2630	2122/2150
800	100 to 500	1470 × 1080	1980	3150	2212/2240
1000	100 to 300	1720 × 1300	1875	2650	2517/2560
1000	100 to 500	1720 × 1300	2135	3170	2637/2680

1 Weights are given for columns with plastic bed support/stainless steel bed support

Column weights and dimensions (stainless steel column tube)

The table below lists column tube weights and the weights of empty columns and crate+column for columns with stainless steel tubes. All weights are given in kg.

Column	Column tube	Empty column [1]	Crate+column [2]
300 short tube 300 long tube	73 89	431/437 454/460	591/597 619/625
400 short tube 400 long tube	92 113	481/490 508/518	641/650 674/683
450 short tube 450 long tube	106 130	730/741 786/797	910/921 971/982
600 short tube 600 long tube	178 209	864/881 930/947	1059/1076 1135/1152
800 short tube 800 long tube	351 394	2231/2259 2318/2346	2581/2609 2678/2706
1000 short tube 1000 long tube	584 637	2738/2781 2841/2884	3178/3221 3291/3334

1 Weights are for columns with plastic bed support/stainless steel bed support.

2 Weights are for columns with plastic bed support/stainless steel bed support. Some crate weights are estimates.

AxiChrom Master weights and dimensions

Parameter	Value
Weight [kg]	73
Length [mm]	670
Width [mm]	590
Height [mm]	1090

Note: *For other specifications, refer to AxiChrom 300-1000 columns User Manual.*

For local office contact information, visit
www.gelifesciences.com/contact

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imagination at work

28-9562-90 AD 05/2013

INSTRUCTIONS

Detoxi-Gel™ Endotoxin Removing Gel

0415.5

Number	Description
20339	**Detoxi-Gel Endotoxin Removing Gel,** 10mL settled resin, supplied as a 50% slurry in 25% ethanol
20340	**Detoxi-Gel Endotoxin Removing Gel,** 1L settled resin, supplied as a 50% slurry in 25% ethanol
20344	**Detoxi-Gel Endotoxin Removing Columns,** 5 × 1mL settled resin, supplied in 25% ethanol, and prepacked in columns having a bottom twist-off tab and an accessory pack containing five white tips

Support: Crosslinked, 6% beaded agarose (wet bead diameter 45-165µm)

Fractionation range: 10,000-4,000,000 for proteins

Capacity: 1mL of resin removes ≥ 9995 EU (endotoxin units) from a 5mL challenge containing 10,000 EU

Storage: Upon receipt store at 4°C. Product is shipped at ambient temperature.

Introduction

The Thermo Scientific Detoxi-Gel Endotoxin Removing Gel uses immobilized polymixin B to bind and remove pyrogens from solution. The polymixins are a family of antibiotics that contain a cationic cyclopeptide with a fatty acid chain. Polymixin B neutralizes the biological activity of endotoxins by binding to the lipid A portion of bacterial lipopolysaccharide. Studies performed by Kluger *et al*. indicate that the immobilized polymixin B inactivates some but not all endotoxins.[1]

The immobilized polymixin B gel is a stable affinity matrix that resists leaching of ligand into the valuable preparation. Making use of an affinity support permits easy cleanup of buffers, cell culture media, solutions containing macromolecules such as proteins, and pharmacologically important components. Detoxi-Gel Endotoxin Removing Gel also has been used to remove endotoxin from nucleic acid (DNA) samples.[2]

Important Product Information

- Good chromatographic technique must be used to obtain optimal performance. Much higher efficiencies of endotoxin removal will result if Detoxi-Gel Resin is used in a column format rather than a batch method.
- Nonspecific binding may occur, especially when hydrophobic molecules are present. To reduce nonspecific binding, buffer all solutions at physiological pH. To decrease weak ionic interactions with the affinity ligand, use a final concentration of 0.1-0.5M NaCl. If the purified sample is to be lyophilized as a salt-free powder, it is convenient to use a volatile buffer such as 0.1M ammonium bicarbonate, pH 7.8.
- Chaotropes (urea and guanidine) and detergents interfere with binding to the polymixin B. Some proteins, such as BSA, bind tightly to endotoxin, reducing the ability of the endotoxin to interact with and bind to polymixin B. This reduction in binding sometimes can be overcome by increasing the volume of resin to endotoxin. Some proteins bind tightly to endotoxin without inhibiting its ability to bind to the support and will remain bound to the resin with the endotoxin.
- The column flow rate can vary widely depending on column dimensions. Gravity-flow chromatography is superior to pumping a solution under pressure as it allows sufficient contact time of the solution with the immobilized ligand and, therefore, better endotoxin removal. Additionally, increasing contact time by stopping the column flow or multiple passes through the resin will result in greater efficiency. Centrifuge-ready columns (see Related Thermo Scientific Products) can be used in a combination of ways, including in batch or gravity-flow mode for binding steps and then centrifuge mode for sample collection.

Additional Materials required

- Empty columns suitable for the amount of Detoxi-Gel Resin and sample to be used (see Related Thermo Scientific Products)

  Note: Detoxi-Gel Columns are pre-packed and, therefore, empty columns are not necessary.

- 1% Sodium deoxycholate (Product No. 89904 or 89905)

  Note: Sodium deoxycholate must be used. Other detergents and free deoxycholic acid cannot be substituted.

- Pyrogen-free buffer or water

Procedure for Endotoxin Removal from a Solution

Notes:

- Detoxi-Gel Resin must be regenerated before each use, including first use.
- Use only pyrogen-free solutions to prevent introducing additional endotoxin into the sample.
- Degas all solutions before applying to the column to prevent air bubbles from clogging the column and reducing flow.
- Detoxi-Gel Resin may be used at least 10 times without loss of activity.
- Equilibrate all solutions and resin to room temperature before use.
- If using Detoxi-Gel Columns, proceed to Step 3. The supplied column has a twist-off bottom tab, which can be replaced with a supplied white tip.

1. To degas the Detoxi-Gel Resin, place slurry in the bottom of a suction filter flask with a magnetic stirrer. While stirring the slurry, use an aspirator to create a vacuum within the flask. Degas for approximately 15 minutes.
2. Pack the appropriately sized column with degassed slurry; allow the resin to settle for 30 minutes.
3. Regenerate the Detoxi-Gel Resin by washing with five resin-bed volumes of 1% sodium deoxycholate, followed by 3-5 resin-bed volumes of pyrogen-free buffer or water to remove the detergent. Regenerate the resin before each use.
4. Equilibrate the Detoxi-Gel Resin with 3-5 resin-bed volumes of a suitable pyrogen-free buffer or water.
5. Apply sample to the column. Add aliquots of pyrogen-free buffer or water and collect the flow-through. With a gravity-flow column, the sample will begin to emerge from the column about 90% of the bed volume has been collected. For greater efficiency, stop column flow after sample has entered the resin bed, and incubate the column for one hour before collecting the sample.

   Caution: Use extreme caution to prevent sample contamination from dust or dirty glassware subsequent to endotoxin removal. Store solutions frozen or assay them before use to ensure sterility. Bacterial contamination does not occur in lyophilized samples, as the environment is not conducive to growth.
6. Repeat Step 3 to remove any bound endotoxin and regenerate the resin. Store columns in 25% ethanol at 2-8°C.

Related Thermo Scientific Products

88270	**Pierce® High Capacity Endotoxin Removal Resin,** 10mL
88282	**Pierce LAL Chromogenic Endotoxin Quantitation Kit**
69705	**Pierce Spin Columns – Screw Cap,** Kit, 25/pkg
89896	**Pierce Centrifuge Columns,** 2mL, 25/pkg
89897	**Pierce Centrifuge Columns,** 5mL, 25/pkg
89898	**Pierce Centrifuge Columns,** 10mL, 25/pkg

Cited References

1. Kluger, M.J., *et al.* (1985). Polymixin B use does not ensure endotoxin-free solution. *J Immunol Meth* **83:**201-7.
2. Wicks, I.P., *et al.* (1995). Bacterial lipopolysaccharide copurifies with plasmid DNA: Implications for animal and human gene therapy. *Human Gene Therapy* **6:**317-23.

General References

Issekutz, A.C. (1983). Removal of gram negative endotoxin from solution by affinity chromatography. *J Immunol Meth* **61:**275-81.

Morrison, D.C. and Jacobs, D.M. (1976). Binding of polymixin B to the lipid A portion of bacterial polysaccharide. *Immunochemistry* **13:**813-18.

Adam, O. *et al*. (1995). A nondegradative route for the removal of endotoxin from exopolysaccharides. *Anal Biochem* **225(2):**321-327.

Current product instructions are available at *www.thermoscientific.com/pierce*. For a faxed copy, call 800-874-3723 or contact your local distributor.

BPG Columns 100, 140, 200, 300 and 450 series

BPG™ columns are glass chromatography columns designed for industrial applications which demand high standards of hygiene. The columns are constructed from component materials of the highest quality and withstand the harsh conditions used for cleaning in place of packed separation media. An overview of column characteristics is shown in Table 1. The columns are characterized by:

- Hygienic design and operation. Microbial attachment and growth is hindered through the use of calibrated precision glass, high grade electropolished stainless steel and an absence of dead pockets.
- Easy, efficient packing and running with the singlescrew adapter.
- Operating pressures matching most BioProcess™ Media.
- All polymeric materials meet the requirements for USP class VI, described in USP <88> Biological Reactivity Tests, *In Vivo*.
- Comprehensive documentation.

Fig 1. BPG column family.

General description

BPG columns are designed to meet the needs of process development and biopharmaceutical manufacture:

- Scalable. Inner diameters (i.d.) of 100 mm to 450 mm, and bed volumes from 2 up to 121 liters.
- Pressure rating up to 8 bar.
- Low flow resistance.
- Single screw adapter.
- Suitability for use in ion exchange, gel filtration, affinity, and hydrophobic interaction chromatography with compatabile BioProcess Media.
- Tubing connections made with hygienic sanitary clamp fittings.
- All gaskets recognized as suitable for use in biopharmaceutical production.
- An instruction manual containing full details of components, packing, testing, procedures for cleaning and sanitizing, troubleshooting, and spare parts lists.
- Packing devices available for long bed heights.
- IQ/OQ documentation packages available.

Design features

Column tube

The columns are designed to very high standards and use high quality materials:

- Manufactured from calibrated precision borosilicate glass.
- Exact internal diameter tolerance of the glass tube.
- Thin O-ring between the column tube and the adapter/ endpiece forms a very tight seal.
- Minimum dead volume.
- Liquid distribution over a great surface area.

Liquid distribution

Efficient liquid distribution is crucial for optimal column performance. In BPG columns this is assured through:

- Adapters and end-pieces based on the well proven design of a single channel inlet/outlet.
- Support nets with a coarse, open structure to distribute liquid from the central inlet rapidly and uniformly over the entire surface area.
- Thin nets to maintain even pressure distribution over the bed surface and permit liquid to pass through quickly and evenly onto the bed, without creating extra back-pressure.
- Polypropylene distribution plates in the adapter, which give uniform distribution/collection of liquid at the interface between the net and the packed bed.

Fig 2. Adapter and net. Flat surfaces give even spread of sample.

Operation

Hygiene

BPG columns are intended for use in environments with some of the toughest regulatory controls:

- Design and materials of construction ensure hygienic operation.
- Little maintenance is required in routine use. The columns are easy to keep clean and free from microbial contamination.
- Autoclavable when disassembled.
- All tubing connections are made with sanitary clamp fittings.
- Columns are easily sanitized. A packed BPG column was subjected to microbial challenge testing using five microorganisms recommended by the United States Pharmacopoeia (USP XX III). Sodium hydroxide (NaOH) was the anti-microbial agent. The study showed that 0.5 M NaOH applied for 30–60 minutes is a good basis for developing an effective sanitisation procedure. The studies are presented in Application Notes 18-1020-86 and 18-1117-76.

Easy to pack

The design of adapter with a single-screw makes light work of all adapter movement. It is easily adjusted during packing and operation, even on the largest columns.

Table 1. Overview of BPG columns

			Bed height (cm)				Volume (l)							
Column Diameter (mm)	Column Area (cm^2)	Column Height (cm)	Min	Max[1]	Packing with extension[2]	Running with extention[3]	Min	Max[1]	Packing with extension[2]	Running with extention[3]	Max. pressure (bar g)[4]	Total weight (kg)	Adapter weight (kg)	Overall dimensions (cm) D×W×H
100	78.5	50	0	26	34	45	0.0	2.0	2.7	3.5	8	15	7	48×48×127
100	78.5	75	25	41	55	65	2.0	3.2	4.3	5.1	8	16	7	48×48×152
100	78.5	95	45	54	72	78	3.5	4.2	5.7	6.1	8	17	7	48×48×172
140	154	50	0	26	34	45	0.0	4.0	5.2	6.9	6	25	11	59×59×127
140	154	75	25	41	55	65	3.9	6.3	8.5	10.0	6	26	11	59×59×152
140	154	95	45	54	72	78	6.9	8.3	11.1	12.0	6	27	11	59×59×172
200	314	50	0	26	34	45	0.0	8.2	10.7	14.1	6	34	13	59×59×127
200	314	75	25	41	55	65	7.8	12.9	17.3	20.4	6	36	13	59×59×152
200	314	95	45	54	72	78	14.1	17.0	22.6	24.5	6	39	13	59×59×172
296	688	50	0	26	34	45	0.0	17.9	23.4	31.0	4	68	29	69×69×133
296	688	75	25	41	55	65	17.2	28.2	37.8	44.7	4	73	29	69×69×158
296	688	95	45	54	72	78	31.0	37.2	49.5	53.7	4	78	29	69×69×178
446	1562	50	11	22	30	45	17.2	34.4	46.9	70.3	2.5	200	100	80×80×140
446	1562	75	36	38	51	62	56.2	59.4	79.7	96.8	2.5	215	100	80×80×165
446	1562	100	61	64	72	78	95.3	100.0	112.5	121.8	2.5	230	100	80×80×190

Bed volumes and bed heights are based on a slurry concentration of 75% and a packing compression of 15%. Where compression is the difference in volume between a sedimented bed and a bed under pressure.

[1] Values achievable without a packing extension

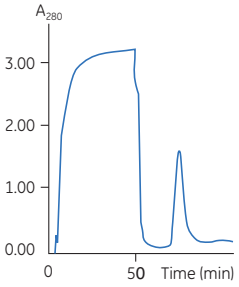
[2] Values achievable when a packing extension is used for sedimentation of the bed (75% of the slurry must fit into the column and extension when the adapter is mounted).

[3] Values achievable when the packing extension remains attached to the column for the duration of column use. The adapter must seal at least 5 cm into the column tube to avoid high tensions in the glass tube

[4] Use a manometer to monitor the pressure (to order, see Tables 5 and 6

Separation at lab scale

Column: XK16/20 (i.d. 16 mm), 10 cm bed height, 20 ml
Medium: Phenyl Sepharose™ 6 Fast Flow (high sub)
Sample: Yeast supernantant, $(NH_4)_2SO_4$ added to 0.5 M
Loading: 450 ml sample: 8.1 mg EGF; 0.41 mg/ml medium
Starting buffer: 0.5 M ammomium sulfate, 20 mM sodium phosphate pH 7.0
Elution buffer: 20 mM sodium phosphate pH 7.0
Flow rate:
Loading: 300 cm/h, 600 ml/h
Eluiton: 60 cm/h, 120 ml/h
Purification time: 1.5 h
System: BioPilot™



Separation at process scale

Column: BPG 300/500 (i.d. 300 mm), 10 cm bed height, 7.1 L
Medium: Phenyl Sepharose 6 Fast Flow (high sub)
Sample: Yeast supernantant, $(NH_4)_2SO_4$ added to 0.5 M
Loading: 80 L sample: 2.56 g EGF; 0.36 mg/ml medium
Starting buffer: 0.5 M ammomium sulfate, 20 mM sodium phosphate pH 7.0
Elution buffer: 20 mM sodium phosphate pH 7.0
Flow rate:
Loading: 300 cm/h, 2100 L/h
Eluiton: 60 cm/h, 42 L/h
Purification time: 1.5 h
System: BioProcess controlled by UNICORN™

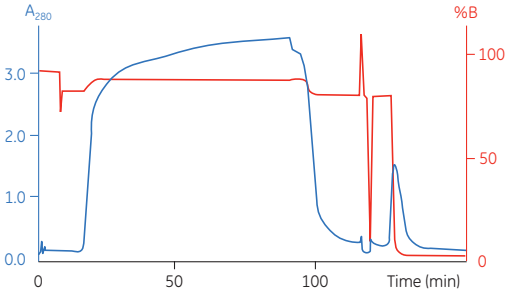


Fig 3. Development and scale-up of a chromatographic downstream process for the purification of recombinant EGF expressed as an extracellular protein from *S. cerevisiae*. The starting material was clarified supernatant. (Daniels, A.I., Petersson, N.T., Scandella, C. Poster presentation, Crystal City, USA, 1992.)

Table 2. Column component materials. Components may be considered to contain "wet" parts, parts coming into contact with process liquids, and dry parts. The table identifies the materials from which the "wet" and dry parts are manufactured

	Major Components							
	Adapter		Tube		End-piece		Stand	
Material	Wet	Dry	Wet	Dry	Wet	Dry	Wet	Dry
Borosilicate glass	–	–	*	–	–	–	–	–
Ethylene Propylene rubber (EPDM)	*	–	–	*	*	–	–	–
Stainless steel: ASTM 316L	*	*	–	*	*	–	–	*
ASTM 304[1]	–	–	–	–	–	–	–	–
Polypropylene (PP)	*	–	–	–	*	–	–	–
Polytetrafluoroethene (PTFE) (Teflon™)	–	–	–	–	*	*	–	–
Polyamide (PA) nylon (10 µm net)	*	–	–	–	*	–	–	–
Polyetheretherketone (PEEK)	–	*	–	–	–	–	–	–
Acetal plastic (POM)	–	*	–	–	–	–	–	–
Fluoroethenepropene (FEP)[2]	*	–	–	–	*	–	–	–
Polyurethane –	–	–	–	–	–	–	*	
Polyvinylchloride (PVC)[3]	–	–	–	–	–	–	–	–

[1] The clamps are made of stainless steel.
[2] Option to EPDM.
[3] The tubing is made of PVC.

Scalable

BPG columns are ideal for scaling up from smaller lab scale or method development columns. Figure 3 shows a chromatogram obtained with an XK 16/20 column, i.d. 16 mm, is consistent with the chromatogram obtained from the scaled up run on BPG 300/500 column, i.d. 300 mm. The scale up factor is 350 and no evidence of dilution or loss of recovery was detectable.

Materials

BPG columns are made with high quality materials (Table 2). All materials used in BPG columns meet the requirements described in the USP XX III:

- Materials are compatible with the liquids commonly used in process scale chromatography (including sanitization and cleaning agents such as NaOH and ethanol), (Table 3).
- Parts in contact with sample and process liquids are made chemically resistant materials.
- All stainless steel components are electropolished for improved resistance to corrosion and reduced friction and contamination.
- All polymeric materials have been tested and meet the requirements for USP class VI, described in USP <88> Biological Reactivity Tests, *In Vivo*.

Chemical resistance

Table 3 is a guide to the resistance of materials to chemical solvents. The information has been complied from published material from several sources. Please note that the effects of a solvent will be more severe at higher temperatures and that combined effects have not been taken into consideration.

Table 3. Chemical resistance of materials of construction

Substance	Concentration	60–90 days[1]	Substance	Concentration	60–90 days[1]
Acetic acid	10%	see note 7	Hydrochloric acid	0.1 M	see note 6, 7
Acetic acid	25%	see note 7	Isopropyl alcohol	100%	see note 2
Acetonitrile	5%	see note 2	Methanol	100%	see note 2
Acetonitrile	50%	see note 3	Nitric acid	0.1 M	see note 7
Acetone	10%	OK	n-Propanol	100%	OK
Cyclohexane	100%	see note 3	Sodium chloride	2 M	see note 5
Ethanol	100%	see note 2	Sodium hydroxide	2 M	OK
Ethyl acetate	100%	see note 4	Trifluoroacetic acid	0.1%	see note 7, 8
Ethylene glycol	50%	OK	Triton™ X-100	100%	OK
Glycerol	100%	OK	Urea	8 M	OK
Hexane	100%	see note 2, 7			

[1] The test does not include PVC tubing.
[2] For repetitive, long-term use, use FEP O-rings instead of EPDM rubber.
[3] Change to FEP O-rings, polypropylene plastic resistence is adequate.
[4] Polyproylene plastic resistance is adequate.
[5] Can be used under normal running conditions. Do not use NaCl in storage solutions. Please note that NaCl can cause corrosion on stainless steel in acid solutions (pH below 4.0).
[6] Not longer than 4 hours.
[7] Not recommended for use with PA nets.
[8] Use EPDM rubber instead of FEP.

Individual testing

As evidence of good manufacturing practice, all BPG columns are individually inspected. A test certificate accompanies each column delivery.

Useful spare parts

Nets

The column is delivered with 23 µm (polypropylene) nets. For media with an average particle diameter <70 µm, change to 10 µm (polyamide) or 12 µm (polypropylene) in both adapters and end-pieces. For Sepharose™ Big Beads, use 54 µm (polypropylene) nets.

O-rings

FEP adapter and sealing O-rings if solvents not compatible with the EPDM O-rings supplied with the column.

Gaskets

If solvents are not compatible with the EPDM gasket supplied with the column, use PTFE gaskets.

Longer bed heights

Packing extensions are available for all diameters.

Isolating the column after packing

We recommend using sanitary stainless steel valves of the appropriate inner diameter to prevent contamination of the packed bed. Either the 2-way or 4-way valves with a 6 mm i.d. are suitable for BPG 100, 140 and 200 columns and with a 10 mm i.d. for BPG 300 and BPG 450 columns. For storage purposes, the 25 mm blind flange with a clamp and gasket can be used to seal off the column.

Connecting the column to your system

A clamp and gasket, 6 or 10 mm i.d., are required to connect the 25 mm sanitary flanged inlet/outlet to either valves or tubing of the same type. Preflanged tubing in 6 and 10 mm i.d. is also available from GE Healthcare.

Assembly/disassembly of column

A torque wrench with a appropriate sized socket is required and can be ordered separately.

Useful column accessories

Technical support online: The process chromatography technical support portal at www.gelifesciences/purification-techsupport provides BPG users with a range of information about spares and accessories for columns and includes packing, and testing information as well as troubleshooting guides.

Column stands: BPG 100, 140 & 200, stand kit must be ordered separately. BPG 100 has adjustable feet, wheels with brakes are available. BPG 140 & 200 stands have wheels with brakes as standard. BPG 300 and 450 are supplied with stainless steel stand with wheels and foot-operated brakes.

Air Traps: BPG Air Trap Complete includes the air trap, mounting bracket, steel valves, clamps and gaskets. For air traps for BPG 100, 140 and 200, tubing is included.

Manometers: Manometer kits contain a pressure gauge, T-junction, necessary clamps and gaskets for sanitary connections.

Pressure relief valves: Connected between the pump and column inlet permit flow delivery at a constant pressure throughout the packing procedure.

Table 4. Recommended spare parts

Spare Parts	BPG 100	BPG 140	BPG 200	BPG 300	BPG 450	Qty/ Pack	Material
Flange O-ring	18-8494-01	18-1113-06	18-8489-01	18-1012-26	18-1105-33	2	EPDM
Flange O-ring	18-0019-41	18-1113-06	18-0019-51	18-1012-27	18-1117-67	1	FEP
Adapter O-ring	18-8475-01	18-1113-10	18-0275-01	18-1012-51	18-1017-47*	2	EPDM
Adapter O-ring	18-0019-40	18-1113-11	18-0019-50	18-1012-52	18-1117-66	1	FEP
U-shaped seal	—	—	—	—	18-1104-40	1	EPDM
U-shaped seal	—	—	—	—	18-1117-55	1	PFR
Support net, adapter	18-1103-04	18-1112-99	18-0252-56	18-1012-53	18-1104-34*	2	PP
Support net, end-piece	18-0251-55	18-1112-98	18-0252-55	18-1012-36	18-1104-35*	2	PP
Net, 10 µm, adapter	18-1103-05	18-1113-03	18-0252-76	18-1012-55	18-1017-46*	2	PA
Net, 10 µm, end-piece	18-0251-77	18-1113-02	18-0252-77	18-1012-35	18-1103-18*	2	PA
Net, 12 µm, adapter	18-1148-37	18-1148-39	18-1148-41	18-1148-43	18-1148-45*	2	PEEK
Net, 12 µm, end-piece	18-1148-38	18-1148-40	18-1148-42	18-1148-44	18-1148-46*	2	PEEK
Net, 23 µm, adapter	18-1103-08	18-1113-01	18-9253-01	18-1012-54	18-1001-62*	2	PP
Net, 23 µm, end-piece	18-9252-01	18-1113-00	18-9254-01	18-1012-34	18-1103-19*	2	PP
Net, 54 µm, adapter	18-1126-96	18-1126-98	18-1127-00	18-1127-02	18-1127-04*	2	PP
Net, 54 µm, end-piece	18-1126-97	18-1126-99	18-1127-01	18-1127-03	18-1127-05*	2	PP

* One piece per pack.

Safety valve: Pre-calibrated valve which releases pressure if the calibrated value is exceeded. Recommended if column may exceed its maximum pressure limit and no other pressure sensor is included in the chromatographic system. A T-junction, clamps and gaskets, which may be needed, must be ordered separately.

Top valve: Manually operated valve is recommended at the top of the airtrap as an air outlet control.

Grounding Kit

A grounding kit is available as an accessory for BPG columns.

Connectors

The connectors shown in Figure 4 are available as accessories from GE Healthcare.

Recommended spare parts

Table 4 lists the recommended spare parts. It is advisable to keep spares of nets, support screens, O-rings, and tubes on site at all times. O-rings and filters should be checked regularly for wear. Worn O-rings may not seal properly and over-used filter nets can affect distribution. If solvents are not compatible with EPDM seals, change to seals in FEP/PFR. Check the HETP and As regularly to prevent poor performance due to old nets. Contact your GE Healthcare representative for advice regarding change of spare parts.

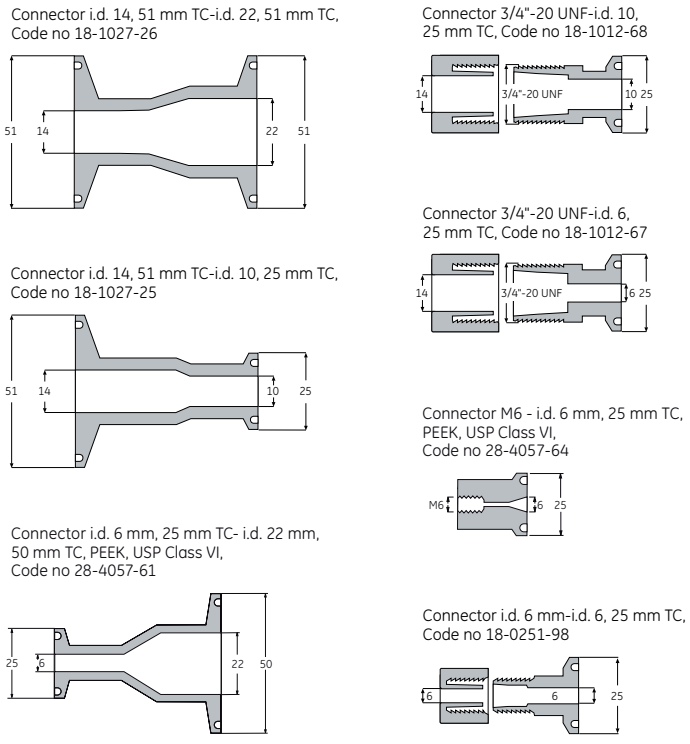


Fig 4. Guide to connectors for process scale columns.

Table 5. Accessories for BPG 100, 140 and 200 columns

Accessory	BPG 100	BPG 140	BPG 200	Qty/ Pack	Material
Air Trap Complete[2]	18-1102-96	18-1102-97	18-1102-97	1	316/glass
Top valve[2]	18-1121-44	18-1121-44	18-1121-44	1	316/EPDM
T-junction i.d. 6 mm[4]	18-1104-29	18-1104-29	18-1104-29	1	316
Valve sealing washer[6]	18-1128-69	18-1128-69	18-1128-69	2	PTFE
Manometer kit[3] (0–10 bar)	18-1031-07	18-1031-07	18-1031-07	1	304/316/EPDM
Manometer[3] (0–10 bar)	18-1103-67	18-1103-67	18-1103-67	1	316
Castor	18-1001-09	18-1001-09	18-1001-09	1	—
Adjustable foot	18-1126-93	18-1126-93	18-1126-93	1	—
Torque wrench	18-0251-37	18-0251-37	18-0251-37		304
12-point opening socket	18-1031-03	18-1031-04	18-1031-04		304
Allen key	18-1030-98	18-1030-98	18-1030-98		304
Packing device[1]	18-1104-75	18-1113-33	18-1104-77	1	glass
Grounding kit	18-1157-87	18-1157-87	18-1157-87	1	—
Media stirrer (80 mm plate diam.)	18-1149-80	18-1149-80	18-1149-80	1	—
Tubing with sanitary fitting[2] i.d. 6 mm					
30 cm	18-0005-42	18-0005-42	18-0005-42	1	PVC
75 cm	18-0005-43	18-0005-43	18-0005-43	1	PVC
125 cm	18-0005-44	18-0005-44	18-0005-44	1	PVC
150 cm	18-0005-45	18-0005-45	18-0005-45	1	PVC
200 cm	18-0005-47	18-0005-47	18-0005-47	1	PVC
Connectors[5]					
i.d. 6, 25 mm TC-6 mm threaded	18-0251-98	18-0251-98	18-0251-98	2	PP
i.d. 6, 25 mm TC-3/4"-20 UNF threaded	18-1012-67	18-1012-67	18-1012-67	2	PP
i.d. 6, 25 mm TC-M6 threaded	18-1031-09	—	—	2	PP
i.d. 6, 25 mm TC-i.d. 22, 51 mm TC	18-1012-69	18-1012-69	18-1012-69	2	PP
Clamps, gaskets					
Clamp 25 mm	18-1001-31	18-1001-31	18-1001-31	1	304
Clamp 25 mm	44-0568-01	44-0568-01	44-0568-01	12	304
Clamp 51 mm	44-7134-01	44-7134-01	44-7134-01	1	304
Gasket 25 mm i.d. 6 mm	18-0019-27	18-0019-27	18-0019-27	2	EPDM
Gasket 25 mm i.d. 6 mm	18-0019-28	18-0019-28	18-0019-28	2	PTFE
Gasket 51 mm i.d. 22 mm	44-7133-01	44-7133-01	44-7133-01	5	EPDM
Gasket 51 mm i.d. 22 mm	44-5512-03	44-5512-03	44-5512-03	2	PTFE
Blind flange 25 mm incl. gasket	18-1001-25	18-1001-25	18-1001-25	1	304/EPDM
Blind flange 51 mm incl. gasket	44-7135-01	44-7135-01	44-7135-01	1	304/EPDM
Valves					
4port, 2way i.d. 6mm[2]	18-5757-01	18-5757-01	18-5757-01	1	316L/PTFE
4port, 4way i.d. 6mm[2]	18-5758-01	18-5758-01	18-5758-01	1	316L/PTFE
Pressure relief valve i.d. 6mm[2]	18-1105-36	18-1105-36	18-1105-36	1	316/FPM
Safety valve[3]	18-1035-80	18-1035-81	18-1035-81	1	316/PTFE

[1] The packing device consists of a 380 mm height glass tube, flanges, rods, O-rings in EPDM, nuts and screws.

[2] 25 mm TC.

[3] 51 mm TC.

[4] 2×25 mm, 1×51 mm TC.

[5] See Figure 4.

[6] Fits 6 and 10 mm, 2- and 4-way valves.

[7] For O-rings as spare parts, see Table 4.

Table 6. Accessories for BPG 300 and 450 columns

Accessory	BPG 300	BPG 450	Quantity/ Pack	Material
Air Trap Complete[3]	18-1102-98	18-1103-00	1	304/316/ glass/EPDM
Top valve[3]	18-1121-44	18-1121-44	1	316/EPDM
Torque wrench	18-0251-37	18-0251-37	1	304
12-point opening socket	18-1031-05	18-1105-31	1	304
Allen key	18-1030-98	18-1030-98	1	304
Packing device[1,8]	18-1108-16	—	1	glass
Packing device[2,8]	—	18-1105-32	1	316
T-junction i.d. 10 mm[5]	18-1003-63	18-1003-63	1	316
Valve sealing washer[7]	18-1128-69	18-1128-69 2	PTFE	
Manometer kit[4] (0–5 bar)	18-1031-08	18-1031-08	1	304/316/EPDM
Manometer[4] (0–5 bar)	18-1103-68	18-1103-68	1	316
Wheel	18-1001-09	18-1001-09	1	—
Media stirrer (150 mm plate diameter)	18-1149-81	18-1149-81	1	—
Tubing with sanitary fitting[3] length i.d.				
30 cm 10 mm	18-1012-85	18-1012-85	1	PVC
40 cm 10 mm	18-1012-86	18-1012-86	1	PVC
75 cm 14 mm	—	18-1027-28	1	PVC
90 cm 10 mm	18-1012-62	18-1012-62	1	PVC
140 cm 10 mm	18-1012-63	18-1012-63	1	PVC
170 cm 10 mm	18-1012-64	18-1012-64	1	PVC
180 cm 14 mm	—	18-1027-29	1	PVC
200 cm 10 mm	18-1012-87	18-1012-87	1	PVC
Connectors[6]				
i.d. 10, 25 mm TC-3/4"-20 UNF threaded	18-1012-68	18-1012-68	2	PP
i.d. 10, 25 mm TC-i.d.14, 51 mm TC	18-1027-25	18-1027-25	2	PP
i.d. 14, 51 mm TC-i.d.22, 51 mm TC	—	18-1027-26	2	PP
Clamps, gaskets				
Clamp 25 mm	18-1001-31	18-1001-31	1	304
Clamp 25 mm	44-0568-01	44-0568-01	12	304
Clamp 51 mm	44-7134-01	44-7134-01	1	304
Gasket 25 mm i.d. 10 mm	18-1035-79	18-1035-7	2	EPDM
Gasket 25 mm i.d. 10 mm	18-1012-40	18-1012-40	2	PTFE
Gasket 25 mm i.d. 12 mm	—	18-0200-00	2	EPDM
Gasket 25 mm i.d. 12 mm	—	44-5506-20	2	PTFE
Blind flange 25 mm incl. gasket	18-1001-25	18-1001-25	1	304/EPDM
Gasket 51 mm i.d. 10 mm	18-1012-88	18-1012-88	5	EPDM
Gasket 51 mm i.d. 14 mm	—	18-1017-57	5	EPDM
Gasket 51 mm i.d. 22 mm	44-7133-01	44-7133-01	5	EPDM
Gasket 51 mm i.d. 22 mm	44-5512-03	44-5512-03	2	PTFE
Blind flange 51 mm incl. gasket	44-7135-01	44-7135-01	1	304/EPDM
Valves				
4port, 2way i.d. 10 mm[3]	18-1012-56	18-1012-56	1	316L/PTFE
4port, 4way i.d. 10 mm[3]	18-1012-57	18-1012-57	1	316L/PTFE
3port, 2way i.d. 15 mm[3]	—	44-5499-90	1	316L/PTFE
Pressure relief valve i.d. 10 mm[3]	18-1106-97	18-1106-97	1	316/FPM
Safety valve[4]	18-1035-82	18-1103-65	1	316/EPDM

[1] The packing device consists of a 380 mm height glass tube, flanges, rods, O-rings in EPDM, nuts and screws.

[2] The packing device consists of a 300 mm high stainless steel tube, O-rings, nuts and a clamp.

[3] 25 mm TC.

[4] 51 mm TC.

[5] 2×25 mm, 1×51 mm TC.

[6] See Figure 4.

[7] Fits 6 and 10 mm, 2- and 4-way valves. For replacement, consult "Instructions for Use".

[8] For O-rings as spare parts, see Flange O-rings for the respective column in Table 4.

Ordering information

	Column tube length (mm)			
Diameter	**500**	**750**	**950**	**Stand kit**
100	18-1103-01	18-1103-02	18-1103-03	18-1031-10
140	18-1113-08		18-1113-09	18-1031-20
200	18-1103-11	18-1103-12	18-1103-13	18-1031-20
300	18-1103-21	18-1103-22	18-1103-23	
450	18-1103-71	18-1103-72	18-1103-73*	

* Tube height for BPG 450 is 1000 mm.

Literature	Code No.
Sanitizing BPG columns with sodium hydroxide	18-1020-86
Sanitizing BPG 450 column with sodium hydroxide	18-1117-76

For contact information for your local office, please visit, www.gelifesciences.com/contact

www.gelifesciences.com/bioprocess

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18-1115-23 AD 05/2007

INSTRUCTIONS

AminoLink® Plus Coupling Resin

20501 20505

0490.5

Number	Description
20501	**AminoLink Plus Coupling Resin**, 10mL resin, 20mL slurry
20505	**AminoLink Plus Coupling Resin**, 50mL resin, 100mL slurry
	Support: 4% crosslinked beaded agarose
	Supplied as 50% slurry in 0.02% sodium azide
	Storage: Upon receipt store at 4°C. Product is shipped at ambient temperature.

Introduction

The Thermo Scientific AminoLink Plus Coupling Resin allows simple and efficient covalent immobilization of proteins to a beaded agarose support, providing a valuable tool for affinity purification of antibodies, antigens or other biomolecules. The activated support contains aldehyde functional groups that spontaneously react with primary amines on proteins or other molecules. The Schiff base bonds that form are reduced to stable secondary amine bonds in the presence of the mild reducing agent, sodium cyanoborohydride. Coupling efficiency by this reductive amination mechanism is typically greater than 80%, regardless of the ligand's molecular weight or pI. The resin is crosslinked beaded agarose with fast linear flow potential, making it useful for gravity flow and low- to medium-pressure applications.

Two coupling protocols (pH 7.2 and pH 10) are offered for use with AminoLink Plus Coupling Resin. The pH 10 coupling protocol typically provides greater immobilization yields and ligand densities than the pH 7.2 protocol. The standard, 7.2 pH protocol is offered as an alternative for proteins that are sensitive to the pH 10 environment required for the enhanced coupling protocol. Once the ligand is immobilized, the prepared resin can be used for multiple rounds of affinity purification.

Material Preparation

A. Additional Materials Required

- Column containing the desired slurry volume of AminoLink Plus Coupling Resin

  Note: The following coupling procedure is for 2mL of AminoLink Plus Resin (4mL resin slurry) in a 5mL gravity-flow column (See Related Thermo Scientific Products). Scale procedure as needed. To dispense the resin, invert bottle of slurry several times and then pipette the desired volume into an empty column using a wide orifice or cut pipette tip. For a centrifuge column procedure, see instructions for Product No. 44894.
- Coupling Buffer: 0.1M sodium phosphate, 0.15M NaCl, pH 7.2 (PBS, Product No. 28372), or 0.1M sodium citrate, 0.05M sodium carbonate, pH 10

  Note: Although the entire coupling reaction is effective over a wide pH range, research has demonstrated that maximum protein coupling occurs if Schiff base formation is performed at pH 10, followed by sodium cyanoborohydride reduction at near-neutral pH. Therefore, two coupling protocols (pH 7.2 and pH 10) are provided. Use the simpler pH 7.2 protocol if the protein is known to be unstable or insoluble in the pH 10 environment required for the enhanced coupling protocol.
- Cyanoborohydride Solution ($NaCNBH_3$, Product No. 44892): 5M $NaCNBH_3$ in 1M NaOH

  Note: Prepare this solution in a fume hood because $NaCNBH_3$ is toxic.
- Quenching Buffer: 1M Tris•HCl, pH 7.4
- Wash Solution: 1M sodium chloride (NaCl)

B. Sample Preparation (Protein Solution)

Dissolve 1-20mg protein or 1-2mg peptide to be immobilized in 2-3mL of Coupling Buffer (choose pH 7.2 or pH 10, see Important Product Information). For proteins already in solution, dilute sample 4-fold in Coupling Buffer; alternatively, desalt or dialyze to buffer-exchange into Coupling Buffer. **Note:** If the protein solution contains primary amines (e.g., Tris or glycine), these compounds must be thoroughly removed or they will compete with the intended protein-coupling reaction.

Procedure for Coupling Protein Using the pH 10 Coupling Buffer

A. Protein Immobilization

1. Equilibrate upright column containing desired amount of AminoLink Plus Resin to room temperature and allow the resin to settle. Open column and drain storage solution into a collection tube. Throughout entire procedure, do not allow the resin bed to become dry. Place bottom cap on the column when the buffer drains down to the top of the resin bed.
2. Equilibrate column by adding 6mL (3 resin-bed volumes) of pH 10 Coupling Buffer and allowing the contents to drain.
3. Replace the bottom cap and add 2-4mL of the protein solution (dissolved in pH 10 Coupling Buffer) to the column. Save 0.1mL of the prepared sample for subsequent determination of coupling efficiency.
4. Place the top cap on the column and mix the reaction slurry by gentle end-over-end rocking for 4 hours.

   Note: For proteins that are sensitive to long-term agitation (e.g., precipitate), mix for 2 hours and then allow the column to remain stationary for an additional 2 hours. Longer incubation times are acceptable, depending on protein stability.
5. Remove top and bottom caps and drain the contents of the column into a new collection tube.
6. Save the flow-through and determine the coupling efficiency while continuing with column blocking steps. Determine coupling efficiency by comparing the protein concentrations of the non-bound fraction to the starting sample (step 3).
7. Wash resin with 6mL of pH 7.2 Coupling Buffer. Replace bottom cap when buffer drains to top of resin bed.
8. In a fume hood, add 2mL of pH 7.2 Coupling Buffer and 40µL of Cyanoborohydride Solution to the reaction slurry (results in ~50mM $NaCNBH_3$ when mixed with resin).
9. Replace top cap and mix column for 4 hours at room temperature or overnight at 4°C.
10. In a fume hood, carefully remove the top cap. Some gas pressure may have formed during the reaction.
11. Remove the bottom cap, place the column in a new collection tube and allow it to drain.

B. Block Remaining Active Sites

1. Wash resin with 4mL of Quenching Buffer, and then replace the bottom cap.
2. In a fume hood, add 2mL of Quenching Buffer and 40µL of Cyanoborohydride Solution to the column (results in ~50mM $NaCNBH_3$ when mixed with resin). Replace the top cap and mix gently for 30 minutes by end-over-end rocking.
3. In a fume hood, carefully remove the top cap. Some gas pressure may have formed during the reaction.
4. Remove bottom cap, place the column in a new collection tube and allow it to drain.

C. Wash Column

1. Wash column with at least 10mL (5 resin-bed volumes) of Wash Solution.

   Note: Monitor the final washes for the presence of protein. Although the washes should remove all non-coupled protein, proteins coupled at high concentrations or at pH 10 may require extensive washing for complete removal.
2. Wash the resin with 6mL of degassed buffer containing 0.05% sodium azide or other preservative. Replace bottom cap while there is still at least 1mL of buffer covering the top of resin bed. Store column upright at 4°C.

   Note: If desired, position a porous disc just above the top of the resin bed. The disc prevents resuspension of packed resin bed when adding solution to the column and it protects the column from drying by automatically stopping column flow when solution drains down to the top of the disc.

Procedure for Coupling Protein Using the pH 7.2 Coupling Buffer

1. Equilibrate upright column containing desired amount of AminoLink Plus Resin to room temperature and allow the resin to settle. Open column and drain storage solution into a collection tube. Throughout entire procedure, do not allow the resin bed to become dry. Place bottom cap on the column when the buffer drains down to the top of the resin bed.
2. Equilibrate column by adding 6mL (3 resin-bed volumes) of pH 7.2 Coupling Buffer and allowing the contents to drain.
3. Replace the bottom cap and add 2-4mL of the protein solution (dissolved in pH 7.2 Coupling Buffer) to the column. Save 0.1mL of the prepared sample for subsequent determination of coupling efficiency.
4. In a fume hood, add 40µL of Cyanoborohydride Solution to the reaction slurry (results in ~50mM $NaCNBH_3$).

5. Place the top cap on the column and mix the reaction by end-over-end rocking for 6 hours at room temperature or overnight at 4°C. For proteins that are sensitive to agitation, mix for 2 hours and then allow column to remain stationary for an additional 4 hours.
6. In a fume hood, carefully remove the top cap. Some gas pressure may have formed during the reaction.
7. Remove the bottom cap and drain the contents of the column into a new collection tube.
8. Save the flow-through and determine the coupling efficiency while continuing with column blocking steps. Determine coupling efficiency by comparing the protein concentrations of the non-bound fraction to the starting sample (step 3).
9. Wash resin with 4mL of pH 7.2 Coupling Buffer. Replace the bottom cap.
10. Proceed with Sections B and C of the **Procedure for Coupling Protein to Column Using the pH 10 Coupling Buffer** (Block Remaining Active Sites and Wash Column).

General Protocol for Affinity Purification of Protein

Note: This protocol uses a gravity-flow column with a resin-bed volume of 2mL. For columns with other bed volumes, adjust all solution (e.g., sample, wash, and elution) volumes accordingly. The amount of protein sample needed and incubation time are dependent upon the affinity system involved (e.g., antibody-antigen interaction) and must be optimized. For a centrifuge column procedure, see instructions for Product No. 44894.

A. Additional Materials Required

- Binding/Wash Buffer: Phosphate Buffered Saline (PBS, Product No. 28372), Tris Buffered Saline (TBS, Product No. 28379) or other buffer that is compatible with the intended affinity interaction.
- Sample: Prepare antigen or other molecule in Binding/Wash Buffer, or dilute sample 1:1 in Binding/Wash Buffer
- Elution Buffer: IgG Elution Buffer (Product No. 21004) or 0.1-0.2M glycine•HCl, pH 2.5-3.0
- Neutralization Buffer (optional): 1mL of high-ionic strength alkaline buffer such as 1M phosphate or 1M Tris; pH 9

B. Procedure

Note: Degas all buffers to avoid introducing air bubbles into the column. Throughout the procedure, do not allow the resin bed to become dry; replace bottom cap as soon as buffer drains down to the top of resin bed.

1. Equilibrate the prepared affinity column to room temperature.
2. Remove top and bottom caps and allow excess storage solution to drain from column.
3. Equilibrate column by adding 6mL of Binding/Wash Buffer and allowing it to drain from column.
4. Add Sample to column and allow it to flow into the resin bed. For samples < 2mL, extend binding time by replacing the bottom cap to stop flow for a time (e.g., 1 hour) after the sample has entered resin bed. For samples > 2mL, extend binding time by capping to stop column flow after each 2mL volume of sample has passed into/through the resin bed.
5. Remove top cap and bottom caps from column, place column in new collection tube, and wash the column with 12mL of Binding/Wash Buffer.
6. Elute the bound protein by applying 8mL of Elution Buffer. Collect 1mL (or 0.5mL) fractions. The pH of each fraction can be adjusted to neutral by adding 50µL of Neutralization Buffer per 1mL of collected eluate.
7. Monitor elution by absorbance at 280nm. Pool fractions of interest and exchange into an appropriate storage buffer by desalting or dialysis.

C. Column Regeneration and Storage

Note: Regenerate the column soon after elution to prevent damage to the immobilized molecule by the low pH elution buffer.

1. Wash column with 16mL of Binding/Wash Buffer to remove any residual protein and reactivate the resin.
2. Equilibrate column with 8mL of Binding/Wash Buffer containing 0.05% sodium azide.
3. Replace bottom cap and add 2mL of Binding/Wash Buffer to the column and cap the top. Store column upright at 4°C.

Troubleshooting

Problem	Cause	Solution
Low coupling efficiency	Primary amines not completely removed from sample before coupling	Ensure primary amines have been completely removed by extensive dialysis or desalting
Protein to be immobilized is not soluble in Coupling Buffer	Molecule was hydrophobic	Dissolve molecule in Coupling Buffer containing up to 4M guanidine•HCl or 20% DMSO (see Additional Information section)
Column flows slowly	Air bubbles in column were restricting flow (air bubbles may not be visible)	Remove air bubbles by stirring or centrifugation (see Additional Information section)
Affinity column loses binding capacity over time	Immobilized sample was damaged by time, temperature or elution conditions	Prepare a new affinity column and alter the procedure responsible for damaging the column
	Nonspecifically bound material had reduced capacity	Wash column with high salt (~1M NaCl) to remove nonspecifically bound material
		Remove precipitate from sample before affinity purification by centrifugation of 0.45µm filter

Related Thermo Scientific Products

89896 **Pierce® Centrifuge Columns, 2mL,** 25 units

89897 **Pierce Centrifuge Columns, 5mL,** 25 units

89898 **Pierce Centrifuge Columns, 10mL,** 25 units

44892 **AminoLink Reductant,** Sodium cyanoborohydride ($NaCNBH_3$), 2 × 1g

28372 **BupH™ Phosphate Buffered Saline (PBS),** each dry-blend pack makes 500 ml with water, 40 packs

21004 **Pierce IgG Elution Buffer,** low-pH elution buffer for general protein affinity purifications, 1 L

Additional Information Available on Our Website

- Centrifuge Protocol: See instructions for the related AminoLink Plus Immobilization Kit (Product No. 44894)
- Tech Tip #12: Prepare molecules with poor solubility for immobilization on affinity supports
- Tech Tip #27: Optimize elution conditions for immunoaffinity purification
- Tech Tip #7: Remove air bubbles from columns to restore flow rate
- Tech Tip #29: Degas buffers for use in affinity and gel filtration columns

General References

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Hornsey, V.S., *et al.* (1986). Reductive amination for solid-phase coupling of protein. A practical alternative to cyanogen bromide. *J Immunol Methods* **93(1)**:83-8.

Lasch, J. and Koelsch, R. (1978). Enzyme leakage and multipoint attachment of agarose-bound enzyme preparations. *Eur J Biochem* **82:**181-6.

Current product instructions are available at *www.thermoscientific.com/pierce*. For a faxed copy, call 800-874-3723 or contact your local distributor.

Heparin Sepharose™ 6 Fast Flow

Heparin Sepharose 6 Fast Flow is a BioProcess™ medium (resin) for affinity chromatography (Fig 1). The medium allows fast and reliable separations of biomolecules with an affinity for heparin, including antithrombin III, coagulation factors and other plasma proteins, DNA binding proteins, lipoproteins, protein synthesis factors, enzymes that act on nucleic acids, and steroid receptors. The excellent flow characteristics and high chemical stability of Heparin Sepharose 6 Fast Flow make the medium highly suitable for process-scale purifications. As a member of the BioProcess family of media, Heparin Sepharose 6 Fast Flow is well-supported with documentation that facilitates development, scale-up, and routine operation in production applications.

- Purification of heparin-binding biomolecules
- High chemical stability based on stable coupling chemistry
- Enhanced binding capacity for antithrombin III due to oriented coupling of the ligand
- Widely used in industrial applications and well-established in approved processes

Fig 1. Heparin Sepharose 6 Fast Flow purifies proteins with an affinity for heparin. As a BioProcess medium, the product is available in process-scale quantities.

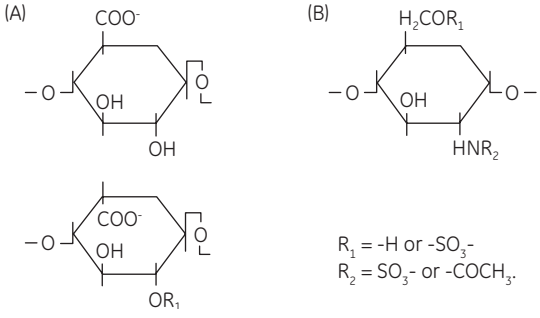


Fig 2. Heparin consists of alternating hexuronic acid (A) and D-glucosamine residues (B). The hexuronic acid can either be D-glucuronic acid (top) or its C-5 epimer, L-iduronic acid (below).

Characteristics

Heparin Sepharose 6 Fast Flow

Heparin is a naturally occuring glycosaminoglycan consisting of alternating hexuronic acid (D-glucuronic or L-iduronic) and D-glucosamine residues. The polymer is heavily sulphated, carrying sulphamino (N-sulphate) groups at C-2 of the glucosamine units as well as ester sulphate (O-sulphate) groups in various positions (Fig 2). The heparin is isolated from porcine intestinal mucosa, and has a molecular weight distribution of M_r 5000 to 30 000. The heparin ligand used for Heparin Sepharose 6 Fast Flow is produced in accordance with guidelines that comply with good manufacturing practise (GMP) for bulk pharmaceutical chemical producers. The heparin of animal origin is strictly controlled. Further information is available in the Regulatory Support File for Heparin Sepharose 6 Fast Flow.

The base matrix of Sepharose 6 Fast Flow is a robust, highly cross-linked 6% agarose.The crosslinking of the base matrix has been optimized to give the matrix good flow properties and high physical and chemical stability, both of which are key factors for cost-effective, large-scale use.

Linear flow velocities at process scale of 200 to 300 cm/h through a 15 cm bed height at a pressure of 1 bar (14.5 psi, 0.1 MPa) are easily achievable. Example of a pressure/flow curve is given in Figure 3. In many applications, lower flow velocities (e.g., 100 to 150 cm/h) are preferred to maximize binding conditions.

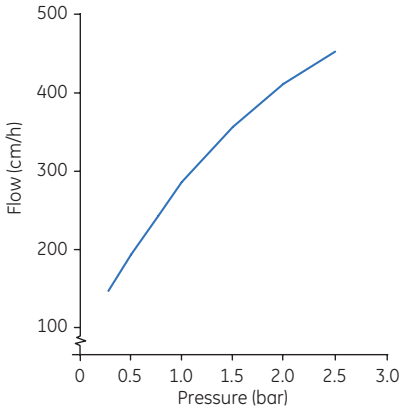


Fig 3. Pressure/flow curve for Heparin Sepharose 6 Fast Flow in BPG 200/500 column, inner diameter 20 cm, bed height 15 cm.

Heparin is linked to the Sepharose matrix by reductive amination and the resulting bond is stable even under alkaline conditions. Thus, the chemical stability of Heparin Sepharose 6 Fast Flow is limited only by the heparin ligand itself. Because of the oriented coupling of the heparin ligand and the used spacer, the specific binding activity is enhanced.

Table 1 lists the basic characteristics of Heparin Sepharose 6 Fast Flow.

Table 1. Characteristics of Heparin Sepharose 6 Fast Flow

Bead structure	6% highly cross-linked spherical agarose
Mean particle size	90 µm (45–165 µm)
Ligand	heparin of porcine origin
Ligand density	approx. 4 mg/mL drained gel
pH stability	
long term[1]	4–12
short term[2]	4–13
Chemical stability	0.1 M NaOH (1 week at 20°C) 0.05 M sodium acetate 4 M NaCl, pH 4.0 8 M urea 6 M guanidine hydrochloride
Pressure/flow specification	200–400 cm/h, 1 bar, XK 50/60 column, bed height 25 cm (base matrix)
Storage buffer	0.05 M sodium acetate containing 20% ethanol

[1] Refers to the pH interval where the medium is stable over a long period of time without adverse effects on its subsequent chromatographic performance.

[2] Refers to the pH interval for regeneration and cleaning.

Experimental procedures

Recommendations and comprehensive instructions for packing and use are included in information supplied with Heparin Sepharose 6 Fast Flow. The following details highlight some key aspects of the operations.

Sanitization

Sanitization reduces microbial contamination of the medium. A recommended sanitization procedure is to treat the packed column with 0.1 M NaOH and 20% ethanol for 1 h or to allow it to stand in 70% ethanol for 12 h. Always wash the packed column with equilibration buffer after sanitization.

Cleaning-in-place (CIP)

Substances such as denatured proteins that do not elute during regeneration can be removed by CIP procedures.

Heparin Sepharose 6 Fast Flow withstands exposure to 0.1 M NaOH for long periods without significant loss of binding capacity for antithrombin III. When contamination is severe, 0.5 M NaOH can be used. However, a decrease in functionality can be seen over time (Fig 4). Other reagents in which the medium is stable include 8 M urea and 6 M guanidine hydrochloride. Recommended CIP procedures are summarized in Table 2.

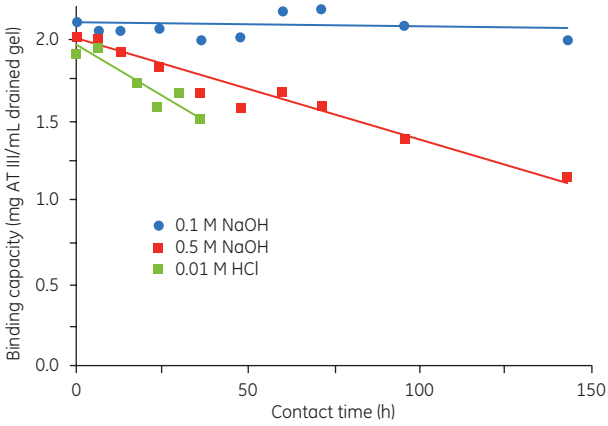


Fig. 4 Functional stability of Heparin Sepharose 6 Fast Flow was tested with three different CIP studies. CIP with 0.5 M NaOH can be used effectively over shorter periods.

More detailed recommendations are included in the instructions enclosed with each pack of medium. Always wash the packed column with equilibration buffer after CIP.

Table 2. Recommended CIP procedures

For removal of	Wash with	Column volumes	Contact time
Ionically bound proteins	2 M NaCl	0.5	10–15 min
Precipitated or denatured proteins	0.1 M NaOH or 6M guanidine hydrochloride or 8 M urea	4 approx. 2 approx. 2	1–2 h 0.5–1 h 0.5–1 h
Hydrophobically bound proteins	0.1% to 0.5% non-ionic detergent	4	1–2 h

Equipment

Heparin Sepharose Fast 6 Flow is well-suited for use with most equipment commonly employed for affinity chromatography, from laboratory to production scale. For optimized performance, we recommend bed heights from 10 to 20 cm.

Table 3 lists recommended empty columns from GE Healthcare Life Sciences for laboratory use, scale-up, and production.

Table 3. Recommended columns for use with Heparin Sepharose 6 Fast Flow at different scales of operation

Column	Inner diameter (mm)	Bed volume	Bed height, max. (cm)
Lab scale			
Tricorn™ 5/20	5	up to 0.55 mL	2.8
Tricorn 5/50	5	up to 1.1 mL	5.8
Tricorn 10/20	10	up to 2.2 mL	2.8
Tricorn 10/50	10	up to 4.5 mL	5.8
Tricorn 10/100	10	up to 8.5 mL	10.8
XK 16/20	16	up to 30 mL	15
XK 16/40	16	up to 70 mL	35
XK 26/20	26	up to 80 mL	15
XK 26/50	26	up to 190 mL	35
XK 50/20	50	up to 275 mL	15
XK 50/30	50	up to 510 mL	25
Production scale			
BPG 100/500	100	up to 2.0 L	26
BPG 140/500	140	up to 4.0 L	26
BPG 200/500	200	up to 8.2 L	26
BPG 300/500	300	up to 18.0 L	26
BPG 450/500	450	up to 36.0 L	23
INdEX 70/500	70	up to 1.2 L	32
INdEX 100/500	100	up to 2.5 L	32
INdEX 140/500	140	up to 4.9 L	32
INdEX 200/500	200	up to 10.0 L	32
Chromaflow™ 400/100–300	400	13–37 L	30
Chromaflow 600/100–300	600	28–85 L	30

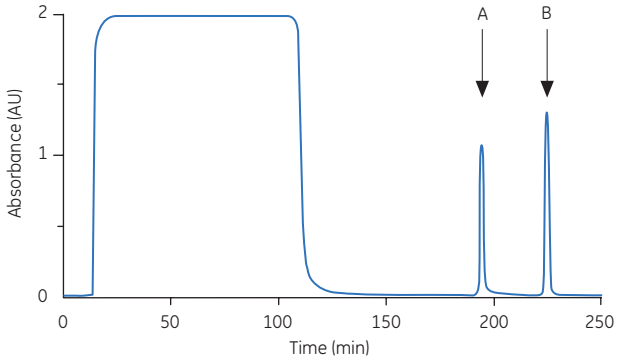
Application

Purification of antithrombin III

Purification of the blood coagulation protein antithrombin III from plasma and recombinant sources is a key industrial application for Heparin Sepharose 6 Fast Flow. One application example of the purification of antithrombin III from human plasma is given in Figure 5. In this example, the binding buffer was a citrate buffer and elution was accomplished by a step gradient of increasing ionic strength.

Sample: 45 mL pooled and filtered (0.45 µM) human plasma from 5 donors (0.45 µM) diluted 2:1 in binding buffer
Binding buffer: 0.1 M Tris-HCl, 0.01 M trisodium citrate, 0.225 M NaCl, pH 7.4
Wash buffer: 0.1 M Tris-HCl, 0.01 M trisodium citrate, 0.330 M NaCl, pH 7.4
Elution buffer: 0.1 M Tris-HCl, 0.01 M trisodium citrate, 2.0 M NaCl, pH 7.4
Column: Heparin Sepharose 6 Fast Flow packed in HR 5/5 column

Chromatographic procedure:
Flow rate: 0.5 mL/min (150 cm/h)
Equilibration: 5 mL binding buffer
Washing step 1: 40 mL binding buffer
Washing step 2: 15 mL wash buffer
Elution: 9 mL elution buffer



Isoelectric focusing-PAGE analysis of the peaks A and B from the affinity chromatography.

Lanes 1 and 4: Peak B
Lanes 2 and 7: IEF calibration kit
Lanes 3 and 6: Antithrombin III (Sigma)
Lanes 5 and 8: Peak A

Fig 5. Purification of antithrombin III from human plasma on Heparin Sepharose 6 Fast Flow. Pure antithrombin III is present in both peak A and B.

Peak A elutes with washing buffer and peak B with elution buffer. Isoelectric focusing-PAGE analysis showed that pure antithrombin III was present in both these peaks. NOR-Partigen antithrombin III test of peaks A and B revealed a more active form of antithrombin III concentrated in peak B (data not shown). Thus, under the given conditions some antithrombin III with lower affinity for heparin was eluted in the washing step, while the more active antithrombin III was eluted in the elution peak. This difference in affinity can be used to separate the two forms of antithrombin III to obtain a highly active end product.

Technical support for process-scale use

For successful use of a chromatography medium in commercial production, rapid process development, smooth scale-up to production, and economic and trouble-free operation are essential. As a member of the BioProcess family of media, Heparin Sepharose 6 Fast Flow fulfils these criteria. BioProcess media meet the rigorous demands of successful downstream processing, including validated manufacture, secure supply, scalability, high productivity, effective sanitization/CIP, and regulatory support.

Evidence of this suitability can be found in numerous examples where purifications based on Heparin Sepharose 6 Fast Flow have been scaled up to reliable and economically viable production processes.

Ordering information

Designation	Quantity	Code number
Heparin Sepharose 6 Fast Flow	50 ml	17-0998-01
Heparin Sepharose 6 Fast Flow	250 ml	17-0998-25
Heparin Sepharose 6 Fast Flow	1 liter	17-0998-03
Heparin Sepharose 6 Fast Flow	5 liter	17-0998-04

Related literature	Code number
Affinity Chromatography, Principles and Methods	18-1022-29

For local office contact information, visit
www.gelifesciences.com/contact

www.gelifesciences.com/bioprocess
www.gelifesciences.com/protein-purification

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Björkgatan 30
751 84 Uppsala
Sweden

imagination at work

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Amersham Place
Little Chalfont
Buckinghamshire, HP7 9NA
UK

GE Healthcare Europe, GmbH
Munzinger Strasse 5
D-79111 Freiburg
Germany

GE Healthcare Bio-Sciences Corp.
800 Centennial Avenue, P.O. Box 1327
Piscataway, NJ 08855-1327
USA

GE Healthcare Japan Corporation
Sanken Bldg., 3-25-1, Hyakunincho
Shinjuku-ku, Tokyo 169-0073
Japan

18-1060-76 AC 10/2013

MILLIPORE

- *Leading-edge void-free membranes to match virtually any separation challenge*
- *Short flow path for higher flux and higher resolution separation capability*
- *Choice of flow channel configuration providing process optimization capability*
- *Predictable, fast, scale-up*
- *True linear scalability from laboratory size modules to industrial assemblies for processing thousands of liters*

DATA SHEET

Pellicon® 2 Filters and Holders

High-performance tangential flow filters for biopharmaceutical process development, scale-up/scale-down and concentration/ purification/cell harvesting applications

Typical Applications

Concentration, desalting or buffer exchange of:

- Protein solutions
- Polysaccharide solutions
- Virus suspensions

Harvest, washing or clarification of:

- Cell cultures and lysates
- Colloidal suspensions
- Viral cultures

Superior TFF Performance

For research, process development, scale-up and production, Pellicon 2 filters and holders offer the following benefits:

Consistent High Flux and High Product Recovery

Millipore's Biomax® polyethersulfone and Ultracel® PLC-composite regenerated cellulose membranes have void-free structures that guard against leakage of solutes through microdefects normally associated with voids beneath the thin skins of conventional UF membranes (Figures 1 and 2).

These void-free membranes are more permeable, resulting in high-flux with equivalent or superior product retention (Figure 3). These void-free membranes provide the advantages of fast, high yield processing and smaller systems.

The long established Durapore® hydrophilic PVDF microfiltration membrane is well known for its exceptional combination of high flux, low protein binding and high product recoveries.

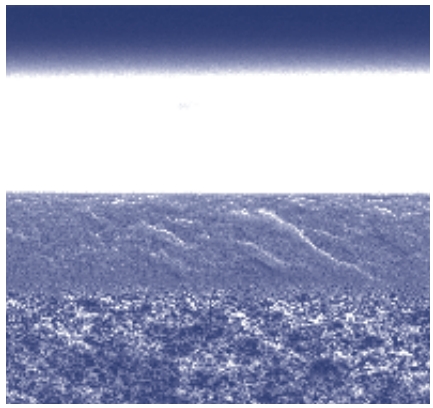


Figure 1. *Void-free Biomax 10 modified polyethersulfone membrane*

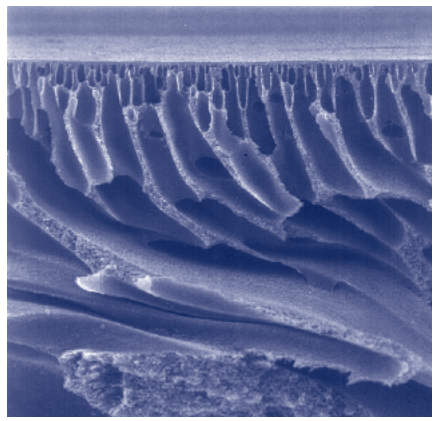


Figure 2. *Conventional 10 kD polyethersulfone membrane with sub-surface voids*

Easy, Reliable Linear Scale-Up from the Lab to the Production Plant

Pellicon 2 Mini filters scale-up easily and reliably from the laboratory to the production plant (Figures 4 and 5). By ensuring every flow channel has the same length, height and turbulence promoter as well as flow direction and materials of construction, we maintain the same ultrafilter/microfilter performance at all scales. Thus, rapid and reliable translation of processes from lab to manufacturing scale is easily achieved.

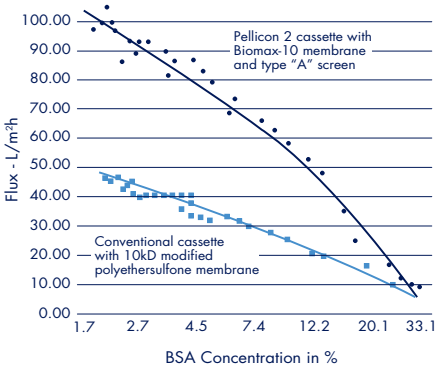
Linear Scale-Up

Mini filters (0.1 m^2/1.1 ft^2) and holders are designed for laboratory ultrafiltration/microfiltration of 100 mL to 10 L volumes, yet scale up linearly to Pellicon 2 Cassette (0.5 m^2/5.4 ft^2) and Maxi (2.5 m^2/26.9 ft^2) filters used in the pilot or manufacturing plant to process volumes from one liter to thousands of liters.

Thus, whether you operate 0.1 m^2 or 100 m^2 of installed area, every Pellicon 2 filter operates with the same pressure drop, flow velocity and concentration profile for true, rapid and simple linear scale-up.

Pellicon 2 Filters Proof of Performance

Improved Flux



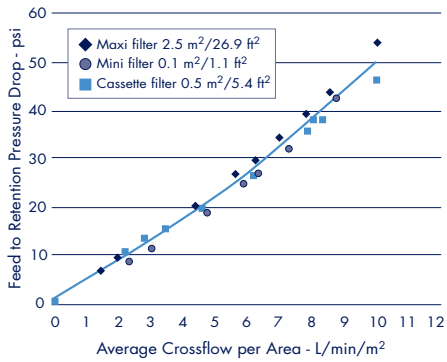
Feed pressure: 5.6 bar/80 psi
Retentate pressure: 2.1 bar/30 psi
Temperature: 10 – 13.5 °C
Initial volume 28 L
Final volume: 2 L

Conclusion

Pellicon 2 filters with Biomax membranes provide up to two-times the process flux of conventional cassettes resulting in faster processing and smaller systems.

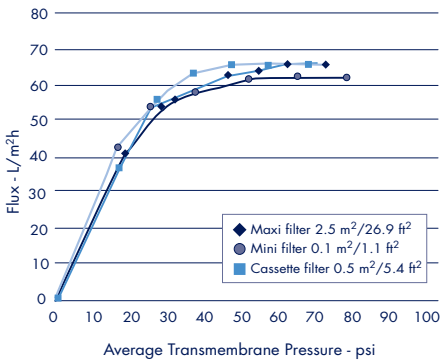
Figure 3. *Flux versus BSA concentration*

Linear Scalability



Temperature: 8 °C

Figure 4. *Feed to retentate pressure drop versus average crossflow on a 10% BSA solution*



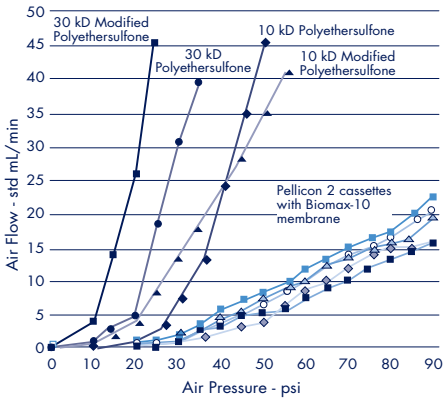
Temperature: 8 °C
Feed to retentate pressure drop: 2.8 bar/40 psi

Conclusion

(Figures 4 and 5) Pellicon 2 family of cassette filters scale linearly from 0.1 to 0.5 to 2.5 m^2 (1.1 to 5.4 to 26.9 ft^2) sizes for rapid, accurate and safe process scale-up and transfer.

Figure 5. *Flux versus average transmembrane pressure on a 10% BSA solution.*

Improved Reliability



Conclusion

The void-free structure of Biomax membranes is demonstrated by low, linear air diffusion values. This performance ensures better process reliability and safety and better product retention for higher yields.

Figure 6. *Integrity test comparison-air flow through wetted cassettes*

Greater Process Reliability and Reproducibility

The combination of defect-free membranes with Millipore's highly reliable manufacturing processes, offers greater consistency of process parameters.

The high quality of Millipore's ultrafiltration membranes is further ensured by our pioneering multiple-solute mixed-dextran retention profile test. Unlike the single solute protein retention test, Millipore's retention profile test measures and ensures reproducible retention performance of our UF membranes over the entire range of molecular weights retained by the membrane, not ¡ust at one or two molecular weights.

Low Product Loss

Pellicon 2 filters have a low minimum working volume – as low as 175 mL of retentate volume per square meter of membrane area. This low retentate volume permits high concentration factors to be reached with low starting volumes and maximizes the recovery of small sample volumes.

To prevent product loss, Pellicon 2 filters are 100% tested in manufacturing to ensure that every filter is integral.

In addition, Biomax and Ultracel membranes are exposed to a new high-pressure integrity test that provides greater sensitivity. The integrity test procedure and specifications are supplied so users can confirm integrity at high pressure when the filter is installed (Figure 6).

Biocompatibility

All wetted parts have been tested and meet the requirements of the USP Class VI biological test for plastics.

Superior Filter Quality

Pellicon cassettes are subjected to a complete array of quality control release tests.

A Certificate of Quality is included with every cassette.

Each casette is identified with a unique serial number.

Validatable

Since 1973, Pellicon filters and systems have been successfully used for development and scale-up of processes for manufacturing injectable protein and polysaccharide drugs, in the serum fractionation, biotechnology, vaccine and pharmaceutical industries.

Pellicon 2 filters and systems were developed based upon Millipore's experience serving these applications, and are supported by an extensive Validation Support Data Package proving performance claims and demonstrating the suitability of these filters for drug manufacturing in validated processes. This package is available upon request.

Millipore can further assist your validation efforts through:

- Design and fabrication of standard and custom turnkey TFF systems for drug manufacturing facilities
- Installation and operational qualification services for these systems
- Validation support services for tangential flow filter use in drug manufacturing processes.
- Training on TFF process scale-up, optimization and development.

A Choice of Feed Channel Screens

For optimal performance in a range of applications Pellicon 2 filters incorporate three types of feed-channel screens:

- *Type A screen (tight screen)* is optimized to operate Biomax membranes with maximum flux with low-viscosity solutions.
- *Type C screen (coarse screen)* is optimized to operate PLC series membranes with maximum flux. The Type C screen is also available with Biomax-50, 100, 300, 500 and Biomax 1000 membranes for concentration and diafiltration of viscous solutions.
- *Type V screen (open channel)* is optimized for very viscous solutions or solutions with higher levels of suspended solids.

Normalized Recirculation Rates

Parameter	Unit	Typical ΔP		
Screen Type		A	C	V
Recirculation Rate	L/min/m^2	4/6	5/35	
Differential Pressure	bar/psi	1.4/20	0.4/6	

Screen Selection Guidelines

Solution Type	Screen Type
Dilute protein solution or low viscosity solutions (MAbs, interferons)	A screen (tight screen)
Concentrated protein solutions or high viscosity solutions (IgG, biopolymers)	C screen (course screen)
High viscosity solutions (polysaccharides, certain microfiltration or clarification applications)	V screen (loose screen)

For More Detailed Information

Request literature number P17512 – User Guide for Pellicon Filters.

Specifications

Temperature Range

Mini, Cassette and Maxi:
4 to 50 °C

Maximum Forward Transmembrane Pressure

Device Size (m^2)	Biomax	Ultracel
0.1	6.8 bar (100 psi) Max	6.8 bar (100 psi) Max
0.5	6.8 bar (100 psi) at 30 °C	3.4 bar (50 psi) at 30 °C
2.5	6.8 bar (100 psi) at 30 °C	3.4 bar (50 psi) at 30 °C

Maximum Reverse Transmembrane Pressure

Device Size (m^2)	Biomax	Ultracel
0.1	0.33 bar (5 psi)	0.33 bar (5 psi)
0.5	0.33 bar (5 psi)	0.33 bar (5 psi)
2.5	0.33 bar (5 psi)	0.33 bar (5 psi)

Prefiltration Required

Mini, Cassette and Maxi:
100 µm

Dimensions

Device	Width	Length	Thickness
Mini	5.6 cm	21 cm	1.5 cm (V screen-2.16 cm)
Cassette	17.8 cm	21 cm	1.5 cm (V screen-2.16 cm)
Maxi	17.8 cm	21 cm	7.6 cm (V screen-9.0 cm)

Membrane Selection Guideline

Membrane Type	Materials	Benefits
Biomax	Modified polyethersulfone	Highest flux ultrafiltration membrane Excellent chemical resistance Void-free structure for higher yield and reliability
Ultracel PLC	Regenerated cellulose (ideal for protein solutions < 20 g/L) PLC membranes are composite membranes cast on a microporous substrate for defect-free membranes with superior adhesion. Brings higher resolution, improved yields and superior back-pressure resistance	Extremely low protein binding hydrophilic membrane Highest product recovery and improved performance with difficult to process streams (antifoams, lipids, protein transmission applications)
Durapore	Hydrophilic PVDF	Very hydrophilic microporous membrane for cell harvest or clarification applications

Pellicon 2 Membrane Selection Chart

Approximate Molecular Weight (range of solutes retained >99%, kD)		Membrane	NMWL (kD) or Microns	Membrane Material	pH Range
High Flux Biomax Membranes – Void-free for Higher Yield and Reliability					
12 – 25	(growth factors, hormones)	Biomax-5	5	modified polyethersulfone	1 – 14
25 – 50	(growth factors, hormones)	Biomax-8	8	modified polyethersulfone	1 – 14
50 – 100	(albumin, hemoglobin)	Biomax-10	10	modified polyethersulfone	1 – 14
100 – 140	(enzymes)	Biomax-30	30	modified polyethersulfone	1 – 14
140 – 300	(IgG's)	Biomax-50	50	modified polyethersulfone	1 – 14
300 – 500	(small viruses and antigens)	Biomax-100	100	modified polyethersulfone	1 – 14
>500	(IgM's, large viruses)	Biomax-300	300	modified polyethersulfone	1 – 14
>0.03 µm	(large viruses, colloids, particulates)	Biomax-500	500	modified polyethersulfone	1 – 14
>0.03 µm	(large viruses, cells, colloids, particulates)	Biomax-1000	1000	modified polyethersulfone	1 – 14
Ultracel PLC Series – for High Recoveries					
8 – 18	(proinsulin, hematopoetic factors)	PLCCC	5	regenerated cellulose	2 – 13
18 – 60	(hemoglobin, enzymes)	PLCGC	10	regenerated cellulose	2 – 13
60 – 200	(monoclonal IgG's)	PLCTK	30	regenerated cellulose	2 – 13
200 – 500	(small viruses, viral antigens)	PLCHK	100	regenerated cellulose	2 – 13
>500	(large viruses, IgM's)	PLCMK	300	regenerated cellulose	2 – 13
>0.03 µm	(large viruses, cells, colloids, particulates)	PLCXK	1000	regenerated cellulose	2 – 13
Durapore Membranes – for Microporous Applications					
Clarify cell lysates and protein solutions, clarify viral cultures		VVPP	0.1 µm	hydrophilic PVDF	2 – 11
Harvest & wash colloidal suspensions, bacterial cells; clarify protein solutions and viral cultures		GVPP	0.22 µm	hydrophilic PVDF	2 – 11
Harvest & wash colloidal suspensions, cell & viral cultures, clarify protein solutions & viral cultures		HVMP	0.45 µm	hydrophilic PVDF	2 – 11
Harvest cell cultures or colloidal suspensions		DVPP	0.65 µm	hydrophilic PVDF	2 – 11

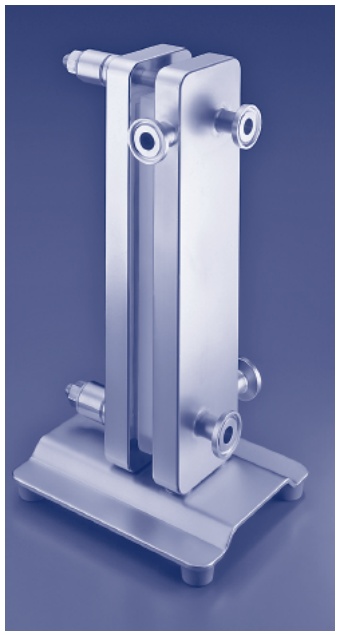
Ordering Information

Pellicon 2 Filters

	Filters with A Screens (Tight Screen)			Filters with Type C Screens (Coarse Screen)		
Membrane	**0.1 m²/1.1 ft²**	**0.5 m²/5.4 ft²**	**2.5 m²/26.9 ft²**	**0.1 m²/1.1 ft²**	**0.5 m²/5.4 ft²**	**2.5 m²/26.9 ft²**
Biomax Series – Modified Polyethersulfone						
Biomax 5	P2B0 05A 01	P2B0 05A 05	P2B0 05A 25	+	+	+
Biomax 8	P2B0 08A 01	P2B0 08A 05	P2B0 08A 25	+	+	+
Biomax 10	P2B0 10A 01	P2B0 10A 05	P2B0 10A 25	+	+	+
Biomax 30	P2B0 30A 01	P2B0 30A 05	P2B0 30A 25	+	+	+
Biomax 50	P2B0 50A 01	P2B0 50A 05	P2B0 50A 25	P2B0 50C 01	P2B0 50C 05	P2B0 50C 25
Biomax 100	P2B1 00A 01	P2B1 00A 05	P2B1 00A 25	P2B1 00C 01	P2B1 00C 05	P2B1 00C 25
Biomax 300	+	+	+	P2B3 00C 01	P2B3 00C 05	P2B3 00C 25
Biomax 500	+	+	+	P2B5 00C 01	P2B5 00C 05	P2B5 00C 25
Biomax 1000	+	+	+	P2B0 1MC 01	P2B0 1MC 05	P2B0 1MC 25
Ultracel PLC Series – Regenerated Cellulose, Composite Construction						
5 kD	NA	NA	NA	P2C0 05C 01	P2C0 05C 05	P2C0 05C 25
10 kD	NA	NA	NA	P2C0 10C 01	P2C0 10C 05	P2C0 10C 25
30 kD	NA	NA	NA	P2C0 30C 01	P2C0 30C 05	P2C0 30C 25
100 kD	NA	NA	NA	P2C1 00C 01	P2C1 00C 05	P2C1 00C 25
300 kD	NA	NA	NA	P2C3 00C 01	P2C3 00C 05	P2C3 00C 25
1000 kD	NA	NA	NA	P2C0 1MC 01	P2C0 1MC 05	P2C0 1MC 25
Durapore – Hydrophilic PVDF						
0.1 µm	+	+	+	P2VV PPC 01	P2VV PPC 05	P2VV PPC 25
0.22 µm	+	+	+	P2GV PPC 01	P2GV PPC 05	P2GV PPC 25
0.45 µm	+	+	+	P2HV MPC 01	P2HV MPC 05	P2HV MPC 25
0.65 µm	+	+	+	P2DV PPC 01	P2DV PPC 05	P2DV PPC 25

Each Pellicon filter is packed one per box and includes Operating Instructions. A Certificate of Quality is included in every box.
Silicone intercassette gaskets are required for use with Pellicon 2 filters. Two gaskets are packed in the box with every Pellicon 2 filter.
+ = On request (custom order)
NA = not available

Filters with V Screens (Loose Screen)		
0.1 m²/1.1 ft²	**0.5 m²/5.4 ft²**	**2.0 m²/21.5 ft²**
P2B0 05V 01	P2B0 05V 05	P2B0 05V 20
P2B0 08V 01	P2B0 08V 05	P2B0 08V 20
P2B0 10V 01	P2B0 10V 05	P2B0 10V 20
P2B0 30V 01	P2B0 30V 05	P2B0 30V 20
P2B0 50V 01	P2B0 50V 05	P2B0 50V 20
P2B 100V 01	P2B1 00V 05	P2B1 00V 20
P2B3 00V 01	P2B3 00V 05	P2B3 00V 20
P2B5 00V 01	P2B5 00V 05	P2B5 00V 20
P2B0 1MV 01	P2B0 1MV 05	P2B0 1MV 20
P2C0 05V 01	P2C005V 05	P2C0 05V 20
P2C0 10V 01	P2C0 10V 05	P2C0 10V 20
P2C0 30V 01	P2C0 30V 05	P2C0 30V 20
P2C1 00V 01	P2C1 00V 05	P2C1 00V 20
P2C3 00V 01	P2C3 00V 05	P2C3 00V 20
P2C0 1MV 01	P2C0 1MV 05	P2C01MV 20
P2VV PPV 01	P2VV PPV 05	P2VV PPV 20
P2GV PPV 01	P2GV PPV 05	P2GV PPV 20
P2HV MPV 01	P2HV MPV 05	P2HV MPV 20
P2DV PPV 01	P2DV PPV 05	P2DV PPV 20



Pellicon 2 Mini Holder

Pellicon 2 Mini holder operates one to three Mini filters in parallel for total areas of 0.1 to 0.3 m² (1.1 – 3.3 ft²). This sanitary holder is tightened with a small torque wrench to compress the filters between a manifold plate that conveys fluids in and out of the filters and an end plate that seals the filters together. The Mini holder is designed for process development and small volume pharmaceutical manufacturing.

Materials of Construction

Manifold and End Plates:
316 L stainless steel

Base, Tie Rods, Spacers and Washers:
304 stainless steel

Feet:
Thermoplastic rubber

Gaskets:
Silicone

Nuts:
Silicone bronze

Separator Plates

An optional separator plate allows processing simultaneously with up to three 0.1 m²/1.1 ft² cassettes to determine the best molecular weight cut-off in a single study on the same feed material.

Connections

All manifold connections are standard ½-inch sanitary clamp type.

Operating Parameters

Temperature Range:
4 to 50 °C. The Mini holder can be autoclaved without filters installed. The filters themselves cannot be autoclaved.

Maximum Pressure:
6.8 bar

Dimensions

Height: 260 mm; *Width:* 114 mm

Length: 140 mm; *Weight:* 5 kg

Holder Manifold Volume:

Feed plus retentate: 5.3 mL

Permeate: 6.4 mL

Stainless Steel Pellicon Holder

XX42P0080

The stainless steel Pellicon filter holder, designed for sanitary applications, can be used alone or to expand existing cassette ultrafiltration (CUF) systems or to replace existing holders.

It requires only to be connected to an existing sanitary pump and piping for tangential flow microporous filtration or ultrafiltration.

It can accomodate up to 5 m^2/55 ft^2 filter area as shipped with long tie rods or 0.5 to 2.5 m^2 (5.4 – 26.9 ft^2) with accessory short tie rods.

Materials of Construction

Wetted Surfaces:
316 L stainless steel

Non-wetted Surfaces:
Silicon bronze nuts

Dimensions

Length: 28 cm; *Width:* 19 cm

Height: 25 cm

Operating Parameters

Operating Temperature Range:
4 to 50 °C. The Pellicon holder can be autoclaved without pressure gauges and filters; holder with gauges cannot be steamed. Pellicon filters cannot be steamed or autoclaved.

Connections

Sanitary ¾" TC connections;
1½" TC connections for gauges.

Shipping Weight

24 kg

Process-scale Pellicon Holder

The Pellicon Process-scale Holder is a unique innovation for production scale Pellicon systems. This holder, vertically mounted, can hold up to 80 m^2/880 ft^2 of membrane area.

Benefits

- Extremely compact footprint
- Easy to change cassettes
- Easy to vent and fully drain
- Simple connections
- Up to 4 levels. Can be easily extended in levels for simple membrane area expansion
- Each level up to 20 m^2/220 ft^2
- Uses standard and Maxi Cassettes
- Can be adapted for series or parallel configurations
- Simplifies pipework connection
- Hydraulic closure systems are available for the stainless-steel Pellicon holder and the process-scale Pellicon holder. These systems are convenient, reliable and easy to use to enable rapid and repeatable loading operation and storage of Pellicon 2 cassettes.

Materials of Construction

Manifold segment, fitting blocks and end plate 316 L stainless steel; tie rods 304 and 304 L stainless steel.

Ordering Information

Pellicon 2 Filter Holders

Description	Catalogue No.
Pellicon 2 Mini filter holder	XX42 PMI NI
Pressure gauges One diaphragm-protected digital pressure gauge, 0 – 7 bar, ¾-inch fittings	XX42 PSG 01L
Pressure gauge adapters	XX42 PM0 01
Fitting kit Contains all tees, clamps, gaskets and a valve to connect tubing and pressure gauges to the Pellicon 2 Mini holder	XX42 PFK 01
Pellicon filter holder (for cassettes and Maxi filters)	XX42 P00 80
Pellicon 2 double thick gasket	PSSP 2XC 10
Pellicon Process-scale holder support and plate	XX42 SSP LT
Pellicon Process-scale holder	On request

To Place an Order or Receive Technical Assistance

For additional information call your nearest Millipore office:
In the U.S. and Canada,
call toll-free **1-800-MILLIPORE (1-800-645-5476)**
In the U.S., Canada and Puerto Rico, fax orders to **1-800-MILLIFX (1-800-645-5439)**
Outside of North America contact your local office. To find the office nearest you visit **www.millipore.com/offices.**
Internet: **www.millipore.com**
Technical Service:
www.millipore.com/techservice

MILLIPORE

A Typical Pellicon Production Processing System

Millipore supplies a range of standard and custom engineered systems. These systems can contain from 1 m^2/11 ft^2 to several hunded m^2 of membrane area, with Clean-in-Place (CIP) or Steam-in-Place (SIP) integrated as appropriate. Systems can also be supplied with integrated process vessels in manual or fully automatic versions.

All systems are designed, engineered and manufactured in ISO® 9001 registered facilities, and are supplied with extensive validation data support packages.

Please contact us to discuss your specific application and process requirements.

Pellicon XL Devices for Process Development

For process development of volumes from 50 mL to 1 liter, Millipore offers Pellicon XL devices. This small volume TFF filter is designed for true scalability by providing the same flow path, channel length, and channel height as the Pellicon 2 cassettes. Based on proven TFF membrane technology, Pellicon XL devices ensure reliable, consistent and predictable performance.

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AUTOJET® PRECISION SPRAY CONTROL SYSTEMS

FOR INDUSTRIAL COATING APPLICATIONS

Spraying Systems Co.®
Experts in Spray Technology

THE SECRET TO UNIFORM COATING: PRECISION SPRAY CONTROL

Applying coatings and release agents can be challenging. In order to achieve uniform coating, processors have often tolerated the waste of costly coatings, misting, excessive maintenance downtime, high scrap rates and more. Now there is a way to eliminate all those problems and apply the exact amount of coating required directly on the target – even when using high-viscosity coatings. AutoJet® Precision Spray Control Systems provide unmatched accuracy to ensure uniform coating with minimal waste.

In the pages that follow, you will learn more about how AutoJet Precision Spray Control Systems work and see how easy it is to configure a system to fit your exact requirements.






TABLE OF CONTENTS

IS YOUR COATING SPRAYABLE?

The answer to this question is, almost always, yes. We have a proven track record of using spray technology to apply just about every coating including viscous wax, oils, gels and more. The best way to determine if your coating is sprayable is with a proof-of-concept test in our spray laboratories.

Here's a partial list of coatings being successfully applied with spray technology:

- Adhesives/glue
- Alcohol (Zone 1 version only)
- Anti-foaming agents
- Ascorbic acid
- De-ionized water
- Detergents
- Dyes and inks
- Emulsions
- Enzymes
- Ethanol
- Fire retardant
- Fragrances/aromas
- Gels
- Lignin powder
- Lotions
- Lubricants/release agents/silicone
- MDI-based polyurethane
- Oils
- Resins
- Rust inhibitor
- Urea
- Wax

AUTOJET® PRECISION SPRAY CONTROL SYSTEMS OVERVIEW: SUPERIOR PERFORMANCE

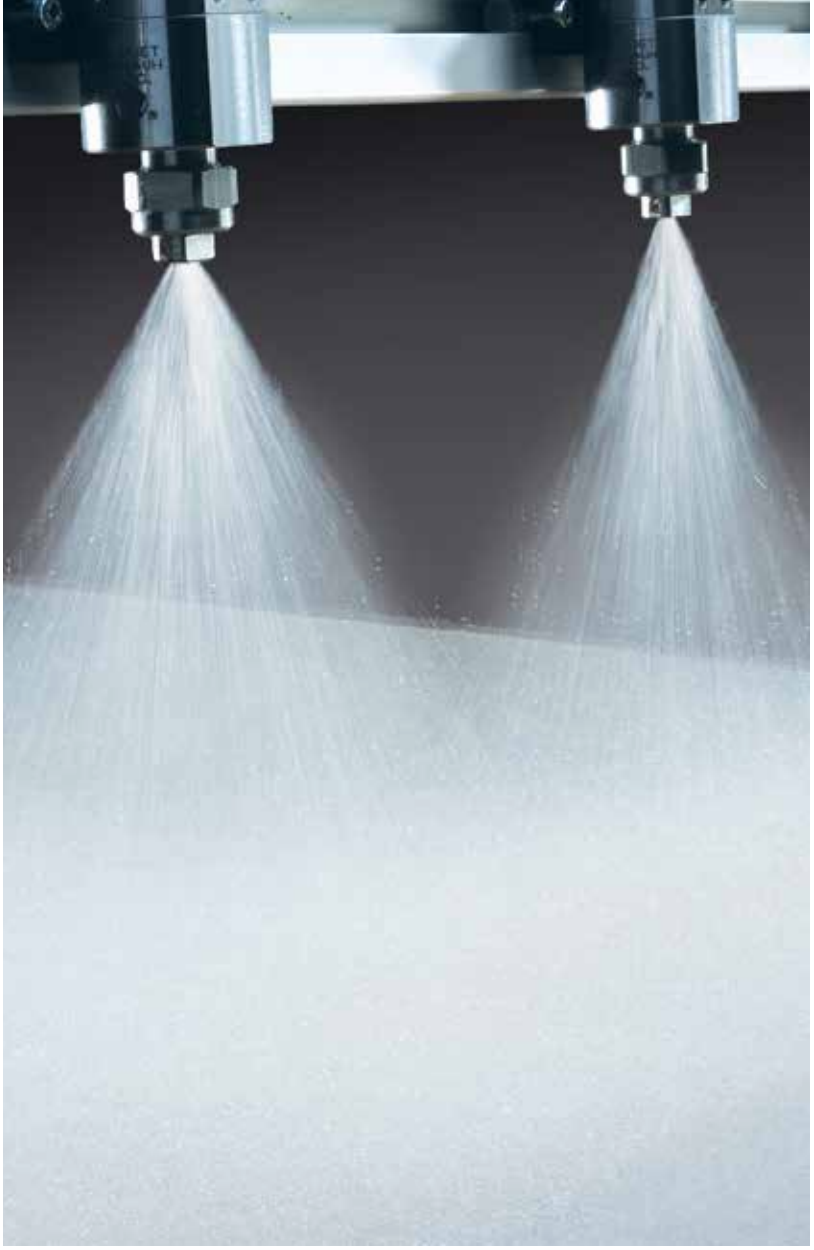
AutoJet® Precision Spray Control Systems consist of PulsaJet® automatic spray nozzles and an AutoJet spray controller. Many systems also include a spray manifold. These systems use Precision Spray Control (PSC) to ensure coatings are applied consistently, uniformly and with minimal waste even when conveyor line speed changes.

PSC uses an AutoJet spray controller to turn electrically-actuated PulsaJet nozzles on and off very quickly to control flow rate. The cycling is so fast that the flow often appears to be constant. Flow rate changes are based on line speed and occur almost instantaneously to ensure the proper application rate.

PSC also enables a single PulsaJet nozzle to produce a wide range of flow rates. Electrically-actuated hydraulic versions can achieve very low flow rates – comparable to the flow rates of air atomizing nozzles. Using hydraulic nozzles eliminates the need for costly compressed air and minimizes the misting and overspray problems often associated with air atomizing nozzles.

PSC BENEFITS:

- Reduces product scrap caused by over- or under-application of coatings
- Reduces the use of costly coatings by applying the proper coating volume directly on the target
- Increases production – fast cycling (up to 15,000 cycles per minute) of nozzles keeps pace with high line speeds



- Eliminates maintenance time to clean excess coating from equipment and/or floor due to over-application
- Improves worker safety by minimizing misting
- Eliminates the need for compressed air in some operations

SEE THE BENEFITS OF PSC:
spray.com/psc

HOW PRECISION SPRAY CONTROL WORKS

Electrically-actuated spray nozzles are turned on and off very quickly to control flow rate. This cycling is so fast that the flow often appears to be constant.

With traditional nozzles, flow rate adjustments require a change in pressure. Changing pressure also changes the nozzle's spray angle/coverage and drop size. With PSC, pressure remains constant enabling flow rate changes without changes in spray performance.

NOZZLES SPRAYING
90% OF THE TIME

NOZZLES SPRAYING
50% OF THE TIME

NOZZLES SPRAYING
25% OF THE TIME

UNMATCHED COATING SYSTEM VERSATILITY

PulsaJet® nozzles and an AutoJet® spray controller are required to achieve PSC. Many systems include a spray manifold as well to ensure proper fluid delivery to the nozzle. A wide range of nozzle, controller and manifold options are available so performance can be tailored to the specifics of the coating viscosity and desired level of automation.

Contact your local sales engineer for system selection assistance and a no-obligation demonstration.

PULSAJET NOZZLES:

- Available with a wide range of flow rates
- Recirculating and temperature control designs
- Hydraulic and air atomizing versions

SPRAY MANIFOLDS:

- **98250 spray manifold** for use with hydraulic PulsaJet spray nozzles
- **63600 heated and non-heated manifolds** for use with hydraulic and air atomizing PulsaJet nozzles
- **Heated manifolds** for use with temperature-controlled hydraulic PulsaJet nozzles
- **Recirculating manifolds** for use with heated fluids and hydraulic PulsaJet nozzles

SEE DETAILED SPECIFICATIONS ON PAGES 10-15

AUTOJET® SPRAY CONTROLLERS:

- **AutoJet Model 1550+ Modular Spray System** with basic on/off spray control for up to eight PulsaJet® nozzles
- **AutoJet Model 2008+ Spray Control Panel** provides timing and sensor control for up to 16 PulsaJet nozzles
- **AutoJet Model 2250+ Spray Control Panel** with sophisticated real-time monitoring and closed-loop control for up to 16 PulsaJet nozzles

AUTOJET PRECISION SPRAY CONTROL SYSTEMS: IDEAL FOR A WIDE RANGE OF COATING, MOISTENING AND LUBRICATING APPLICATIONS

Here are just a few examples of how others are using our systems:

- Coating wood chips with resin in the production of engineered wood panels
- Coating flat glass with zinc citrate on float line to prevent corrosion
- Coating aluminum or steel strips with oil to prevent corrosion
- Spraying de-dusting oil to prevent fibers from becoming airborne in the production of fiberglass insulation
- Applying release agent to prevent concrete building materials from sticking to molds
- Spraying wax in wood chip blender in MDF production
- Adding moisture to panel boards before pressing
- Applying adhesive for tail tie of tissue rolls
- Spray nonskid coating to packaging materials to prevent movement during shipping
- Spraying fire retardants on textiles
- Applying release agents mats, cauls and press belts in board production
- Spraying lubricants on metal sheets before stamping
- Adding fragrance to kitty litter
- Spraying release agent onto metal belts to prevent plastic pellets from sticking
- Applying moisture to textiles to properly control dyeing and finishing operations

ACHIEVING RESULTS WITH AUTOJET® PRECISION SPRAY CONTROL SYSTEMS

80,000 POUNDS OF MONTHLY REWORK ELIMINATED WITH NEW SPRAY SYSTEM

Problem: An aluminum producer was using flat spray nozzles mounted on a header to apply oil to strip to facilitate forming and help prevent corrosion. The nozzles sprayed the same amount of oil continuously. Changes in line speed resulted in over- and under-application problems. Coil rejection rates were high.

Solution: Oil coverage on the strip is now uniform and waste has been eliminated since the installation of the AutoJet® system. Precision Spray Control ensures the proper application rate based on line speed variations from 300 to 1200 ft/min (91 to 366 m/min). In addition, the system uses zone control to turn nozzles off when narrower strip widths are run to prevent oil waste.

RESULTS:

System payback: four months

Coil reject rate due to uneven oil application: 0%

Decreased oil consumption: 40%

Reduced maintenance time: workers no longer clean excess oil from equipment and floor

NEW SPRAY SYSTEM HELPS REDUCE SCRAP BY 75%

Problem: A glass manufacturer needed to apply a thin coating of zinc citrate on flat glass while it was on the float line. The coating protects the glass from corrosion and discoloration. The current system didn't apply the coating uniformly and required excessive maintenance. Product quality suffered.

Solution: An AutoJet Precision Spray Control system now provides a uniform coating of the zinc citrate solution even when line speed changes. The hydraulic nozzles can be activated individually to accommodate different ribbon widths. In addition, the nozzles are mounted on a frame which can be easily rolled away from the production line for quick maintenance.

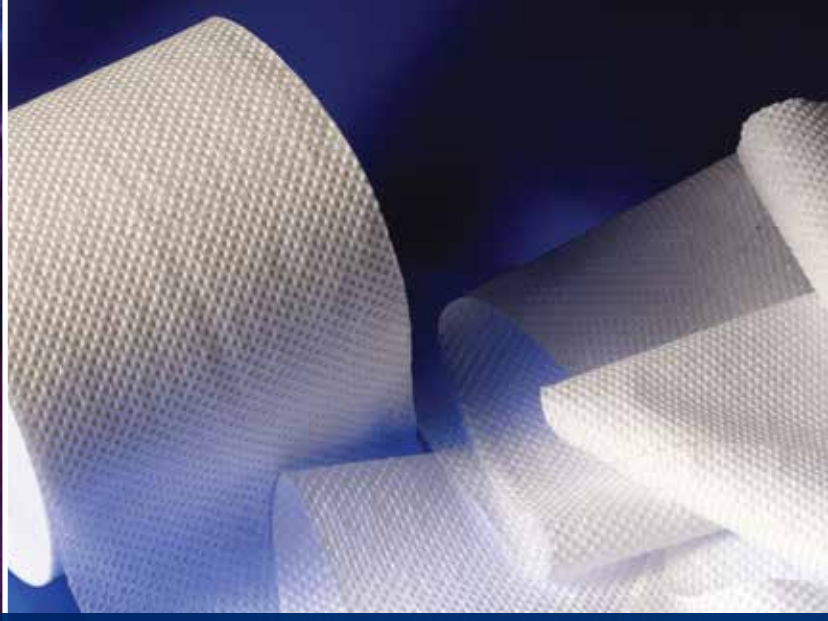
RESULTS:

System payback: less than one month

Scrap reduction: 75%

Decreased use of zinc citrate solution: 60%

Maintenance time decrease: one hour daily to 3 hours per month



SEE MORE DETAILS ON THESE &
DOZENS MORE RESULTS STORIES AT
spray.com/results

AUTOMATED SPRAY SYSTEM LOWERS OPERATING COSTS AND IMPROVES PRODUCT QUALITY

Problem: A manufacturer of high-quality, custom-dyed textiles needed to control the amount of moisture in the fabric to ensure proper dyeing and finishing. Spinning discs were being used to apply water, but the droplet size and coverage were inconsistent. In addition, frequent disc breakdowns caused excessive downtime and reduced production time.

Solution: An AutoJet Precision Spray Control System applies the required volume of water to maintain the desired 12% moisture content. Flow rate is automatically adjusted by the system based on line speed that varies up to 20%. Coverage is uniform across the entire width of the fabric.

RESULTS:

System payback: less than 11 months

Quality: improved, enabling a price increase

Decreased maintenance downtime: reduced significantly

Annual savings: US$19,000

TISSUE PRODUCT MANUFACTURER REDUCES OPERATING EXPENSES AND REDUCES WASTE STREAM

Problem: A commercial tissue manufacturer wound toilet tissue around a cardboard tube. Plastic end caps were inserted into individual rolls after they were cut from the long tissue "log" into individual rolls. The core tubes and caps were costly and ultimately discarded after the tissue roll was used, creating unnecessary waste.

Solution: An AutoJet® Model 1550+ Modular Spray System applies a light mist onto tissue as it is wound directly onto a thin metal rod. PulsaJet® nozzles are triggered by the winding machine and spray just long enough to ensure the tissue sticks to the metal rod. After the tissue roll is fully formed, the metal rod is pushed out of the roll, leaving only tissue product. Cardboard tubes and plastic end caps are no longer used.

RESULTS:

System payback: less than seven months

Sustainable product: cardboard core tubes and plastic end caps have been eliminated from the waste system

AUTOJET® SPRAY CONTROLLERS

System control options range from simple to sophisticated and offer Precision Spray Control. Choose the level of automation best suited to your operation.

AUTOJET MODEL 1550+ MODULAR SPRAY SYSTEM: BASIC CONTROL

- Automatic on/off control of up to eight PulsaJet® nozzles
- Self-contained unit – set-up takes minutes
- Wetted parts available with food contact materials of construction
- Equipped with a pump, a pressure pot or without any integrated liquid supply
- Touch screen HMI with diagnostic screens for easy user control and troubleshooting
- Precision Spray Control ensures uniform coverage and accurate flow rate adjustments based on line speed
- Easily configured spray timing control for accurate placement of sprayed liquid to help ensure product quality and minimize waste

AUTOJET® MODEL 2008+ SPRAY CONTROL PANEL: INTERMEDIATE CONTROL

- Automatic control of up to 16 PulsaJet® nozzles
- Cycles PulsaJet nozzles up to 50% faster to ensure uniform coverage of conveyors and moving objects at even faster line speeds
- Operates PulsaJet nozzles at up to 250% higher pressure to spray higher viscosity coatings
- Distance-based timing control ensures more accurate placement of intermittent sprays at variable line speeds
- Wide range of input and output signals to allow use of a variety of sensors, including trigger sensors, line speed sensors, pressure transducers and more
- Optional zone control to turn individual nozzles in a manifold on/off
- Precision Spray Control ensures uniform coverage and accurate flow rate adjustments based on line speed
- Integrates easily with other plant control systems
- Available with food contact materials of construction
- Touch screen HMI with diagnostic screens for easy user control and troubleshooting

AUTOJET MODEL 2250+ SPRAY CONTROL PANEL: ADVANCED SPRAY CONTROL

- Automatic control of up to 16 PulsaJet nozzles
- Real-time monitoring and closed-loop control of spray pressure and flow control
- Optional second channel provides independent control for a second spray manifold or a second production line
- Cycles PulsaJet nozzles up to 50% faster to ensure uniform coverage of conveyors and moving objects at even faster line speeds
- Operates PulsaJet nozzles at up to 250% higher pressure to spray higher viscosity coatings
- Precision Spray Control ensures uniform coverage and accurate flow rate adjustments based on line speed
- Integrates easily with other plant control systems
- Available with food contact materials of construction
- Touch screen HMI with diagnostic screens for easy user control and troubleshooting

APPLICATION-SPECIFIC AUTOJET SYSTEMS

Standard AutoJet Systems are also available for specific coating applications. **Ask your sales engineer for additional information.**

- AutoJet Lubrication Systems
- PanelSpray® Systems
- AccuOil™ Systems

PULSAJET® AUTOMATIC SPRAY NOZZLES

PulsaJet® automatic spray nozzles are constructed of stainless steel, PPS, PEEK™ and EPDM or Viton® seals for maximum chemical resistance. PulsaJet nozzles are also available for spraying alcohol in Zone 1 hazardous locations. Certified by FM approvals, these nozzles are constructed of stainless steel, PPS, PEEK™ and have FFKM seals.

The compact design and simple mounting options for PulsaJet nozzles enable them to be easily integrated into most production areas. Wear parts for all PulsaJet nozzles are easily accessible to minimize routine maintenance time.

PulsaJet nozzles are available in a wide variety of configurations, including:

- Hydraulic or air atomized sprays
- Auto-alignment of flat spray tips
- Recirculation of sprayed liquid
- Temperature control to enable spraying of heated viscous liquids
- Special coatings for improved corrosion resistance
- Special construction for enhanced moisture protection

Precise liquid distribution for all PulsaJet automatic spray nozzles is provided using UniJet® spray tips. Standard UniJet tips are available in 303 or 316 stainless steel and offer a wide range of flow rates and spray angles.

Premium UniJet PWMD and PWMM spray tips offer improved spray uniformity for critical coating applications. The tapered edges ensure even coverage when overlapping sprays are required and the low volume behind the spray orifice results in improved spray distribution. UniJet PWMD and PWMM tips are available in 303 stainless steel and offer a wide range of flow rates.

MODELS
AA10000AUH-03
AA10000AUH-03-QC

Liquid inlet connection	1/8" NPT or BSPT
Minimum flow rate at 40 psi (2.8 bar) and 10% duty cycle	.0017 gpm (0.006 lpm)
Maximum flow rate at 100 psi (7 bar) and 100% duty cycle	0.47 gpm (1.8 lpm)
Maximum rated pressure	100 psi (7 bar) (250 psi with 2008+ controller)
Maximum liquid temperature	200°F (93°C)
Power	24VDC, 0.36 amp
Maximum operating speed	10,000 cpm (15,000 cpm with Model 2008+ controller)

Model -03 accepts UniJet® TPU spray tips.*

Model -03-QC accepts QuickJet® QSVV quick-connect spray tips.*

Construction: Stainless steel, Viton® or EPDM seals, PPS and PEEK™.

MODEL
AA10000AUH-03-Z1

Liquid inlet connection	1/8" NPT or BSPT
Minimum flow rate at 40 psi (2.8 bar) and 10% duty cycle	.0017 gpm (0.006 lpm)
Maximum flow rate at 100 psi (7 bar) and 100% duty cycle	0.47 gpm (1.8 lpm)
Maximum rated pressure	100 psi (7 bar)
Maximum liquid temperature	104°F (40°C)
Power	24 VDC, 0.36 amp
Maximum operating speed	10,000 cpm

Accepts UniJet TPU tips.*

Used in Zone 1 hazardous areas.

Construction: Stainless steel, FFKM seals, PPS and PEEK.

*More information: *Industrial Spray Products Catalog* 75-HYD, pages C24-C31.
**More information: Data Sheet, PWMD UniJet® Tips.

MODEL
AA10000AUH-10

Liquid inlet connection	1/8" NPT or BSPT
Minimum flow rate at 40 psi (2.8 bar) and 20% duty cycle	.02 gpm (0.075 lpm)
Maximum flow rate at 100 psi (7 bar) and 100% duty cycle	1.6 gpm (6.1 lpm)
Maximum rated pressure	100 psi (7 bar)
Maximum liquid temperature	150°F (65°C)
Power	24VDC, 1.05 amp
Maximum operating speed	5,000 cpm

Accepts UniJet TPU tips.*

Construction: Stainless steel, Viton® or EPDM seals, PPS and PEEK.

MODELS
AA10000AUH-104210
AA10000AUH-104214
AA10000AUH-104215

Liquid inlet connection	1/8" NPT or BSPT
Minimum flow rate at 40 psi (2.8 bar) and 10% duty cycle	.0017 gpm (0.006 lpm)
Maximum flow rate at 100 psi (7 bar) and 100% duty cycle	0.47 gpm (1.8 lpm)
Maximum rated pressure	100 psi (7 bar) (250 psi with 2008+ controller)
Maximum liquid temperature	200°F (93°C)
Power	24VDC, 0.36 amp
Maximum operating speed	10,000 cpm (15,000 cpm with Model 2008+ controller)

All three models accept Premium UniJet PWMD spray tips with 5° offset for auto spray pattern alignment.**

Model 104210 – Rear liquid inlet

Model 104214 – Side liquid inlet for low profile mounting

Model 105215 – Rear liquid inlet with front port for liquid recirculation

Construction: Stainless steel, Viton® or EPDM seals, PPS and PEEK.

MODEL AA10000AUH-72440-1/4

Liquid inlet connection	1/4" NPT or BSPT
Minimum flow rate at 40 psi (2.8 bar) and 10% duty cycle	.0017 gpm (0.006 lpm)
Maximum flow rate at 100 psi (7 bar) and 100% duty cycle	0.47 gpm (1.8 lpm)
Maximum rated pressure	100 psi (7 bar) (250 psi with 2008+ controller)
Maximum liquid temperature	150°F (65°C)
Power	24VDC, 0.36 amp
Maximum operating speed	10,000 cpm (15,000 cpm with Model 2008+ controller)

Accepts Standard UniJet® tips. Jacketed design keeps unit at consistent temperature.*

Construction: Electropolished or Chromium Nitride coated magnetic SS, Stainless steel, Viton® or EPDM seals, PPS and PEEK.

MODEL AA10000AUH-0050

Liquid inlet connection	5/32" (4mm) tube fittings
Minimum flow rate at 40 psi (2.8 bar) and 5% duty cycle	.0009 gpm (0.003 lpm)
Maximum flow rate at 100 psi (7 bar) and 100% duty cycle	0.080 gpm (0.303 lpm)
Maximum rated pressure	200 psi (14 bar)
Maximum liquid temperature	150°F (65°C)
Power	48VDC, 1.0 amp
Maximum operating speed	25,000 cpm (sold only with Model 2008+ controller)

Accepts Premium UniJet PWMM spray tips with 5° offset for auto spray pattern alignment.***

Construction: Stainless steel, Viton® or EPDM seals, PPS and PEEK.

For dosing applications, spray time as low as 1 ms can be achieved.

Available only as part of the PuslaJet Mini Low Flow Spray System.

MODEL AA10000JJAU

Liquid inlet connection	1/8" NPT or BSPT
Minimum flow rate at 5 psi (0.34 bar) and 10% duty cycle (1650 Fluid Cap)	0.0017 gpm (0.0064 lpm)
Maximum flow rate at 40 psi (2.8 bar) and 100% duty cycle (2850 Fluid Cap)	0.14 gpm (0.53 lpm)
Maximum rated pressure	100 psi (7 bar) (250 psi with 2008+ controller)
Maximum liquid temperature	200°F (93°C)
Power	24VDC, 0.36 amp
Maximum operating speed	10,000 cpm (15,000 cpm with Model 2008+ controller)

Accepts standard JJ air atomizing setups.****

Specify appropriate retainer cap when ordering.

Construction: Stainless steel, Viton® or EPDM seals, PPS and PEEK.

MODEL AA10000JAU-10

Liquid inlet connection	1/4" NPT or BSPT
Minimum flow rate at 5 psi (0.34 bar) and 20% duty cycle (2050 Fluid Cap)	0.0027 gpm (0.010 lpm)
Maximum flow rate at 20 psi (1.4 bar) and 100% duty cycle (80150 Fluid Cap)	.75 gpm (2.84 lpm)
Maximum rated pressure	100 psi (7 bar)
Maximum liquid temperature	200°F (93°C)
Power	24VDC, 1.05 amp
Maximum operating speed	5,000 cpm

Accepts standard J air atomizing setups.****

Construction: Stainless steel, Viton® or EPDM seals, PPS and PEEK.

*More information: *Industrial Spray Products Catalog* 75-HYD, pages C24-C31

**More information: Data Sheet, PWMD UniJet® Tips

***More information: *PuslaJet Mini Low Flow Spray System*, Bulletin 705

****More information: *Air Atomizing and Automatic Spray Nozzles Catalog* 75AA-AUTO, pages B24-B31

SPRAY MANIFOLDS

98250 HYDRAULIC PULSAJET® SPRAY MANIFOLD

- Use with PulsaJet hydraulic spray nozzles
- User specified lengths, number of nozzles and nozzle spacing
- User-adjustable nozzle spacing
- Dual inlet ports for liquid recirculation
- Aluminum construction
- IP64 wiring configuration available for single channel or independent banking of nozzles

63600 HYDRAULIC SANITARY JACKETED PULSAJET MANIFOLD

- Heated or non-heated operation
- Hot water jacket can be used as a cooling jacket
- Housing and all internal liquid and conduit lines are 316L stainless steel construction

63600 AIR ATOMIZING SANITARY JACKETED PULSAJET MANIFOLD

- Heated or non-heated operation
- Hot water jacket can be used as a cooling jacket
- Housing and all internal liquid and conduit lines are 316L stainless steel construction

HELPFUL RESOURCES

AutoJet® Model 1550+ Modular Spray Systems	**Bulletin 626**
PanelSpray® Systems	**Bulletin 632**
AutoJet® Lubrication Systems	**Bulletin 685**
Industrial Hydraulic Spray Products	**Catalog 75**
Industrial Hydraulic Spray Products	**Metric Catalog 75M**
Air Atomizing & Automatic Spray Nozzles	**Catalog 75**
Air Atomizing & Automatic Spray Nozzles	**Metric Catalog 75M**

Spraying Systems Co.®
Experts in Spray Technology

North Avenue and Schmale Road, P.O. Box 7900, Wheaton, IL 60187-7901 USA

Tel: 1.800.95.SPRAY Intl. Tel: 1.630.665.5000
Fax: 1.888.95.SPRAY Intl. Fax: 1.630.260.0842

www.spray.com

ISO 9001:2008 14001:2004 CERTIFIED

Stainless Supply

METAL PROCESSING & DISTRIBUTION

Stainless Steel

304 Sheet

316L Sheet

430 Sheet

304 Plate

316L Plate

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Stainless Steel

Stainless Supply
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Selection Guide

Stainless Steel

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Alloy **Description**	**Available Finishes**	**Pg#**
304 The most widely used of the stainless and heat resisting steels. It is essentially non-magnetic when annealed, and can become slightly magnetic when cold worked. This product has a good resistance to many chemical corrodents as well as industrial atmospheres.	#1 #4 2b #8 BA	 5 7 6 6
316L Has better corrosion and pitting resistance as well as a higher strength at elevated temperatures than Type 304. A low-carbon, austenitic chromium-nickel-molybdenum stainless steel with general corrosion resistance similar to Type 316, but with superior resistance to intergranular corrosion following welding or stress relieving.	#1 #4 2b #8	 8 9 7
430 Is very popular of the non-hardenable chromium stainless steels. Oxidation resistance to 1500°F widely used in both industrial and consumer products.	#4 #8 BA	10 11 11

Finish Description

Stainless Steel

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#1 Finish Finish is produced by rolling stainless steel that has been heated prior to rolling (hot-rolling). This is followed by a heat treatment that produces a uniform microstructure (annealing) and ensures that the stainless steel will meet mechanical property requirements. After these processing steps, the surface has a dark non-uniform appearance called “scale”. Surface chromium has been lost during the previous processing steps, and, without removal of the scale, the stainless steel would not provide the expected level of corrosion resistance. Chemical removal of this scale is called pickling or descaling, and it is the final processing step. A No. 1 finish has rough, dull, and non-uniform appearance. There may be shiny spots were surface imperfections were removed by grinding. It is generally used in industrial applications, such as equipment for elevated temperature service.

#4 Finish is characterized by short, parallel polishing lines, which extend uniformly along the length of the coil. Depending on the requirements of the application, the typical final finish is normally between 120 and 150 gri

#2b Finish iis a cold rolled finish. This produces a more reflective finish that resembles a cloudy mirror. Finish reflectivity can vary from manufacturer-to-manufacturer and normally is fairly dull. No. 2B is a general purpose cold rolled finish commonly used for all but exceptionally difficult deep drawing applications.

#8 Finish is the most reflective polished finish that is covered by the ASTM standards. It is produced by being heavily buffed. The resulting finish is mirror-like.

Bright Annealed (BA) is produced by heat-treating (annealing) in a controlled atmosphere furnace. It has a mirror like appearance but may have some cloudiness and other imperfections.

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Stainless Steel Sheet

304

Stainless Steel Sheet | #4 Finish

Gauge	Width X Length	Thickness
26	48 x 120	.0178″
	48 x 96	
	48 x 48	
	48 x 24	
24	48 x 120	.0235″
	48 x 96	
	48 x 48	
	48 x 24	
22	48 x 120	.0293″
	48 x 96	
	48 x 48	
	48 x 24	
20	48 x 120	.0355″
	48 x 96	
	48 x 48	
	48 x 24	
18	48 x 120	.0480″
	48 x 96	
	48 x 48	
	48 x 24	
16	48 x 120	.0595″
	48 x 96	
	48 x 48	
	48 x 24	
14	48 x 120	.0751″
	48 x 96	
	48 x 48	
	48 x 24	
12	48 x 120	.1054″
	48 x 96	
	48 x 48	
	48 x 24	
11	48 x 120	.1200″
	48 x 96	
	48 x 48	
	48 x 24	
10	48 x 120	.1350″
	48 x 96	
	48 x 48	
	48 x 24	

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304

Stainless Steel Sheet | #8 Mirror

Stainless Supply
METAL PROCESSING & DISTRIBUTION

Gauge	Width X Length	Thickness
26	48 x 120	.0178”
	48 x 96	
	48 x 48	
	48 x 24	
24	48 x 120	.0235”
	48 x 96	
	48 x 48	
	48 x 24	
22	48 x 120	.0293”
	48 x 96	
	48 x 48	
	48 x 24	
20	48 x 120	.0355”
	48 x 96	
	48 x 48	
	48 x 24	
18	48 x 120	.0480”
	48 x 96	
	48 x 48	
	48 x 24	
16	48 x 120	.0595”
	48 x 96	
	48 x 48	
	48 x 24	
14	48 x 120	.0751”
	48 x 96	
	48 x 48	
	48 x 24	
11	48 x 120	.1200”
	48 x 96	
	48 x 48	
	48 x 24	

304

Stainless Steel Sheet | BA (Bright Annealed)

Gauge	Width X Length	Thickness
26	48 x 120	.0178”
	48 x 96	
	48 x 48	
	48 x 24	
24	48 x 120	.0235”
	48 x 96	
	48 x 48	
	48 x 24	
22	48 x 120	.0293”
	48 x 96	
	48 x 48	
	48 x 24	
18	48 x 120	.0480”
	48 x 96	
	48 x 48	
	48 x 24	

304

Stainless Supply
METAL PROCESSING & DISTRIBUTION

Stainless Steel Sheet | 2b Finish

Gauge	Width X Length	Thickness
26	48 x 120	.0178″
	48 x 96	
	48 x 48	
	48 x 24	
24	48 x 120	.0235″
	48 x 96	
	48 x 48	
	48 x 24	
22	48 x 120	.0293″
	48 x 96	
	48 x 48	
	48 x 24	
20	48 x 120	.0355″
	48 x 96	
	48 x 48	
	48 x 24	
18	48 x 120	.0480″
	48 x 96	
	48 x 48	
	48 x 24	
16	48 x 120	.0595″
	48 x 96	
	48 x 48	
	48 x 24	
14	48 x 120	.0751″
	48 x 96	
	48 x 48	
	48 x 24	
12	48 x 120	.1054″
	48 x 96	
	48 x 48	
	48 x 24	
11	48 x 120	.1200″
	48 x 96	
	48 x 48	
	48 x 24	
10	48 x 120	.1350″
	48 x 96	
	48 x 48	
	48 x 24	

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316L

Stainless Supply
METAL PROCESSING & DISTRIBUTION

Stainless Steel Sheet | #4 Finish

Gauge	Width X Length	Thickness
24	48 x 120	.0235”
	48 x 96	
	48 x 48	
	48 x 24	
22	48 x 120	.0293”
	48 x 96	
	48 x 48	
	48 x 24	
18	48 x 120	.0480”
	48 x 96	
	48 x 48	
	48 x 24	
16	48 x 120	.0595”
	48 x 96	
	48 x 48	
	48 x 24	
14	48 x 120	.0751”
	48 x 96	
	48 x 48	
	48 x 24	
11	48 x 120	.1200”
	48 x 96	
	48 x 48	
	48 x 24	

316L

Stainless Steel Sheet | #8 Mirror

Gauge	Width X Length	Thickness
24	48 x 120	.0235”
	48 x 96	
	48 x 48	
	48 x 24	
22	48 x 120	.0293”
	48 x 96	
	48 x 48	
	48 x 24	
18	48 x 120	.0480”
	48 x 96	
	48 x 48	
	48 x 24	
16	48 x 120	.0595”
	48 x 96	
	48 x 48	
	48 x 24	
14	48 x 120	.0751”
	48 x 96	
	48 x 48	
	48 x 24	

316L

Stainless Supply
METAL PROCESSING & DISTRIBUTION

Stainless Steel Sheet | 2b Finish

Gauge	Width X Length	Thickness
24	48 x 120	.0235”
	48 x 96	
	48 x 48	
	48 x 24	
22	48 x 120	.0293”
	48 x 96	
	48 x 48	
	48 x 24	
20	48 x 120	.0355”
	48 x 96	
	48 x 48	
	48 x 24	
18	48 x 120	.0480”
	48 x 96	
	48 x 48	
	48 x 24	
16	48 x 120	.0595”
	48 x 96	
	48 x 48	
	48 x 24	
14	48 x 120	.0751”
	48 x 96	
	48 x 48	
	48 x 24	
12	48 x 120	.1054”
	48 x 96	
	48 x 48	
	48 x 24	
11	48 x 120	.1200”
	48 x 96	
	48 x 48	
	48 x 24	

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430

Stainless Supply
METAL PROCESSING & DISTRIBUTION

Stainless Steel Sheet | #4 Finish

Gauge	Width X Length	Thickness
26	48 x 120	.0178”
	48 x 96	
	48 x 48	
	48 x 24	
24	48 x 120	.0235”
	48 x 96	
	48 x 48	
	48 x 24	
22	48 x 120	.0293”
	48 x 96	
	48 x 48	
	48 x 24	
20	48 x 120	.0355”
	48 x 96	
	48 x 48	
	48 x 24	
18	48 x 120	.0480”
	48 x 96	
	48 x 48	
	48 x 24	
16	48 x 120	.0595”
	48 x 96	
	48 x 48	
	48 x 24	

430

Stainless Supply
METAL PROCESSING & DISTRIBUTION

Stainless Steel Sheet | #8 Mirror

Gauge	Width X Length	Thickness
26	48 x 120	.0178”
	48 x 96	
	48 x 48	
	48 x 24	
24	48 x 120	.0235”
	48 x 96	
	48 x 48	
	48 x 24	
22	48 x 120	.0293”
	48 x 96	
	48 x 48	
	48 x 24	
18	48 x 120	.0480”
	48 x 96	
	48 x 48	
	48 x 24	
16	48 x 120	.0595”
	48 x 96	
	48 x 48	
	48 x 24	
14	48 x 120	.0751”
	48 x 96	
	48 x 48	
	48 x 24	

430

Stainless Steel Sheet | BA (Bright Annealed)

Gauge	Width X Length	Thickness
26	48 x 120	.0178”
	48 x 96	
	48 x 48	
	48 x 24	
24	48 x 120	.0235”
	48 x 96	
	48 x 48	
	48 x 24	
22	48 x 120	.0293”
	48 x 96	
	48 x 48	
	48 x 24	
18	48 x 120	.0480”
	48 x 96	
	48 x 48	
	48 x 24	

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Stainless Supply
METAL PROCESSING & DISTRIBUTION

Stainless Steel Plate

304

Stainless Steel Plate

Gauge	Width X Length	Thickness
3/16”	48 x 96	.1875”
	48 x 120	
1/4”	48 x 96	.25”
	48 x 120	
5/16	48 x 96	.3125”
	48 x 120	
3/8”	48 x 96	.375”
	48 x 120	
1/2”	48 x 96	.5”
	48 x 120	

304

Stainless Steel Diamond Floor Plate

Gauge	Width X Length	Thickness
1/8”	48 x 96	.125”
	48 x 120	
3/16”	48 x 96	.1875”
	48 x 120	
1/4”	48 x 96	.25”
	48 x 120	

Stainless Supply
METAL PROCESSING & DISTRIBUTION

316L

Stainless Steel Plate

Gauge	Width X Length	Thickness
3/16”	48 x 96	.1875”
	48 x 120	
1/4”	48 x 96	.25”
	48 x 120	
5/16	48 x 96	.3125”
	48 x 120	
3/8”	48 x 96	.375”
	48 x 120	
1/2”	48 x 96	.5”
	48 x 120	

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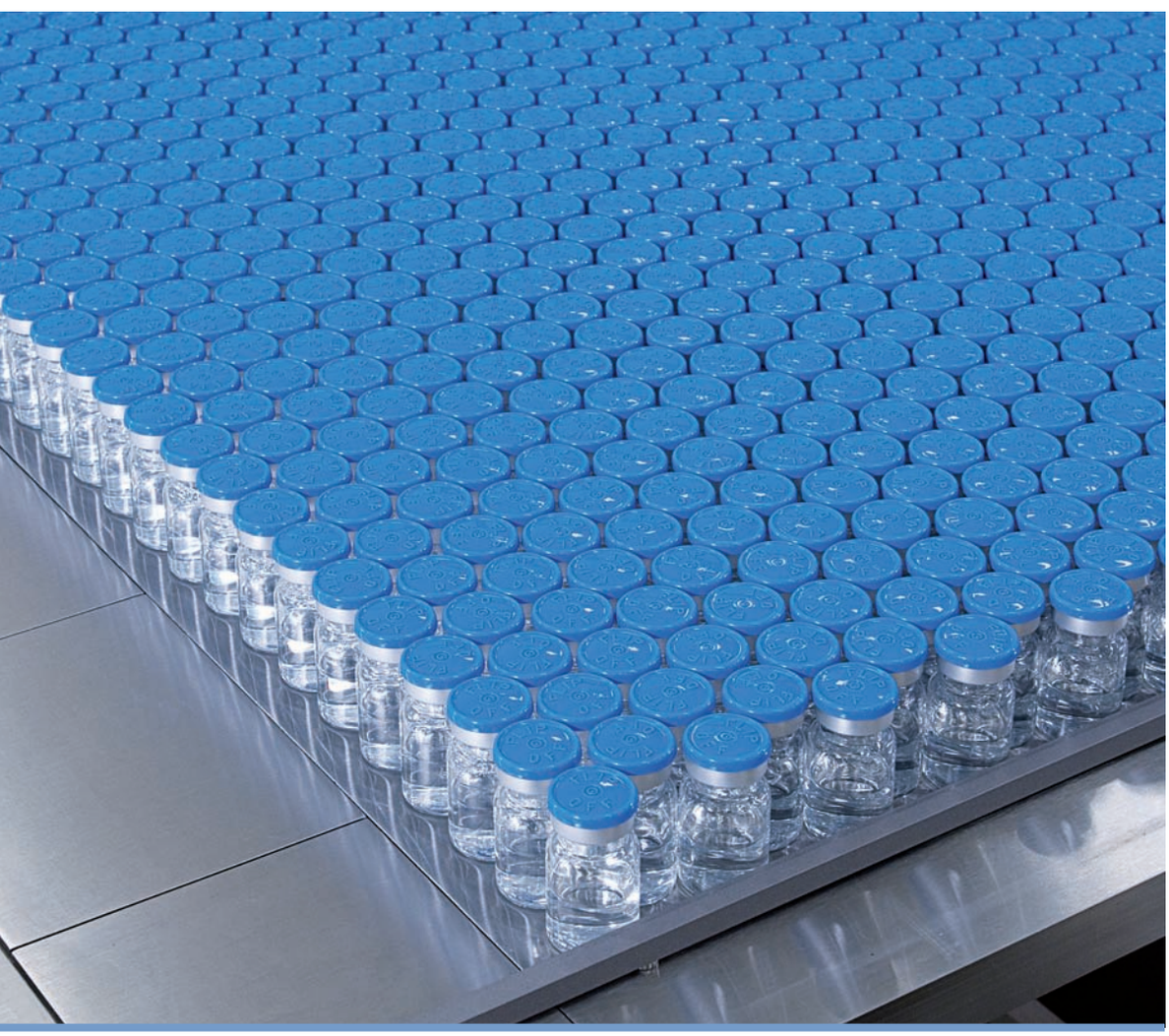
SMART LYO®



the SMART way to make Freeze Drying affordable

GEA Pharma Systems

GEA Pharma Systems supplies advanced technologies for the processing of Active Pharmaceutical Ingredients (API) for the production of oral and parenteral dosage forms.

GEA Pharma Systems strives for ***Price/Performance Leadership*** providing its customers with highly cost-effective, integrated systems for the pharmaceutical industry. GEA Pharma Systems is dedicated to innovation and thereby providing durable quality through its well-established brands: **Aeromatic-Fielder™** and **Collette™** - batch and continuous granulation, drying, pelletizing and coating; **Buck®** - contained materials handling; **Courtoy™** - tablet compression; and **Lyophil™** - pharmaceutical freeze drying and automated vial handling systems.

GEA Pharma Systems' activities include partnering with customers to develop new products and enhance clinical effectiveness; the supply of R&D-scale and stand-alone production equipment; and the installation of complete integrated production lines.

Financial Strength with GEA Group

As an internationally operating technology group the company focuses on process technology and components for demanding production processes in various end markets. GEA Group is a market and technology leader in 90% of its business areas. It has a workforce of over 20,000 serving customers in 50 countries.

GEA Lyophil

For more than half a century GEA Lyophil has designed and manufactured freeze dryers for the pharmaceutical and biotech industry.

Leader in Technology

GEA Lyophil supplies a comprehensive range of products and services, comprising laboratory freeze dryers, both pilot scale for R&D and small production batches; industrial freeze dryers; and complete freeze dryer systems. These include Automatic Loading and Unloading Systems (ALUS®);integrated isolators; and CIP-Skids in a complete system with freeze dryer.

- 55 years of experience in lyophilization development, engineering and manufacturing;
- More than 1000 freeze dryers and automated (un)loading systems in production globally;
- Proven reliability for shelf, chamber, slot door and condenser design;
- Innovative technology to avoid sticking stoppers and to minimise footprint and energy usage;
- Innovators of H_2O_2 sterilisation technology to save cost and cycle times;
- Customer base includes major Pharma companies, Contract Manufacturing Organisations, and Generics manufacturers, demonstrating operational reliability and quality of components and reputation.

In-depth Technical Understanding

GEA Lyophil uses its proven technology to provide either **standard** or **customised** solutions.
Capacities range from R&D, to stand-alone production plants, to high-capacity systems for bulk APIs, blood plasma, vaccines, hormones, antibiotics/anti-infectives, bacteria, sera, enzymes and diagnostic agents.
Plant configuration extends from specialised solutions for highly potent products to two-storey units and fully integrated systems with multiple freeze dryers and loading systems, with or without the integration of your chosen filling system supplier.

SMART LYO®

SMART LYO® is a new range of competitively-priced pharmaceutical freeze dryers with advanced technology from GEA Lyophil – a world leader in freeze drying technology.

Standardised & Customised - SMART LYO® pharmaceutical freeze dryers are designed from proven standardised modules of the required size to create a plant customised specifically for the needs of each customer. By standardising the technology SMART LYO® reduces costs; makes planning, validation and documentation easier; and significantly reduces delivery times. With SMART LYO® there's no need for compromise: every customer receives exactly the plant they need, when they need it, to suit their existing facilities and production requirements.

Made in Germany - German engineering and project control in balance with GEA controlled supply chains make the SMART LYO® freeze dryer a top quality product*. GEA Lyophil's committed team of engineers and specialists all work to ensure that Lyophil freeze dryers are of a consistently high quality. It is this quality that creates reliable, trouble-free pharmaceutical production and whole life economy.

* Quality Management System certified to ISO 9001 since 1997.

German engineering and project control

Affordable - Standardised modules are cost efficient to produce and are more reliable than bespoke systems meaning lower purchase and maintenance costs for the customer. Using prefabricated units also reduces delivery times and validation periods giving customers a clear commercial advantage by allowing products to be launched and brought to market more quickly.

Reliable - GEA Lyophil has been providing a trusted service and reliable products, configured to minimise production batch loss for more than 50 years. SMART LYO® freeze dryers are no exception. The modules themselves have been tested extensively. They, together with proven process technology and the specialist knowledge of the GEA Lyophil team, guarantee trouble-free operation for smooth production and minimum downtime. Should a problem occur, the Global Service Network is ready to spring into action immediately by dispatching spare parts or a service engineer to assist staff.

Technology - SMART LYO® freeze dryers use only proven technology and can be supplied with filling systems, isolators and full inspection services to provide a completely integrated production facility from a single supplier. Each component meets the highest possible technical requirements and the strict standards of the global licensing authorities as well as complying with all the current guidelines such as GAMP, cGMP, FDA, etc.

SMART LYO® freeze dryers are available in shelf sizes of 0.57 m² up to 20 m² with a condenser capacity of up to 400kg.

Options

Smart Features:

- The entire system is constructed on a single-floor plant frame for fast, simple commissioning. The system includes: the compact chamber/condenser unit, all system modules (hydraulics, venting system, vacuum) and available options such as CIP and SIP.
- It is possible for the refrigeration unit to be installed remotely from the plant frame, even on a different floor if necessary. This allows the installation to be adapted as required to fit the customer's infrastructure.
- The electrical cabinet can be positioned conveniently within the freeze dryer plant or centrally in a control room.
- Frame mounting allows SMART LYO® freeze dryers to be installed within the existing building architecture, i.e. the machinery room and the sterile area. This means that installation and assembly is very simple requiring just the connection of the plant to the unit frame and the switch cabinet.
- The GEA Lyophil Global Service Network provides rapid availability of original manufacturers' spare parts worldwide, with comprehensive service and repair to minimise downtime and keep costs under control.
- Comprehensive documentation explaining both the operation and maintenance of the freeze dryer plant.

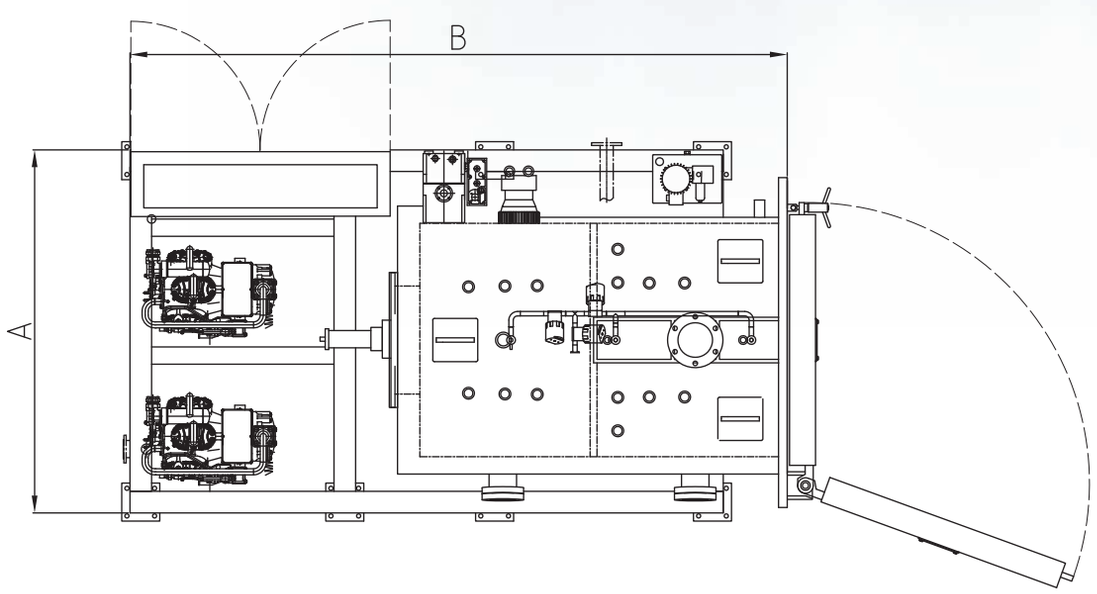
- **H_2O_2 sterilisation** with VAPOVAC™ steriliser.
- **CIP system** for cleaning the chamber and condenser.
- **SIP system** for steam sterilisation of the plant including all the necessary instruments and components as well as the upgrading of the chamber and condenser to one pressure vessel.
- **Re-cooling of the freeze-drying chamber** including the door, constructed as a jacket for effective and rapid re-cooling of the plant following steam sterilisation.
- **FAT** (Factory Acceptance Tests) to demonstrate the conformance of installation and key performance of the equipment with the specifications.
- A standardised **IQ/OQ package** allows rapid validation of the plant.

Model	SL 10 - 80 No CIP / SIP	SL 10 - 80 CIP / SIP
Chamber	•	•
Rectangular chamber	•	•
Pressure less	•	≠
CIP	≠	•
SIP	≠	•
Material 316 L	•	•
"Surface Ra 0,8 µm "	•	•
Ports 3d	•	•
Door	•	•
Full size door	•	•
automatic locking	≠	≠
Condenser rectangular Single Skid	•	•
Rear	•	•
"Ra<0,8µm "	•	•
CIP	o	•
CIP Chamber + Condenser	≠	•
Lost water	•	•
SIP	≠	•
PED	≠	•
ASME	≠	o
Hydraulic	•	•
Stoppering	o	o
Shelf package	•	•
Bellow	o	•
Refrigeration	•	•
Compressor Bitzer	•	•
Vacuum	•	•
Oil sealed vacuum pump	•	•
Pressure regulation	•	•
on/off	•	•
MKS Flow controller	o	o
Process sensors	•	•
Pirani	•	•
MKS	o	o
Venting System incl. filter	•	•
Sterilisable	≠	•
Ports for I-Test	o	•
Control System and Documentation	•	•
Siemens	•	•
Allen-Bradley	o	o
SCADA - WIN CC	•	•
Recorder	o	o
GAMP	o	•
FAT	o	•
IQ/OQ Documents and Tests	o	•
Material Certificates	o	o

• included o Option ≠ not available

Types and Sizes
Model SL10 - SL80

Model	Units	SL 10	SL 20	SL 40	SL 60	SL 80
Shelves						
Shelf area	m^2	"0,57 / 0,71"	"1,1 / 1,4"	"1,8 / 2,2 "	"2,7 / 3,3"	"4,1 / 5"
No. of Vials (Ø 16mm)	Quantity	"2,390"	"4,741"	"7,994"	"11,894"	"17,851"
No. of Vials (Ø 22mm)	Quantity	"1,247"	"2,474"	"4,186"	"6,228"	"9,379"
No. of Vials (Ø 30mm)	Quantity	658	"1,306"	"2,221"	"3,304"	"4,999"
No. Of Shelves	Quantity	4 / 5	4 / 5	5 /6	5 /6	5 /6
Shelf size	mm	460 x 310	460 x 615	615 x615	615 x 915	915 x 915
Clearance	mm	120 / 90	120 / 90	120 / 100	120 / 100	130 / 110
Shelf temperature	°C	-55 … +70	-55 … +70	-55 … +70	-55 … +70	-55 … +70
Condenser						
Condenser Capacity	kg/24h	10	20	40	60	80
Condenser temperature	°C	-75	-75	-75	-75	-75
Unit Dimensions						
Length (B)	mm	2600	2800	3400	3800	3800
Width (A)	mm	1400	1400	2100	2100	2100
Height	mm	2400	2400	2400	2400	2400
Weights						
Unit	t	1.5	2.5	3	4.5	5.5



Technical information

Utilities						
Pure Steam	barg	1.5	1.5	1.5	1.5	1.5
	°C	126	126	126	126	126
CIP Water	barg	3-5	3-5	3-5	3-5	3-5
	°C	80	80	80	80	80
	m^3	1.5	2	2.5	3	3.5
Cooling Water	°C	< 20	< 20	< 20	< 20	< 20
	m^3/h (peak)	2.4	5.5	6.5	10.6	10.6
Electrical Power Supply	kW	6	15	21	30	38

Options

Model	SL 100 - 400 No SIP	SL 100 - 400 SIP
Chamber	•	•
Rectangular chamber	•	•
Pressure less	•	≠
CIP	o	•
SIP	≠	•
VHP	o	≠
Material 316 L	•	•
"Surface Ra 0,8 µm "	•	•
Ports 3d	•	•
Door	•	•
Full size door	•	•
automatic locking	•	•
Pizza door (constant level loading)	o	o
Door in door	o	o
Condenser rectangular Single Skid	•	•
Rear	•	•
Side	o	o
Bellows	o	•
Perl blasted	•	≠
"Ra<0,8µm "	o	•
CIP	o	•
CIP Chamber + Condenser	•	•
Lost water	•	•
Recirculation	o	o
2 CIP cleaning media	o	o
SIP	≠	•
PED	≠	•
ASME	≠	o
Recooling (Silicone Oil)	≠	o
Hydraulic	•	•
Lift / lower	•	•
Stoppering	o	•
Shelf package	•	•
without rails	•	≠
with rails and fully collapsible	o	•
Bellow	o	•
Interface for ALU	o	o
Refrigeration	•	•
Compressor Bitzer	•	•
Liquid Nitrogen	o	o
Screws	o	o
Vacuum	•	•
Skid (Pump + Blower)	•	•
Redundancy	o	o
Dry Pumps	o	o

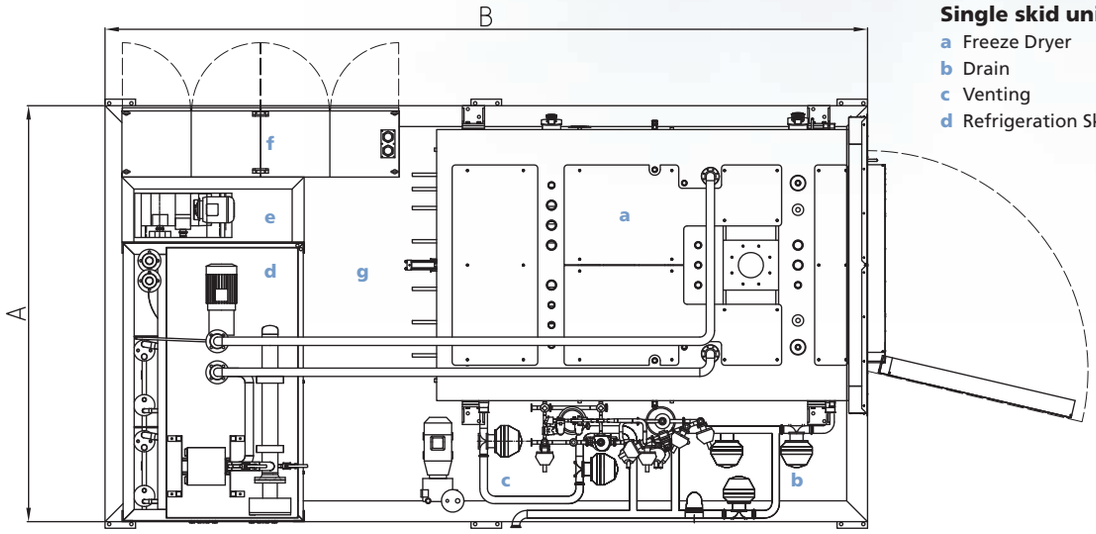
• included o Option ≠ not available

Model	SL 100 - 400 No SIP	SL 100 - 400 SIP
Pressure regulation	•	•
on/off	•	≠
MKS Flow controller	o	•
Process sensors	•	•
Pirani	•	≠
MKS	o	•
Venting System incl. filter	•	•
Second venting media	•	•
Sterilisable	≠	•
Ports for I-Test	o	•
Automatic WIT Test	o	o
2nd filter	o	o
Control System and Documentation	•	•
Siemens	•	•
Allen-Bradley	o	o
SCADA - WIN CC	•	•
Wire Numbering	•	•
Recorder	o	o
GAMP	o	•
FAT	o	•
IQ/OQ Documents and Tests	o	•
Welding documentation	o	o
Material Certificates	o	o

• included o Option ≠ not available

Types and Sizes
Model SL100 - SL400

Model	Units	SL 100	SL 150	SL 200	SL 250	SL 300	SL 350	SL 400
Shelves								
Shelf area	m^2	5	7.5	10.3	12.3	14.9	17.8	20.4
No. of Vials (Ø 16mm)	Quantity	"21,374"	"32,061"	"42,760"	"52,263"	"63,648"	"76,378"	"87,531"
No. of Vials (Ø 22mm)	Quantity	"11,230"	"16,845"	"22,466"	"27,458"	"33,497"	"40,197"	"46,066"
No. of Vials (Ø 30mm)	Quantity	"5,985"	"8,978"	"11,973"	"14,634"	"17,894"	"21,472"	"24,608"
No. Of Shelves	Quantity	6 + 1	9 + 1	9 + 1	11 + 1	10 + 1	12 + 1	11 + 1
Shelf size	mm	914 x 914	914 x 914	914 x 1219	914 x 1219	1219 x 1219	1219 x 1219	1219 x 1524
Clearance	mm	105	105	105	105	105	105	105
Shelf temperature	°C	-55 … +70	-55 … +70	-55 … +70	-55 … +70	-55 … +70	-55 … +70	-55 … +70
Condenser								
Condenser Capacity	kg/24h	100	150	200	250	300	350	400
Condenser temperature	°C	-75	-75	-75	-75	-75	-75	-75
Unit Dimensions								
Length (B)	mm	5000	5000	5600	5600	6000	6000	6500
Width (A)	mm	3000	3000	3000	3000	3400	3400	3400
Height	mm	3500	3500	4000	4000	4200	4200	4300
Weights								
Unit	t	7.5	8	9	10	12.5	12.5	15



Single skid unit consisting of:

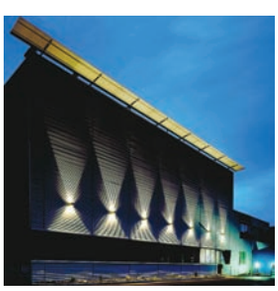
- **a** Freeze Dryer
- **b** Drain
- **c** Venting
- **d** Refrigeration Skid
- **e** Vacuum Skid
- **f** Electrical Cabinet
- **g** Maintenance Area

Technical information

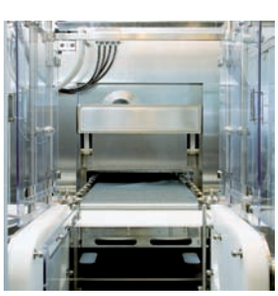
Utilities								
Pure Steam	barg	1.5	1.5	1.5	1.5	1.5	1.5	1.5
	°C	126	126	126	126	126	126	126
CIP Water	barg	3-5	3-5	3-5	3-5	3-5	3-5	3-5
	°C	80	80	80	80	80	80	80
	m^3	3	4	4.5	5	5.5	6.5	7
Cooling Water	°C	< 20	< 20	< 20	< 20	< 20	< 20	< 20
	m^3/h (peak)	10.6	10.6	16	16	20	20	30
Electrical Power Supply	kW	33	40	55	65	70	90	105

www.geapharmasystems.com

Central Know-How on a Global Scale
Based on a strong commitment to research and development, pharmaceutical technology centres in Belgium, Denmark, Switzerland, the UK, Singapore, and USA provide global technical support and know-how to the pharmaceutical industry. These centres of excellence give customers access to a range of test facilities and expert teams with technical and process know-how. Our teams work closely with our customers to optimise processes and evaluate their products, enabling them to achieve their process and production goals.



Contracting Profitable Experience
A world leader in supplying pharmaceutical equipment, GEA Pharma Systems offers manufacturers all over the world the opportunity to enter into a profitable partnership for development and contract. GPS combine advanced in-house technology with a thorough understanding of the pharmaceutical industry to help customers maximize their development results.



Leader in Technology
GEA Lyophil's thorough understanding of the Freeze Drying process enables them to supply a comprehensive range of products and services, comprising laboratory freeze dryers, both pilot scale for R&D and small production batches; industrial freeze dryers; and complete freeze dryer systems. These include Automatic Loading and Unloading Systems (ALUS®); integrated isolators; and CIP-Skids in a complete system with freeze dryer.

GEA Pharma Systems

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Kalscheurener Strasse 92, D-50354 Hürth, Germany
Tel: +49 2233 6999-0, Fax: +49 2233 6999-10
lyophil@geagroup.com

Cold Storage Rooms

For over 35 years Budzar Industries has specialized cooling and heating systems and has earned a global reputation for quality and ingenuity in the design, engineering, and manufacturing of temperature control systems. Budzar Industries systems are found in action throughout the world, delivering accurate temperature measurement and control.

Budzar Industries has extensive experience in cold storage facility chiller systems in Class L Cold Rooms, Class D Freezer Rooms, Class J Low Temperature Freezer Rooms and Ultra Low Temperature Freezer/Cold Storage Facilities with temperatures down to -80°C. Important features include:

- Temperature Stability throughout the room
- PLC Temperature Control System with PID Capability
- Multiple Temperature Sensors
- 100% Redundancy Options
- Hot Gas or Electric Defrost Cycles

BUDZAR INDUSTRIES, INC.

Your Single Source Solution Provider

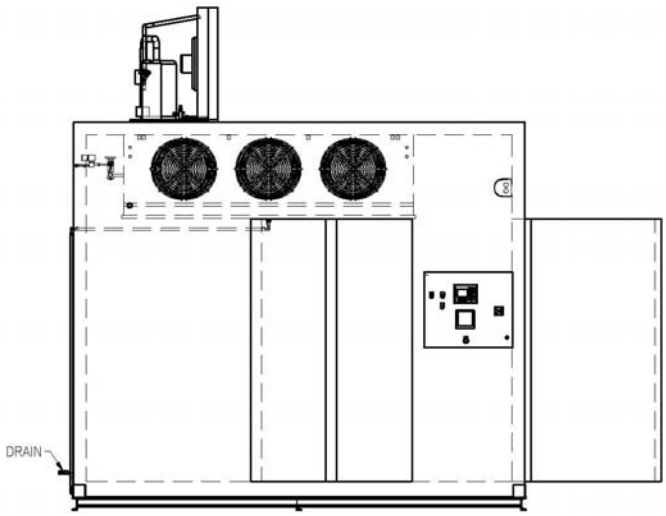
engineering **PRECISION**

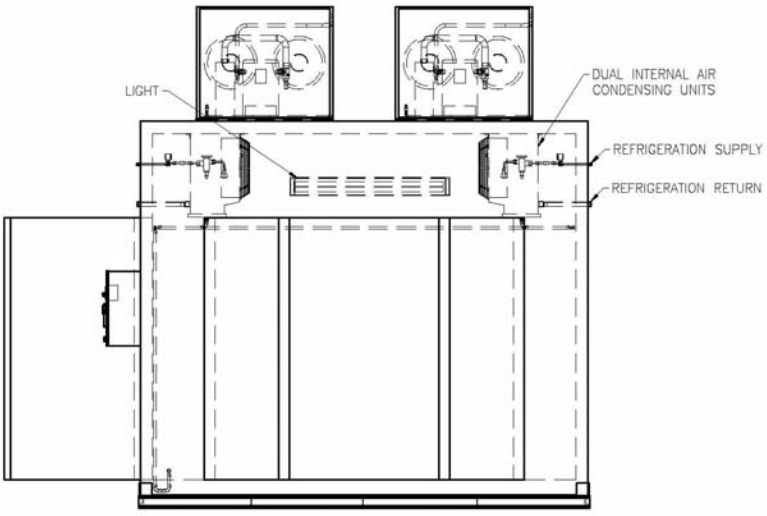
COMPARE THESE FEATURES

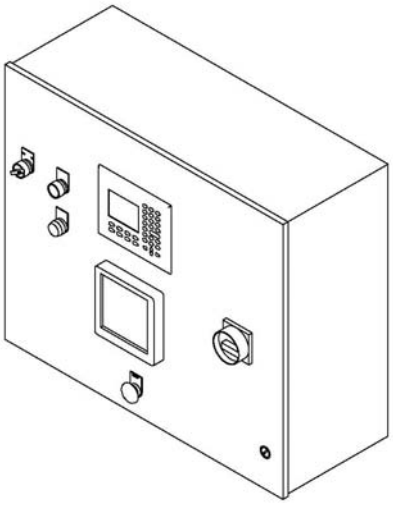
- Each Budzar Industries Unit is designed to maximize the productivity of your process. Budzar Industries quality and reliability provide excellent value for each dollar invested.
- Each Unit is constructed for temperature stability within 1°C gradient
- Multiple Fans provide Precise Air Circulation ensuring Temperature Stability
- A PLC Temperature Control System with PID Capability provides Temperature Accuracy within 1°C and is essential in preventing under/over temperature swings
- Finger-Safe Terminal Blocks, Large Onboard Non-Volatile Memory, Real Time Clock capabilities and Data Access Tool for Data Monitoring and Adjustments
- Multiple Temperature Sensors distributed throughout the room constantly monitor the temperature
- A Temperature Probe strapped to the Evaporator Coil continually monitors the Evaporator Temperature
- Defrost Cycle in initiated when the temperature difference between the Evaporator Coil and Room Set Point reaches the Critical Set Point
- Defrost Cycle Design includes:
  - -Door Limit Switch which turns off the Cooling Unit whenever the Door is Opened
  - -Defrost Heater Around Door Seals and Drip Pan
  - -Drain Pipe and Heat Trace
  - -Critical Temperature Alarm
- Chamber and Doors are Designed for Walk-In or Drive-In Compatibility.
- The Design of the Doors accommodates racking, bulk or individual vials
- **Made in the USA**

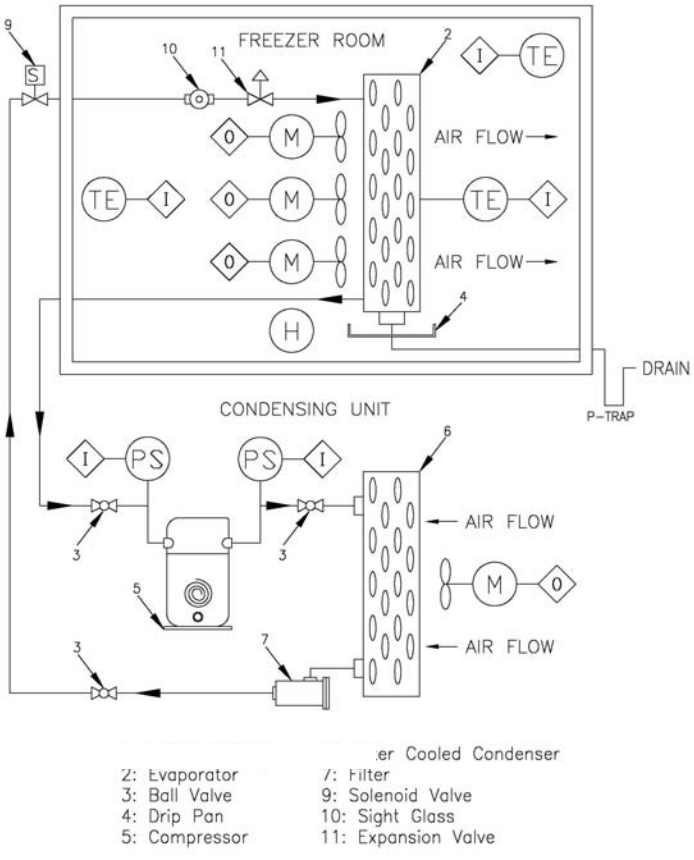
process **TEMPERATURE** control

Cold Storage Rooms

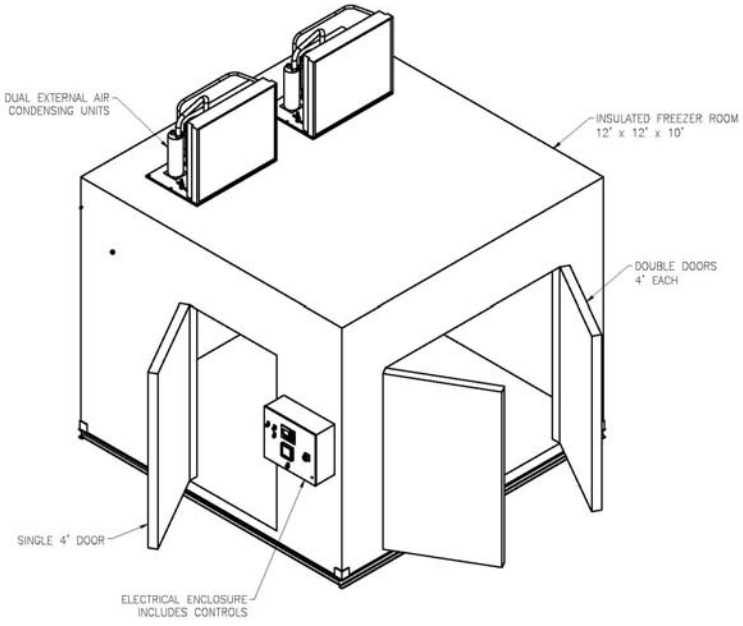








2: Evaporator
3: Ball Valve
4: Drip Pan
5: Compressor
7: Filter
9: Solenoid Valve
10: Sight Glass
11: Expansion Valve



BUDZAR INDUSTRIES, INC.
38241 Willoughby Parkway • Willoughby, Ohio 44094
440-918-0505 • Fax 440-918-0606
www.Budzar.com • Sales@Budzar.com

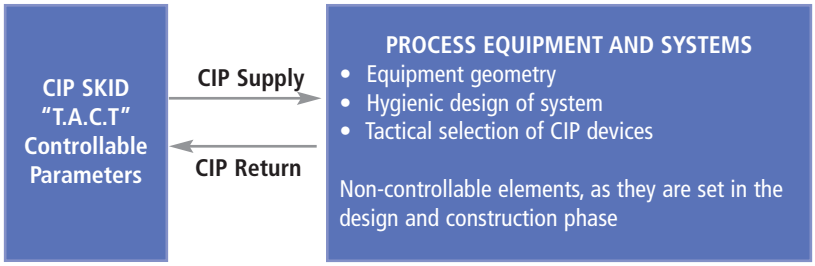
Standard Single Use CIP System and Integration

Leading Technologies. Individual Solutions.

CIP System

In today's pharmaceutical and biologic manufacturing, cleaning the process equipment and systems is crucial to the overall success of the enterprise. For larger production and bulk facilities, cleaning is accomplished by a centralized CIP system and is considered a critical utility.

Elements of a CIP System:



There are three important elements to consider in the design and implementation of any CIP System; the CIP Skid, the equipment & systems to be cleaned and the CIP supply & return lines.

The CIP Skid controls the cleaning ("T.A.C.T.") parameters of **T**emperature, **A**ction (velocity/pressure), **C**hemical concentration and **T**ime of exposure. It can be configured with many different options as required by the owner to achieve the desired cleaning results.

Knowledge and Experience Required

More of a challenge is the design considerations of the equipment & systems to be cleaned. In recent years the industry has given more attention to this and important guidelines have been published by ASME-BPE, ISPE, etc. And while these guideline have made large strides addressing the mechanical aspects, it is not mandatory (or sometimes possible!) for equipment suppliers to follow them. Thus it requires knowledge and experience in identifying potential CIP issues relating to equipment geometry and developing a tactical CIP approach to the process system.

There are several integration techniques for connecting the CIP skid with the targeted processes to be cleaned with the CIP supply & return circuits. Perhaps the most known is the use of flow-plates so that "make-break" circuits can be established, thus giving the owner a safe operation with a degree of flexibility albeit a manual operation. In more advanced operations, the use of matrix piping technology is used which employs mix-proof valves that allow the CIP supply & return to be totally "hardpiped" and automated, thus maximize the efficiency of the CIP operation.

GEA Liquid Processing takes complete responsibility for all aspects of the CIP System.

Our Process Engineers will audit your process for cleanability. Our CIP System skids are completely designed, engineered, fabricated, automated and tested in our workshop. We can further integrate the CIP System Skid into your operating plant utilizing the latest integration techniques.

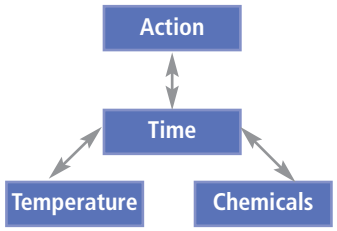
We assign a qualified Process Engineer to your project to facilitate discussions regarding site-specific requirements, integration concerns and final FAT/SAT protocols. This vertically integrated project approach has the benefit of:

- Seamless communications between disciplines
- Eliminates budget variances that would result from having multiple contracts
- Enhances the "speed to market" of the overall project

Recommended flow rates for cleaning vertical cylindrical vessels having dished heads			
Vessel ID		Flow rate	
ft	mm	gpm	lpm
1.5	457	12 to 14	45 to 53
2	610	16 to 19	60 to 72
3	914	24 to 28	90 to 106
4	1219	31 to 38	117 to 144
5	1524	39 to 47	148 to 178

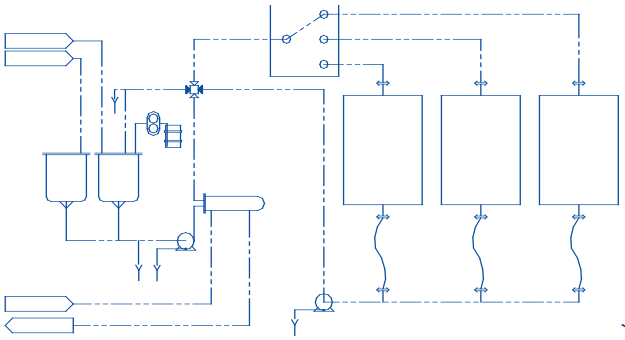
ASME-BPE 2005 Table SD-4

Controllable CIP Parameters: T.A.C.T.

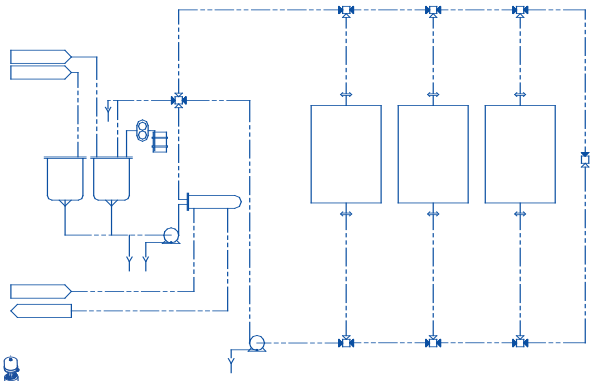


Flow Rates to achieve 5 f/s (1.5 m/s)					
SANITARY TUBE SIZE					
OD		ID		Flow rate	
inch	mm	inch	mm	gpm	lpm
0.5	12.7	0.37	9.4	1.7	6.5
0.75	19.1	0.625	15.9	4.8	18
1.0	25.4	0.875	22.2	9.4	35
1.5	38.1	1.375	34.9	24.0	90
2.0	50.8	1.85	47.0	42.8	162
3.0	76.2	2.875	73.0	102.0	386

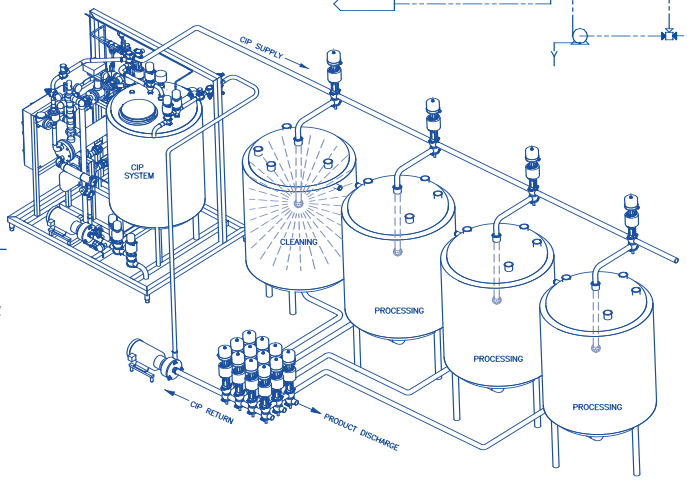
ASME-BPE 2005 Table SD-5



Manual Flow Plate Configuration



Automatic Matrix Piping



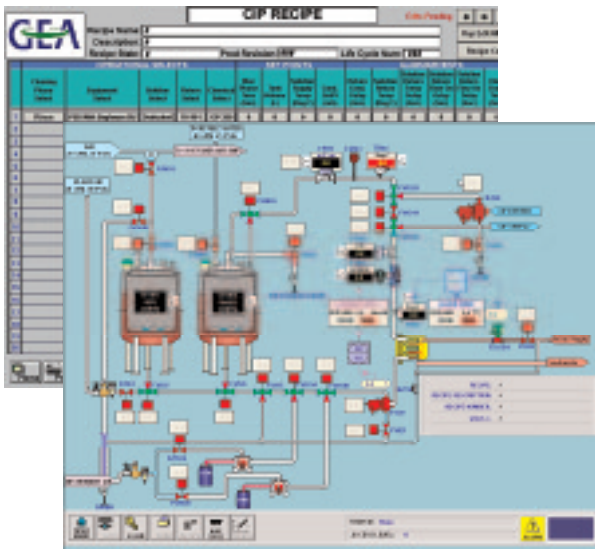
Matrix Piping Integration of a CIP System

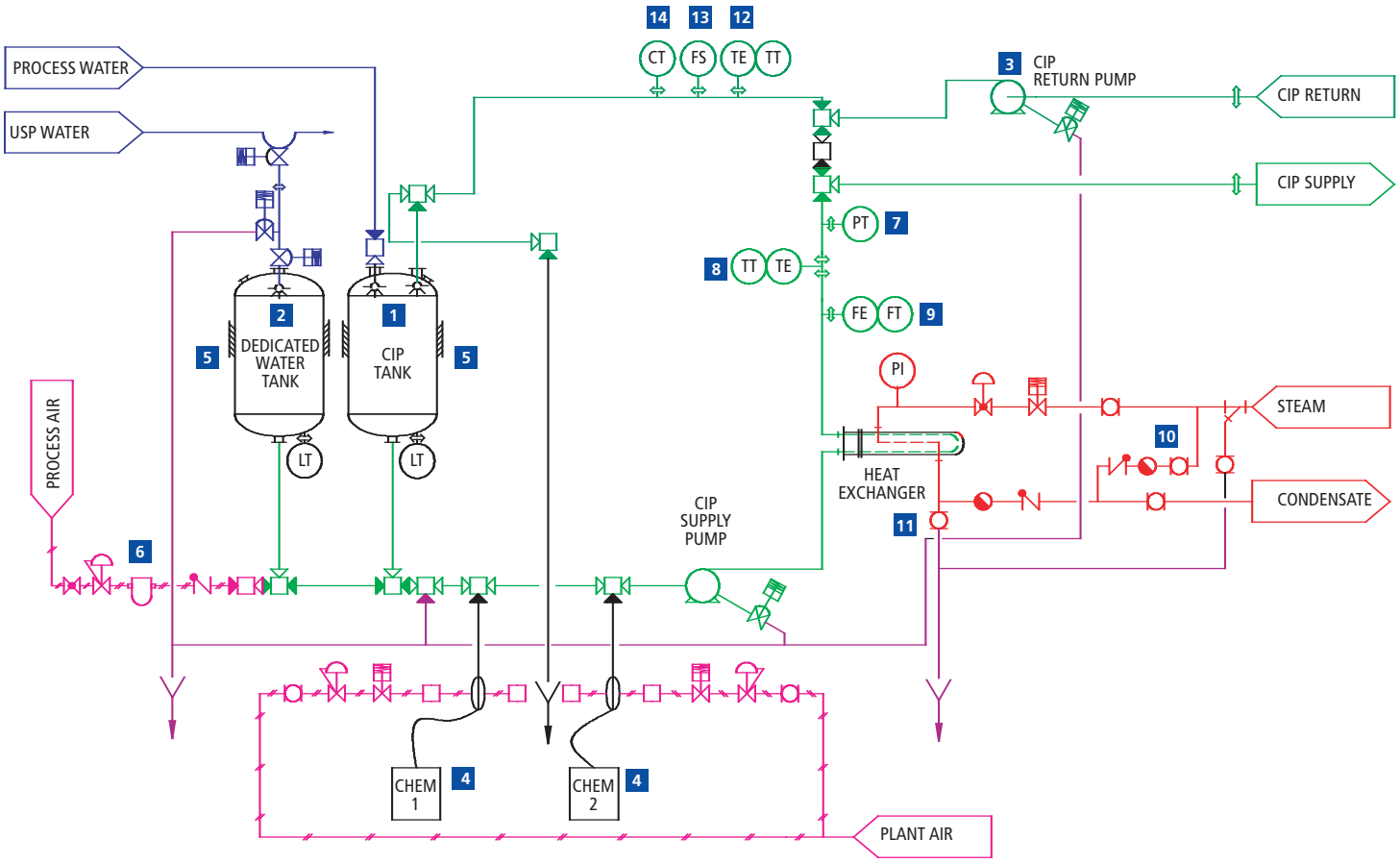
Control System Integration

One of the keys to success is the correct integration of the control system to the process design and the CIP elements. In many cases, the CIP flow path will share process devices such as valves, pumps, agitators etc. which will need to be energized in sequential fashion to ensure that cleaning will take place.

Furthermore, CIP programs are set-up to allow configuration of the controllable parameters by authorized operators, thus allowing the system to be easily optimized during commissioning or during the life cycle of the process. The result is a secure CIP system that will be repeatable and reliable in operation!

GEA Liquid Processing is staffed with knowledgeable Control Engineers that are experienced with GAMP guidelines and can deliver complete, seamless control systems or provide the required interface with existing control systems.





Options

GEA's single use CIP System Skid can be configured with the following options to meet your specific needs.

- **1** CIP tank
- **2** Secondary dedicated water tank
- **3** CIP return pump with low point drain valve
- **4** Chemical addition system(s)
- **5** Tank insulation
- **6** Air blow
- **7** CIP supply pressure transmitter
- **8** CIP supply temperature transmitter
- **9** CIP supply flow transmitter
- **10** Steam supply condensate drip leg
- **11** Heat exchanger drain
- **12** CIP return temperature transmitter
- **13** CIP return flow switch
- **14** CIP return conductivity transmitter
- **15** Portable
- **16** Explosion Proof (Class I / Div 1,2)

For detailed technical support, call us at 410-997-8700. Our engineers will assist you with the final CIP system skid configuration required to deliver specified CIP solutions and discuss plant integration options.

Technical Data

Typical Utility Requirements

Steam . . . . . .1000 lb/hr at 35 psi.
Process water . . . . . .30-60 gpm
Electrical . . . . . .120 VAC, 20 Amp for control cabinet.
460V, 3 phase 60 Hz for the MCC
Air . . . . . .90 psi (30CFH for airblow)

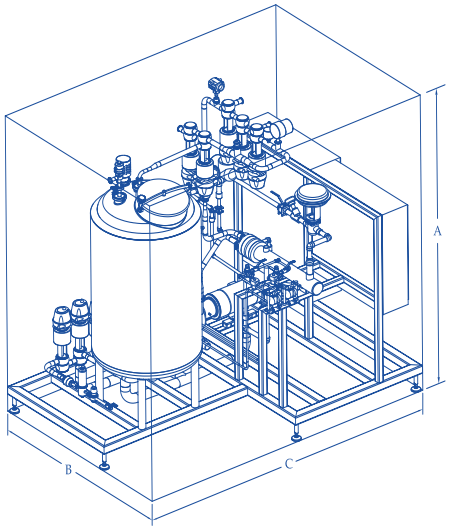
*Specific flow data and utility requirements will be altered to suit individual process requirements.

Standard Documentation Package

- Pipe and Instrument Diagram (P&ID)
- Dimensional drawings
- Complete set of electrical drawings
- Functional Design Specification (FDS)
- Software Design Specification (SDS)
- I/O list
- Set of software applications
- Maintenance manuals and spare parts list for all components
- Welding & inspection documentation
- Material certificates and surface finish reports for all process components

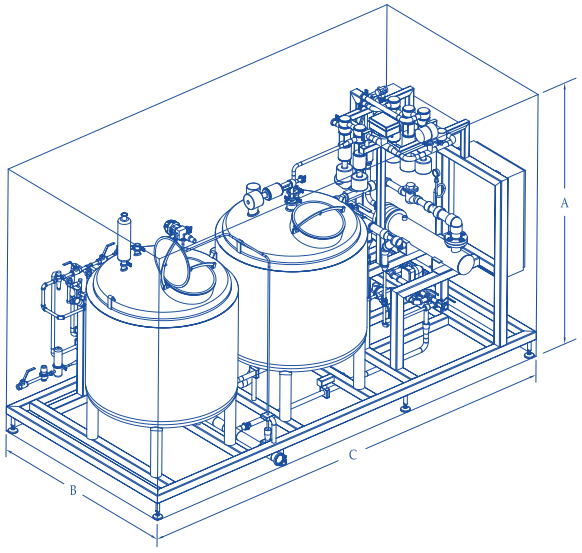
Dimensional Information

One-tank system
A = Height: 8′
B = Width: 6′
C = Length: 9′
Dry weight: 4200 lbs



Two-tank system
A = Height: 8′
B = Width: 6′
C = Length: 13′

Dry weight: 6800 lbs



cGMP Process Solutions

for the Pharmaceutical and Biotech Industries

GEA Liquid Processing is a world leader in providing technically advanced cGMP process solutions for liquid processes. Utilizing good engineering practices and GAMP compliant automation, our knowledgeable staff delivers completely integrated and reliable hygienic liquid process systems that meet the most stringent regulations.

Columbia, MD

Hudson, WI

GEA Process Engineering Inc.
9165 Rumsey Road • Columbia, MD 21045 • Tel: 410-997-8700 • Fax: 410-997-5021
1600 O'Keefe Road • Hudson, WI 54016 • Tel: 715-386-9371 • Fax: 715-386-9376
E-mail: gea-pe.us@gea.com • Website: www.niroinc.com

MASTERFLEX® B/T®

MASTERFLEX® B/T® Pump 77111-60

OPERATING MANUAL:

B/T® RAPID-LOAD® PERISTALTIC PUMPS AND DRIVES

System Model Nos.

77111-00
77111-07
77111-10
77111-12
77111-15
77111-17
77111-40
77111-47
77111-50
77111-55
77111-60
77111-67
77111-80

A-1299-5152
Edition 01

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Chem-Durance, B/T, Rapid-Load and Masterflex – Reg TM of Cole-Parmer
NORPRENE, PHARMAPURE, PHARMED and TYGON – Reg TM Saint-Gobain Performance Plastics Corp.

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A-1299-5152

REV	ECR/ECN	DATE	DESCRIPTION	By
REV 1	16011	081101	RELEASED FOR PUBLICATION	JSK

SAFETY PRECAUTIONS

DANGER: High voltages exist and are accessible. Do not remove cover of Drive or Controller. Use extreme caution when servicing internal components.

CAUTIONS: Risk of electric shock – this pump is supplied with a grounding conductor and grounding-type attachment plug. To reduce risk of electric shock, be certain that it is connected only to a properly grounded, grounding-type receptacle.

Electrical connections and grounding (earthing) must conform to local wiring codes.

WARNINGS: Tubing breakage may result in fluid being sprayed from pump. Use appropriate measures to protect operator and equipment.

To reduce the risk of injury, use hose clamps on all tubing connections. All tubing connections, must be made outside of the pump.

To reduce risk of injury, power must be removed from pump before removing or installing tubing. Fingers or loose clothing could get caught in drive mechanism. Do not operate this pump without cover or interlock door properly closed and latched. Rotating parts can cause serious injury.

To reduce risk of injury, do not pump materials hotter than 150 degrees Fahrenheit, (65.5°C).

Before permanent installation, test the equipment with the chemicals and under the specific conditions of your application.

Verify tubing material chemical compatibility prior to use. It is the sole responsibility of the user to determine suitability of the product for the application

Explanation of Symbols

CAUTION: Risk of Danger. Consult Operator's manual for nature of hazard and corrective actions.

CAUTION: Risk of crushing. Keep fingers away from rotor while pump is in operation. Stop pump before loading or unloading tubing.

CAUTION: Hot Surface. Do not touch.

CAUTION: Risk of electric shock. Consult Operator's manual for nature of hazard and corrective actions.

WARNING: Product Use Limitation

This product is not designed for, nor intended for use in, patient-connected applications, including, but not limited to, medical and dental use, and, accordingly, has not been submitted for FDA approval. If drive is used in a manner not specified in this manual the protection provided by the equipment may be impaired.

Use only MASTERFLEX® PERFECTPOSITION® B/T® precision tubing with MASTERFLEX pumps to ensure optimum performance. Use of other tubing may void applicable warranties.

Table of Contents

Figures

Tables

Section 1 Introduction

This manual provides information for installing, operating and servicing the following models of MASTERFLEX® B/T® RAPID-LOAD® Peristaltic Pumps and Drives.

MODEL	TYPE
77111-00	Fixed Speed w/TEFC, 115V AC @ 60 Hz
77111-07	Fixed Speed w/TEFC, 230V AC @ 50 Hz
77111-10	Controller Only 115VAC for 77111-40
77111-12	Drive Only 115VAC for 77111-40
77111-15	Controller Only 230VAC for 77111-47
77111-17	Drive Only 230VAC for 77111-47
77111-40	Modular Drive, Digital 115V AC system.
77111-47	Modular Drive, Digital 230V AC system.
77111-50	Drive Only NEMA56C mount less motor
77111-55	Drive Only IEC72 mount less motor
77111-60	Modular Drive, Analog 115V AC system
77111-67	Modular Drive, Analog 230V AC system
77111-80	Air-Powered Variable Occlusion Peristaltic Pump and Drive.

The unique design of these peristaltic pumps provides a greatly simplified means for rapid loading and changing of tubing. In addition, the following features are incorporated:

Pumps up to 10 GPM (37 LPM).

Uses continuous tubing to ensure a sanitary and non-contaminating system.

Fluid contacts only the tubing.

Handles wide range of viscosities.

Several different sizes and formulations of tubing can be used.

Application Data

The gentle peristaltic action of these pumps is ideal for pumping highly viscous and shear-sensitive liquids. These pumps are also ideally suited for use where sterile conditions and purity are required. Toxic and hazardous fluids can be pumped with the proper selection of MASTERFLEX *PERFECTPOSITION* B/T tubing since the fluid contacts only the tubing and not the pump.

Use only MASTERFLEX® PERFECTPOSITION® B/T® precision tubing with MASTERFLEX pumps to ensure optimum performance. Use of other tubing may void applicable warranties.

⚠ ***WARNING: Tubing breakage may result in fluid being sprayed from pump. Use appropriate measures to protect operator and equipment.***

⚠ ***Verify tubing material chemical compatibility prior to use. It is the sole responsibility of the user to determine suitability of the product for the application.***

General Description

The RAPID-LOAD® B/T peristaltic pump (see Figure 1) is mounted on a base and attached to a NEMA 56C frame motor or IEC-72 71-14F130 frame motor through a 5.45:1 gear head and adapter. Depending on the model, the motor is either supplied or customer furnished and is attached to the adapter by four bolts. A modular controller is furnished with some models. The modular controller can be wall mounted.

Figure 1-1. RAPID-LOAD Pump and Drive Family

Due to its unique design, different MASTERFLEX *PERFECTPOSITION* B/T tubing sizes can be accommodated by this RAPID-LOAD peristaltic pump.

For an indirect estimate of flow rate, a reflective element attached to the rotor has been provided for use with an optical tachometer. Point tachometer beam through front cover window and target the reflective element.

To obtain flow rate in mL/min., multiply tachometer rpm reading times the nominal flow per revolution value provided in TABLE 1 (**Note:** 3,785 mL = 1 U.S. liquid gallon).

The maximum recommended rotor speed is 321 rpm. The pump rotor can turn either clockwise or counterclockwise. When turning clockwise (FWD) the top connection is for suction and the bottom connection is for discharge. The 321 rpm speed is obtained from the standard 1725 rpm fractional horsepower motor through the 5.45:1 gear reduction. Faster speeds will increase flow, but will also considerably shorten average tubing life. (Manufacturer cannot be responsible for pump performance when operated at speeds higher than 321 rpm.)

WARNING: To reduce the risk of injury, use hose clamps on all tubing connections.

Silicone or C-FLEX® tubing, because of their highly elastic natures, can expand very quickly if back-pressure is present and could create leakage at the fittings if not securely retained. It is this same elastic nature, however, that makes them such excellent materials for this peristaltic type pump. NORPRENE® tubing yields longer life, especially under pressure. Refer to Table 1 for tubing recommendations. Do not attempt to use other materials in lieu of these, as pump performance could be severely compromised with possible damage to the pump.

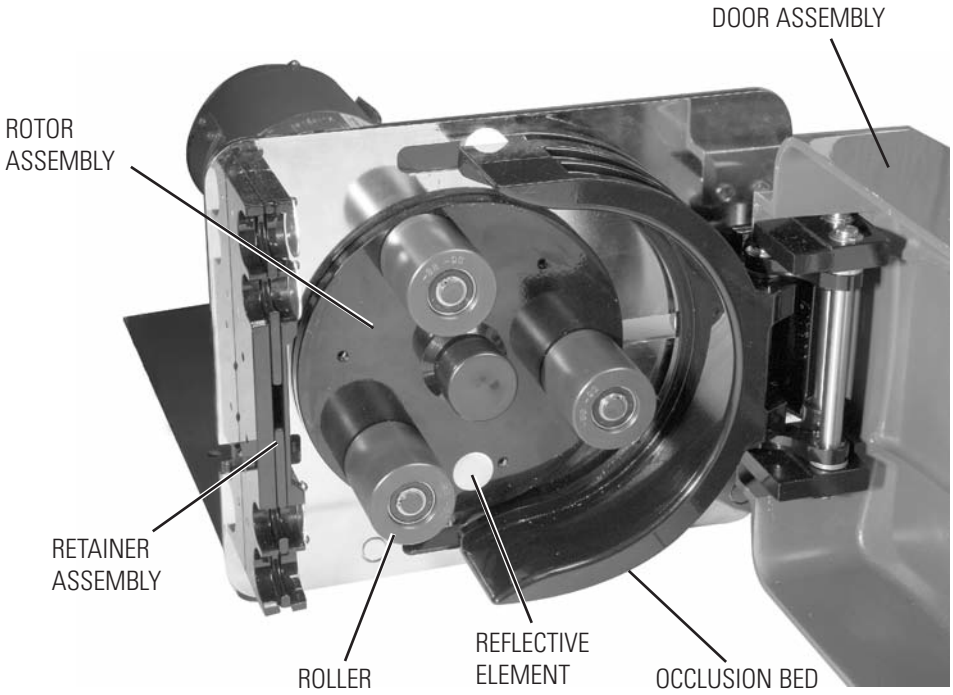


Figure 1-2. RAPID-LOAD Pump and Drive

Section 2 Installation and Setup

These units should be placed on a flat surface such as a floor, bench or table and should be near an electrical power source. Be sure to check data plate for proper voltage rating(s).

PUMP MOUNTING DIMENSIONS (All Models)

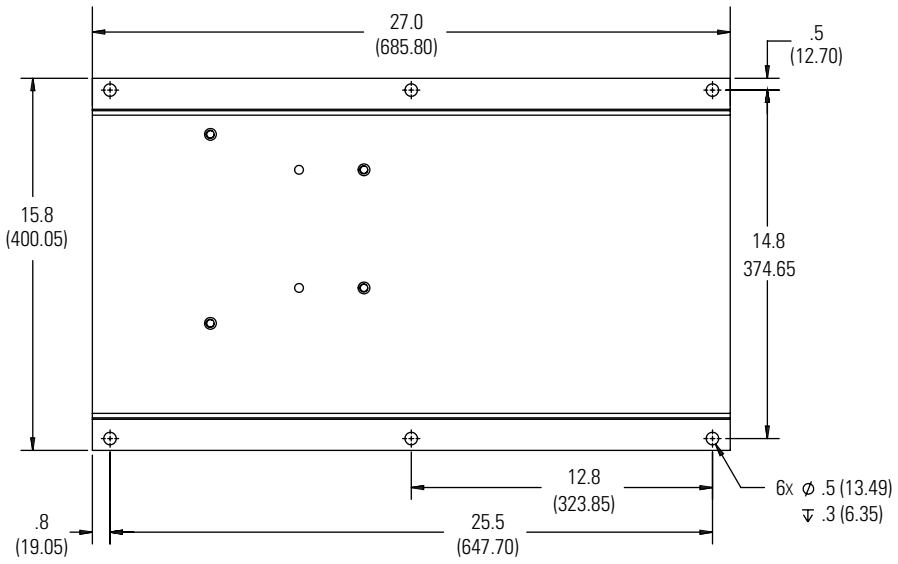


Figure 2-1. Pump Mounting Dimensions, applies to all Pump Systems.

CONTROL BOX MOUNTING DIMENSIONS (Digital Models Only)

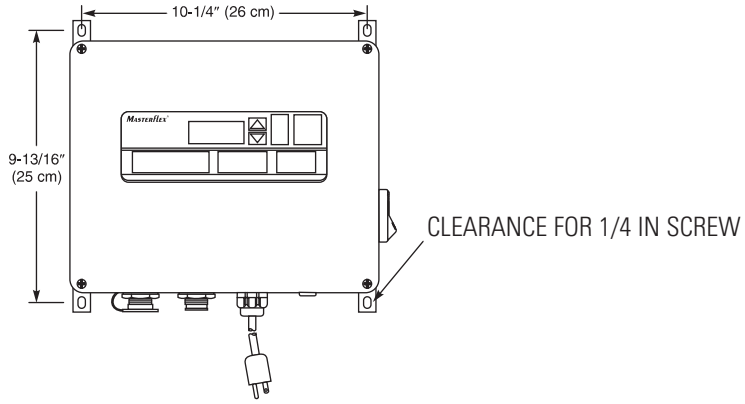


Figure 2-2. Control Box Mounting Dimensions 77111-10, 77111-15, 77111-40 and 77111-47.

CONTROL BOX MOUNTING DIMENSIONS (Analog Models 77111-60 and 77111-67 Only)

NOTE: The controller and bracket can be removed and located up to 10 feet away.

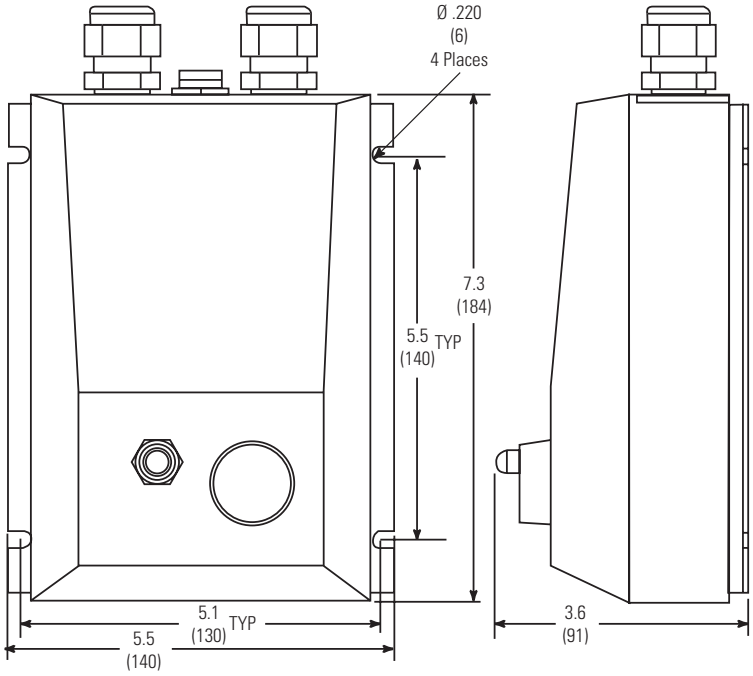


Figure 2-3. Control Box Mounting Dimensions 77111-60 (115V).

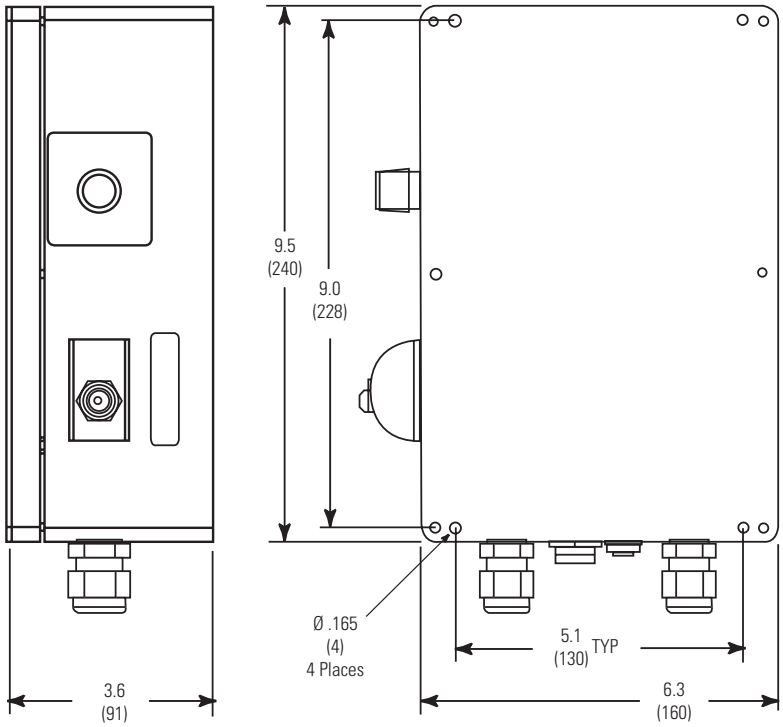


Figure 2-4. Control Box Mounting Dimensions 77111-67 (230V).

Model 77111-80

This unit should be placed on a flat surface such as a floor, bench, or table and should be near a compressed air source.

Unpack the drive and save packaging material until proper product operation has been verified.

Install the following components: pressure gauge, pressure filter/regulator and lubricator assembly, pipe nipple, elbow, and muffler. See Figure 2-5 for proper orientation, (all items and fittings included except as noted). Use a thread seal such as PTFE tape for all connections to reduce the possibility of air leakage.

Connect compressed air line to the 1/4 NPT connection on the regulator (fitting not supplied). Turn on compressed air line to start pumping. (Maximum 100 psig inlet.)

NOTE: Pump will not run unless Door Assembly is closed.

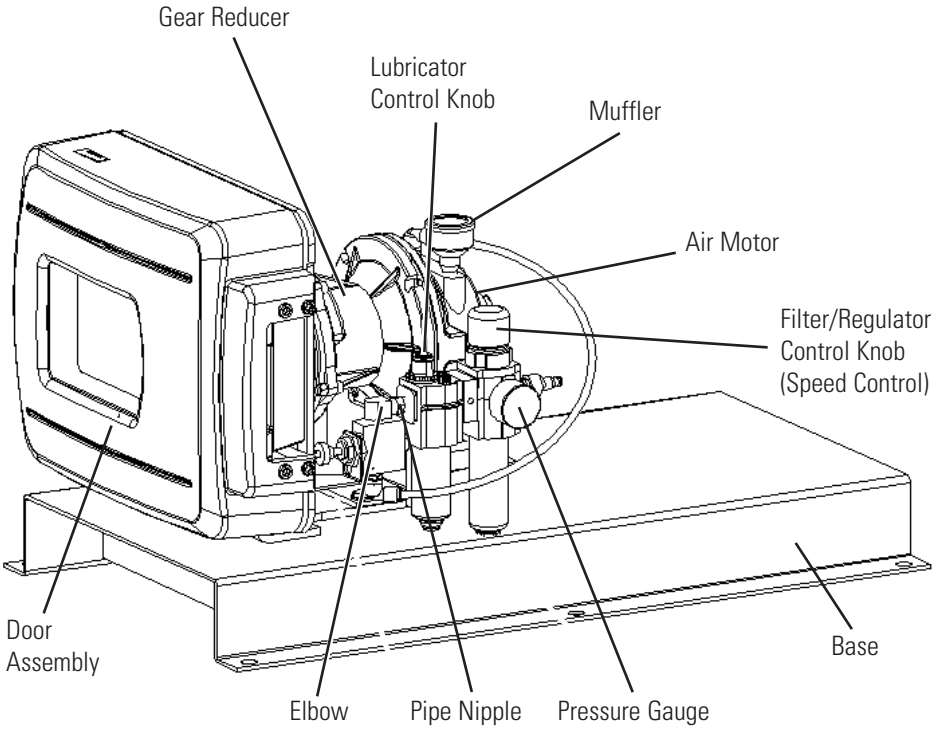


Figure 2-5. Air-Powered Rapid-Load Pump and Drive

MODEL 77111-50

Install customer-supplied motors in accordance with the following procedure.

CAUTION: This product is intended for use with a motor that has a maximum speed of 1800 rpm, @ 0.5 HP (0.67 KW). Do not use a motor with a higher speed capacity.

WARNING: Electrical connections and grounding (earthing), must conform to local codes. (See motor wiring diagram for motor wiring instructions.)

Tools required: 5/16 inch Hex Key.

Model 77111-50 is designed to be installed to a customer-supplied NEMA Type 56C frame motor. To install the unit, refer to Figure 2-6 and follow these steps:

1. Using a 5/16 inch Hex Key, and the supplied hardware, bolt the motor to the gear reducer by installing the four flat washers on the bolts and inserting the bolts through the gear head adapter into the motor. Torque bolts from 17 to 19 foot pounds.

2. Cutoff connector from end of interlock cable and strip outer jacket.

3. Strip individual conductors and wire in series with the power to the motor turned off. Failure to do so will result in defeating the door interlock, creating a potential crushing hazard.

CAUTION: Risk of crushing. Keep fingers away from rotor while pump is in operation. Stop pump before loading or unloading tubing.

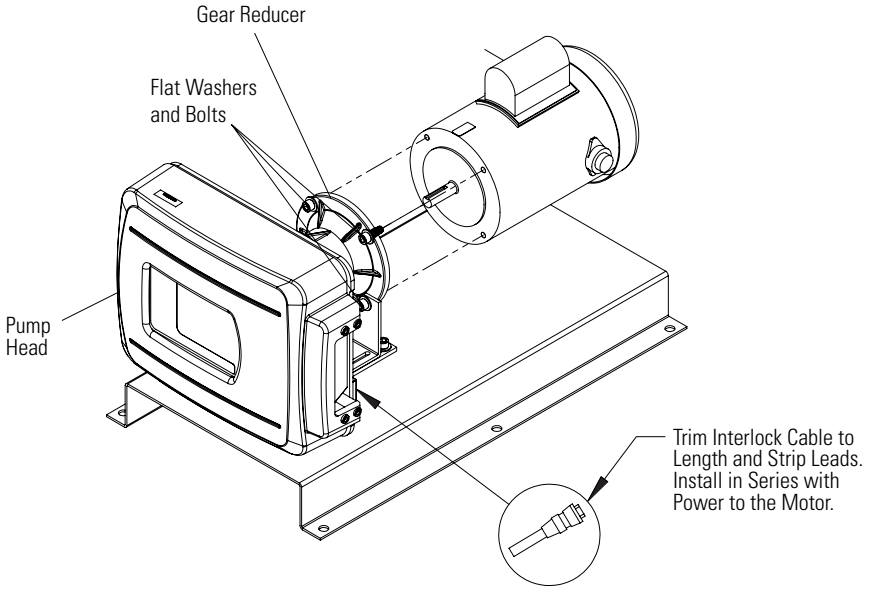


Figure 2-6. Motor Mounting NEMA TYPE 56C Motor Fame

MODEL 77111-55

Install customer-supplied motors in accordance with the following procedure.

CAUTION: This product is intended for use with a motor that has a maximum speed of 1800 rpm, @ 0.5 HP (0.67 KW). Do not use a motor with a higher speed capacity.

WARNING: Electrical connections and grounding (earthing), must conform to local codes. (See motor wiring diagram for motor wiring instructions.)

Tools required: 13 mm Wrench.

Model 77111-55 is designed to be installed to a customer-supplied IEC-72-71-14F130 frame motor with foot mountings. To install the unit, refer to Figure 2-7 and follow these steps:

1. Using a 13 mm wrench, and the supplied hardware, bolt the motor to the gear reducer by installing the four flat washers on the bolts and inserting the bolts through the gear head adapter into the motor. Torque bolts from 1.73 to 2.00 kilogram-meters (12.5 to 14.5 foot pounds.)

2. Cutoff connector from end of interlock cable and strip outer jacket.

3. Strip individual conductors and wire in series with the power to the motor turned off. Failure to do so will result in defeating the door interlock, creating a potential crushing hazard.

CAUTION: Risk of crushing. Keep fingers away from rotor while pump is in operation. Stop pump before loading or unloading tubing.

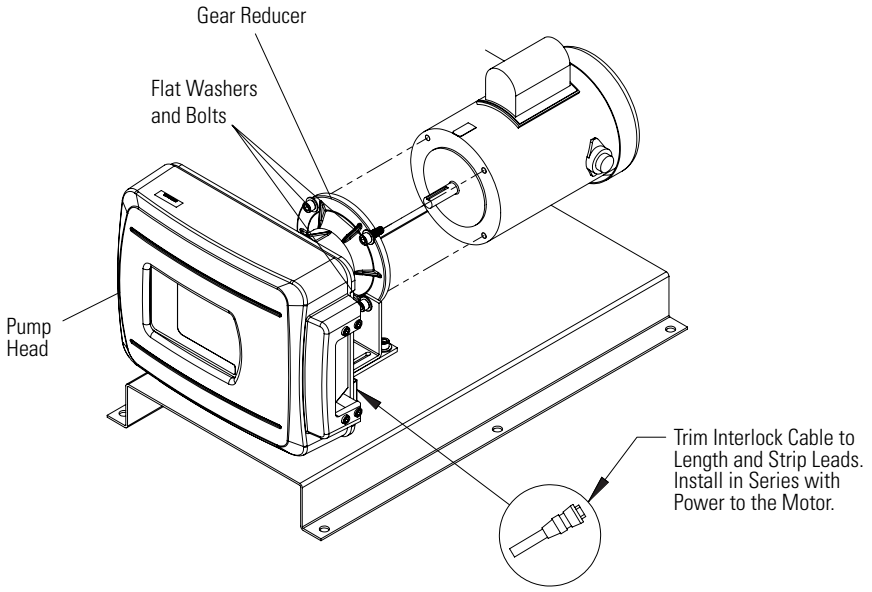


Figure 2-7. Motor Mounting IEC-72 71-14F130 Motor Frame

TUBING TYPES

Use only MASTERFLEX *PERFECTPOSITION* B/T precision tubing with MASTERFLEX pumps to ensure optimum performance.

Use of other tubing may void applicable warranties.

NOTE Use MASTERFLEX *PERFECTPOSITION* B/T tubing. These pumps are designed to use *PERFECTPOSITION* B/T tubing sizes 87 and 91 only. The tubing sizes refer to the last two digits of the MASTERFLEX *PERFECTPOSITION* B/T tubing model number.

Table 1. Tubing Types

	Tubing Size	
Characteristics	**B/T 87**	**B/T 91**
Inside Dia. in (mm)	0.5 (12.7)	0.75 (19.05)
Hose barb size in (mm)	1/2″ (12.7)	3/4″ (19.0)
Flow Range (with 321 rpm drive)	0.17-5.0 GPM (0.010-18.9 L/m)	0.37-10 GPM (1.40-37.85 L/m)
Nominal Flow Per Revolution	70.46 mL	141 mL
Maximum Vacuum	28.5 in Hg	28.5 in Hg
Maximum Pressure	35 PSI	30 PSI

All MASTERFLEX *PERFECTPOSITION* B/T tubing formulations in sizes B/T 87 and B/T 91 can be used with this pump. Be sure tubing material matches application.

WARNING: Verify tubing material chemical compatibility prior to use. It is the sole responsibility of the user to determine suitability of the product for the application.

***PERFECTPOSITION* Pump Tubing**	**B/T 87**	**B/T 91**
Silicone - 10 ft. (3.0 m), Platinum cured	96510-87	96510-91
Silicone - 10 ft. (3.0 m), Peroxide cured	96400-87	96400-91
BioPharm silicone - 10 ft. (3.0 m), Platinum cured	96421-87	96421-91
BioPharm silicone - 3 ft. (0.9 m)	96424-87	96424-91
BioPharm Plus silicone - 10 ft. (3.0 m), Platinum cured	96441-87	96441-91
BioPharm Plus silicone - 3 ft. (0.9 m)	96444-87	96444-91
C-FLEX - 10 ft. (3.0 m)	06424-87	06424-91
Chem-Durance® 25 ft. (7.6 m)	06432-87	06432-91
Chem-Durance® BIO 25 ft. (7.6 m)	06442-87	06442-91
PharMed® BPT - 25 ft. (7.6 m)	06508-87	06508-91
PharMed® BPT - 3 ft. (0.9 m)	95668-87	95668-91
PharmaPure® - 25 ft. (7.6 m)	06435-87	06435-91
NORPRENE® food - 25 ft. (7.6 m)	06402-87	06402-91
NORPRENE® food - 3 ft. (0.9 m)	06403-87	06403-91
TYGON® LFL - 25 ft. (7.6 m)	06429-87	06429-91
TYGON® LFL - 3 ft. (0.9 m)	06430-87	06430-91

WARNING: Before permanent installation, test the equipment with the chemicals and under the specific conditions of your application.

INSTALLING THE PUMP TUBING (All Pump Models)

WARNING: Power must be removed from pump before removing or installing tubing. Fingers or loose clothing could get caught in drive mechanism. Do not operate this pump without cover or interlock door properly closed and latched. Rotating parts can cause serious injury.

1. Cut off power to the pump by disconnecting line cord or, if wired permanently, by removing the fuse. Do not assume that turning off the switch at the motor (or controller) is "safe enough."

2. Unlatch the door latch and open the cover.

3. Insert the tube in the appropriate upper tube retaining pocket (see Figure 2-10). Line up the "*PERFECTPOSITION*" placement marks printed on the tube with the outside edge of the retainer assembly (see Figure 2-8).

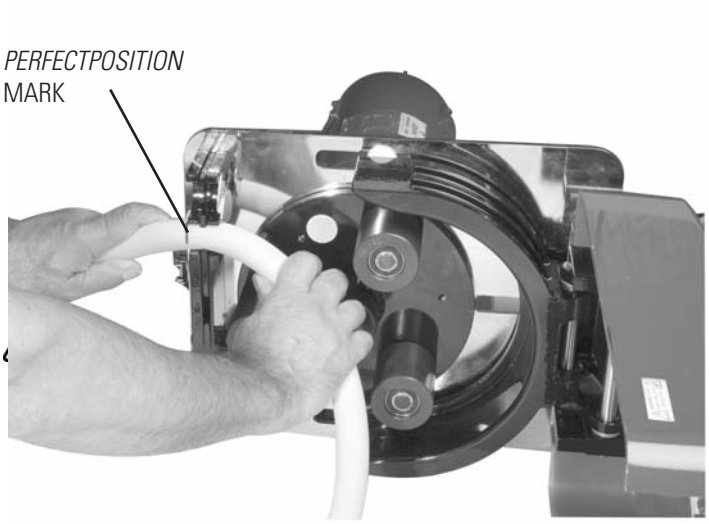


Figure 2-8. Tubing Retaining Pockets

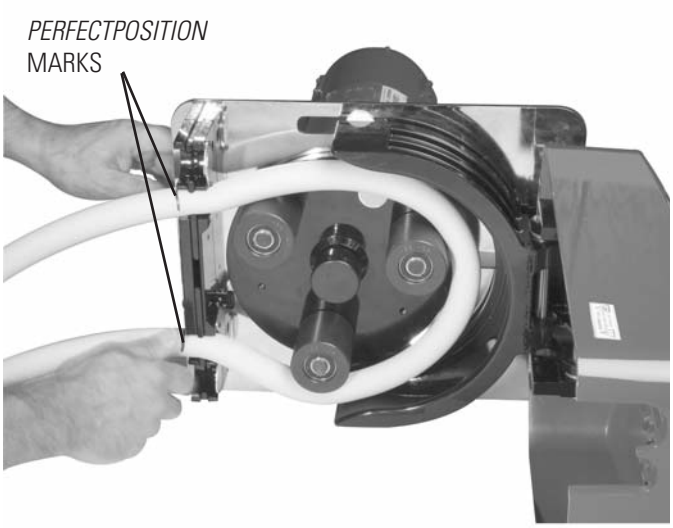


Figure 2-9. *PerfectPosition* Marks

4. If the new tube must be cut from a length of approved replacement tubing, a minimum of 32 inches will be required for a new tube.

5. Going with the natural lay or curvature of the tubing, wrap the tubing around the assembly and insert the tubing in the lower retaining pocket.

6. Close the door and insure that door latch is engaged and locked.

⚠ ***WARNING: Do not operate this pump without cover or interlock door properly closed and latched. Rotating parts can cause serious injury.***

7. Restore power to the pump.

⚠ ***WARNING: To reduce the risk of injury, use hose clamps on all tubing connections.***

All tubing connections must be made outside of the pump.

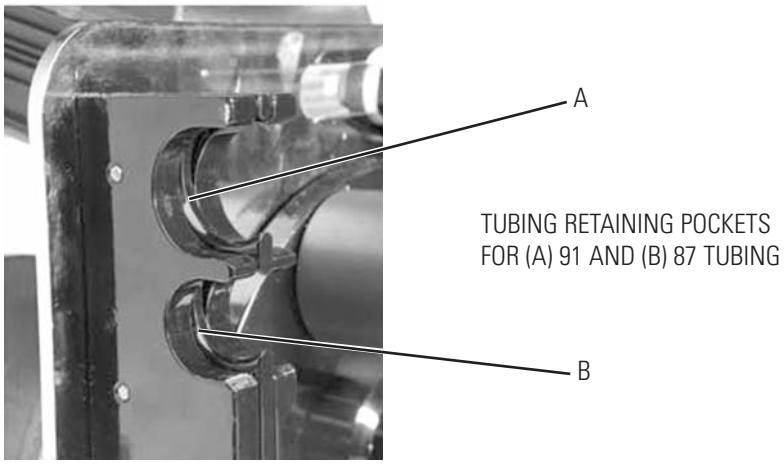
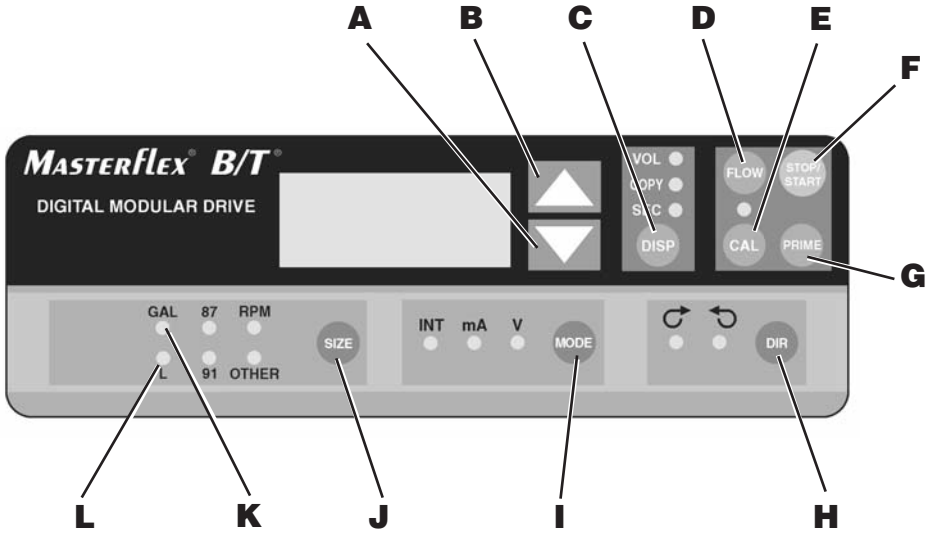


Figure 2-10. Tubing Retaining Pockets

Section 3 Operation

Control Display Functions Models 77111-10 77111-15 77111-40 77111-47



A) DOWN ARROW (DECREMENT)—Decrease value of a flashing display.

B) UP ARROW (INCREMENT)—Increase value of a flashing display.

C) DISPENSE/COPY—Set dispense volume, copy amount, or dispense time.

D) FLOW CONTROL—Set flow rate for selected tubing size. To change flow rate, press ▲ or ▼ arrows. (If pump is running, its speed will change with new settings.)

E) CAL CONTROL—Refine built-in calibration, using a measured volume.

F) STOP/START—Stop/Start motor.

G) PRIME—Run pump at full speed to fill or clear lines.

H) DIRECTION—To change motor direction.

I) MODE SELECT—INT for internal control; mA for remote current control; V for remote voltage control.

J) SIZE—Select tubing size and flow units, also displays maximum flow rate.

K) GALLONS—Flow and Volume units indicator.

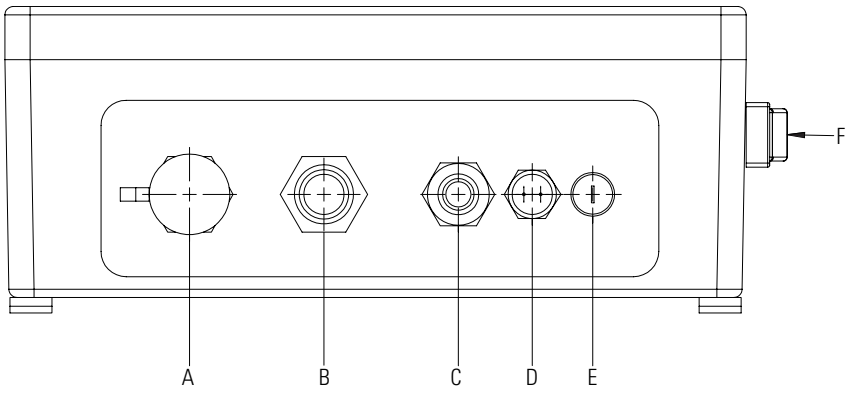
L) LITERS—Flow and volume units indicator.

Figure 3-1. Control Panel

Press buttons to activate function.

Use up/down (▲, ▼) arrows to correct/change a flashing display.

Press STOP/START to enter new values.



A) EXTERNAL RECEPTACLE
B) MOTOR RECEPTACLE
C) LINE CORD
D) INTERLOCK CONNECTOR
E) T8A FUSE (115V AC); T4A FUSE (230V AC)
F) POWER SWITCH — ALL SETTINGS ARE RETAINED IN MEMORY

Figure 3-2. Connectors and Switch on Controller Side Panel

Controller Setup

1. Connect Motor Cable plug to mating receptacle on the Controller.
2. Connect Interlock Cable plug to mating receptacle on the controller.
3. Connect power cord of Controller to grounded power line outlet.
4. Turn controller on and select TUBING SIZE.

NOTE: If CAL LED is lit, that tubing size has been previously field calibrated. If LED is not lit, the drive is operating with the built-in factory calibration. To clear a field calibration, press and hold the CAL switch until the CAL light goes out. This will take about 3 seconds. To recalibrate for better accuracy, see Calibration section.

5. MODE selection (INT, mA, V).
6. Select MOTOR DIRECTION (CW or CCW).
7. PRIME and CALibrate the pump (if required).
8. Press FLOW key and watch display to set the flow rate with UP/DOWN keys.
9. Press STOP/START key to begin pumping.

NOTE: Under some circumstances, tubing may creep into pump. If this problem occurs it can be remedied by installing a hose clamp or fitting immediately upstream of and very close to the inlet port.

NOTE: Pump will restart automatically after a brownout or powerout condition.

Calibration

1. Select correct tubing size and flow rate.
2. Press CAL, calibration volume appears.
3. Press STOP/START, the pump will use its stored memory to dispense the specified calibration sample quantity. The pump will stop automatically.
4. Weigh/measure the sample.
5. Use UP/DOWN arrow keys to correct the flashing display.

NOTE: If the adjusted calibration is too great, "Err" will appear in the display. If this occurs, press the CAL control and repeat the calibration procedure. The microprocessor will retain one special calibration value per tubing size, even when power is turned off. The next calibration will replace the existing value.

6. Press size to exit the calibration cycle.

Maximum Flowrate (OTHER Tubing)

1. To set the maximum flowrate for non-standard pumps or tubing sizes, OTHER press CAL, then FLOW. The maximum flowrate will then flash on the display.
2. Use UP/DOWN arrow keys to set desired flowrate.
3. Press SIZE to exit.

DISPense/copy

A first press of the DISP key results in the last entered dispense volume being displayed. The "VOL" annunciator will illuminate and flash. The INC/DEC keys are used to change the dispense volume, if desired. The STOP/START key then initiates delivery of the set volume. The amount remaining to be dispensed will be displayed during countdown. The dispense function is exited by pressing any key except Increment, Decrement, DISP, or STOP/START.

A second press of the DISP key causes the COPY annunciator to illuminate and flash. The STOP/START key is then used to set the desired volume without the need to know the volume in specific units. A third press of the DISP key enters the volume dispensed. The COPY annunciator stops flashing. The STOP/START key is then used to initiate delivery of the copied volume. The number of copies dispensed will be displayed after each dispense. The STOP/START key is used to pause the copy dispense during dispensing; copy dispense can then be continued using the STOP/START key.

A fourth press of the DISP key results in the last entered dispense time being displayed. The SEC annunciator will illuminate and flash. The INC/DEC keys are used to change the dispense time, if desired, from 1 to 9999 seconds. The STOP/START key then initiates delivery for the set time interval. The remaining time will be displayed during countdown. Pressing the DISP key a fifth time exits this mode.

Keypad Lockout Enable/Disable

Press and hold FLOW. After five (5) seconds, display will change to all dashes. Then, while holding FLOW, press PRIME five (5) times.

The MODE "INT": annunciator will flash when the keypad is locked.

Remote Control

Selectable input (0–20 mA, 4–20 mA, 0–10V DC)

±0.5% linearity control

2300V isolation potential

STOP/START; CW/CCW; PRIME via contact closure

Remote Control Setup

1. Place the power switch in the off position.

CAUTION: Power must be turned off before connecting the external remote control cable to prevent damage to the drive.

2. Connect the cable from the external remote control to the mating receptacle on the bottom panel.

3. Select type of remote control input and output required as follows:

    a). Press and hold the MODE key while turning the power switch to the "ON" (1) position. After two seconds, release the MODE key. The initial display will show: "inP". After two seconds the display will show either 0–20 or 4–20.

NOTE: Press the up (increment) or down (decrement) arrows to select between 4–20 and 0–20 for current loop control.

    b). Press the MODE key again. The initial display will show: "out". After two seconds the display will show either 0–20, 4–20, or 0–10.

NOTE: Press the up (increment) or down (decrement) arrows to select between 4–20 and 0–20 for current loop output, or 0–10 for voltage output.

4. Press the MODE key to select mode of operation. The LED's indicate the selected mode. Select either mA or V.

NOTE: If only remote STOP/START, PRIME and/or CW/CCW is to be used, the MODE control can be set to any of the three positions.

5. To adjust the voltage or current scaling for other than zero to full scale:

    a). Press the MODE key and then the FLOW key at the same time. The display will show "LO" and then the flow rate for minimum current/voltage (factory default = 0).

    b). Use the UP/DOWN arrow keys to change the flow rate for minimum current/voltage.

    c). Press the FLOW key. The display will show "HI" and then the flow rate for maximum current/voltage. Use the UP/DOWN arrow keys to change the flow rate for maximum current/voltage or press the SIZE key to set it to maximum flow rate (factory default). Press any other key to save and exit.

    The same scaling will be used for both input and output. Each tube size has its own scaling.

Remote Control Setup (continued)

NOTE: The maximum flow rate for a tubing will change after a calibration is performed. To retain control of the entire flow range, the "HI" scale setting must be changed to the new maximum flow rate after a calibration is performed.

6. Remote STOP/START can be configured to be optional ("OFF") or mandatory ("ON"). When "ON" is selected, drive will not run unless remote STOP/START is closed When "OFF" is selected (factory default), remote STOP/START can be used to start drive, but drive can also be started by keypad or remote inputs when remote STOP/START is open. Internal mode or remote mode (mA or V) each have their own STOP/START configuration, so first select the desired operating mode before changing STOP/START setup.

    a) Press and hold the MODE key until the display changes to "STOP". The display will alternate with an "ON" or "OFF".

    b) Use the UP/DOWN arrow keys to select "ON" or "OFF".

    c) Press any other key to save and exit.

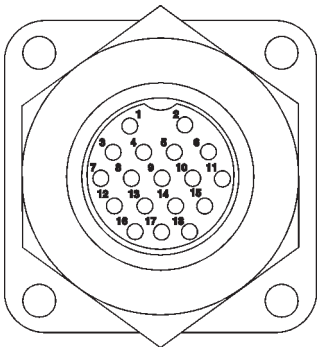
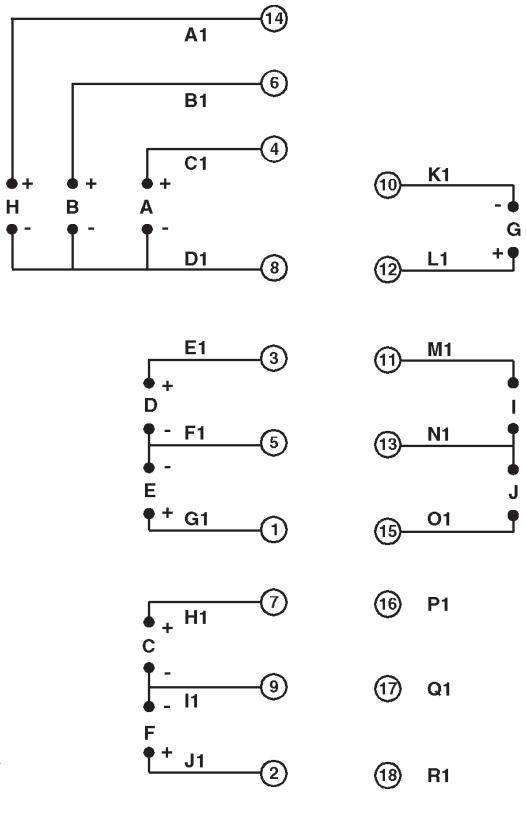


Figure 3-3. Remote Control Connector Pin Configuration

Remote Control Setup (continued)

A1) RED/YELLOW
B1) BLUE
C1) GREEN
D1) YELLOW
E1) WHITE
F1) ORANGE
G1) BLACK
H1) BROWN
I1) VIOLET
J1) RED
K1) GREY
L1) TAN
M1) PINK
N1) RED/GREEN
O1) RED/BLACK
P1, Q1, R1) N.C.

A) STOP/START
B) CW/CCW
C) OUTPUT 0-20mA; 4-20mA
D) INPUT 0-20mA; 4-20mA
E) INPUT 0-10V
F) OUTPUT 0-10V
G) TACH OUTPUT
H) PRIME
I) MOTOR RUNNING N.O. CONTACT
J) MOTOR RUNNING N.C. CONTACT



NOTE: Colors are those of Remote Cable, Cat. number 77300-32.

Figure 3-4. Remote Control Wiring Schematic

Models 77111-60 and 77111-67 Controller

Models 77111-60 (115V model) and 77111-67 (230 V model) are supplied with an electronic controller (see Figure 3-5) for controlling pump speed.

1. Place FWD-OFF-REV switch in the desired position, clockwise (FWD) or counterclockwise (REV) direction.

2. Adjust SPEED control for the desired pump speed.

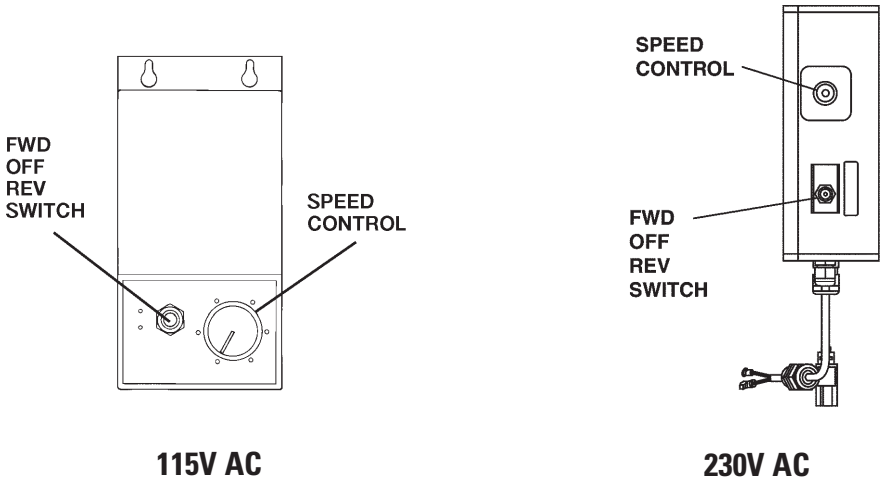


Figure 3-5. Controller

Model 77111-80

Adjust flow rate with adjustment knob on top of regulator. Vary flow rate from 20 psig to 100 psig. At higher pressures, the pump speed may exceed 321 rpm.

⚠ ***CAUTION: Do not exceed 321 rpm. Speeds in excess of 321 rpm may cause damage to unit.***

(Lock flow rate by using snap-action push-pull knob on filter regulator.) For continuous-duty or high-speed application, use of the lubricator is recommended. Adjust the lubricator with the adjustment knob on top. For higher speeds, set lubricator to provide 1–3 drops/minute. Use a lower setting for lower speeds. See below for RECOMMENDED LUBRICANTS. (Lock lubrication rate by using snap-action push-pull knob.)

Figure 3-6. Model 77111-80

Recommended Lubricants

Use a misting type oil rated 50 to 200 SSU (ISO Grade 7 to 46) at 100°F (38°C). Unscrew the bowl to fill the lubricator. Press up on the bottom drain to empty bowl.

Models 77111-00 and 77111-07 Operating Controls

The following chart highlights items included in each model and the operating controls.

Model No.	Motor Included	ON-OFF Switch
77111-00	Yes	Yes
77111-07	Yes	Yes

Figure 3-7. Model 77111-00

Section 4 Maintenance and Troubleshooting

REPLACING MOTOR BRUSHES

MODELS 77111-12 77111-17 77111-40 77111-47 77111-60 77111-67

Tools Required: Phillips screwdriver

WARNING: Power must be removed from motor before performing this procedure.

1. Cut off power to the pump by disconnecting line cord or, if wired permanently, by removing the fuse. Do not assume that turning off the switch at the motor (or controller) is "safe enough."
2. To access the motor brushes, remove six screws securing the access plate and remove plate (see Figure 4-1).
3. Loosen screw terminal at top of brush housing and disconnect brush wire.
4. Press down on brush retainer to disengage tabs then rotate brush retainer slightly toward front of motor and remove brush retainer.
5. Slide brush assembly out of housing.
6. Install new brush assembly with brush wire toward rear of motor and spring assembly on top.
7. Insert brush retainer against brush springs and push down, then rotate retainer slightly toward rear of motor to engage tabs of retainer under rear edge of brush housing.
8. Attach brush wire to screw terminal at top of brush housing. Be sure wire is clear of access opening.
9. Attach cover plate with six screws.

NOTE: Always replace both brushes at the same time.

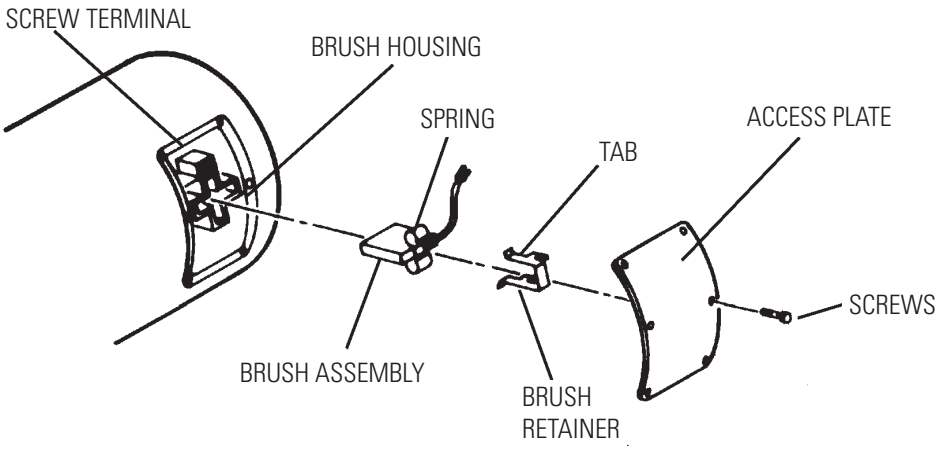


Figure 4-1. Motor Brush

REPLACING ROLLERS

To replace rollers:

1. Using a retaining ring tool (Part Number 109852-CR), remove the retaining rings from the ends of the roller axles and slide the rollers off. Take care to avoid opening the retaining rings too wide.

2. Check to be sure that the wave washers are installed on the axles against the rotor plate.

3. Slide the new rollers, Replacement Roller Kit 07584-02, onto the axles, placing the ends with the flush bearing surface inward toward the rotor plate against the wave washers, and the etched ends with the recessed bearing surface outward toward the free ends of the roller axles.

4. Replace the retaining rings. You may have to push the rollers in to compress the wave washers to allow the retaining rings to engage the grooves in the axles.

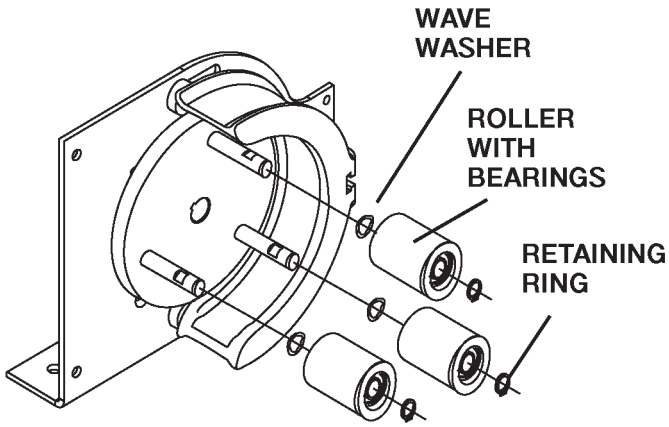


Figure 4-2. Exploded Roller Sub-Assembly

MOTOR REPLACEMENT

Tools required:

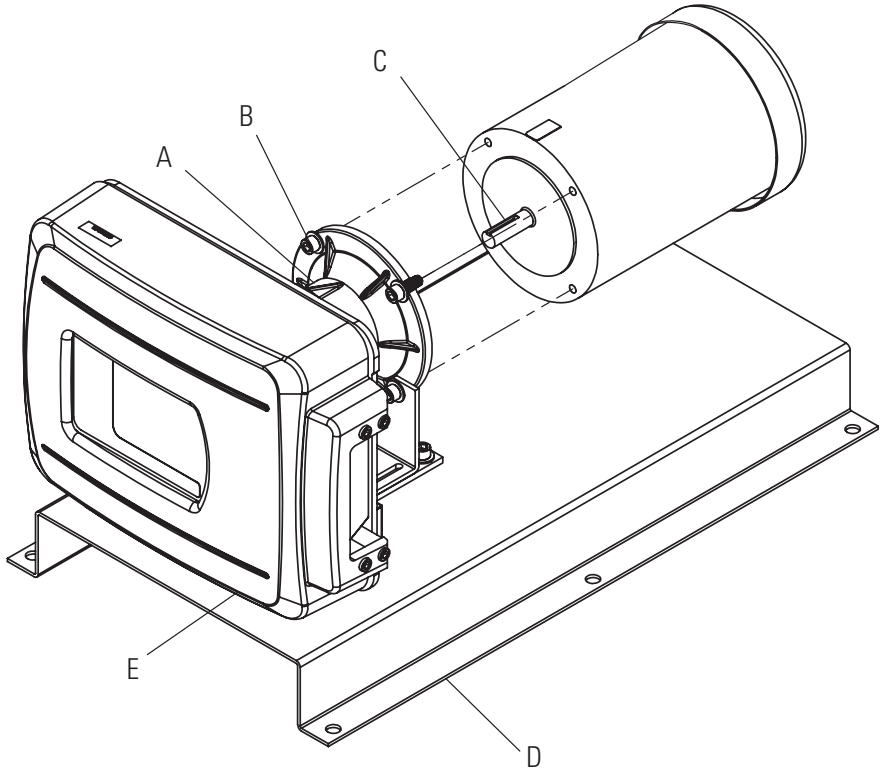
56 C frame mounting, 5/16 inch Hex key.

ISO-71 frame mounting, 10 mm wrench.

To install replacement motor refer to Figure 4-3 and follow these steps:

1. Apply anti-seize compound to shaft and key. Slide motor forward to engage the male motor coupling with the female gear head coupling. Rotate pump rotor if necessary to align the couplings.

2. Using the 5/16 inch hex key, bolt the motor to the gear head adapter by inserting the four bolts through the gear head adapter into the motor. Torque bolts from 17 to 19 foot-pounds.



A) Gear Head B) Bolt C) Shaft
D) Base E) Door Assembly

Figure 4-3. Motor Mounting

Replacement Parts

The following list identifies the replaceable parts and includes the part numbers.

Description	Part Number	Qty per Unit
Motor Brush Set (115V AC), Models 875-2612, 945-1610 and 945-2610	A-4156-CR	1
Motor Brush Set (230V AC), Models 875-2614, 945-1615 and 945-2615	A-4158-CR	1
Door Assembly	109473-CR	1
MASTERFLEX B/T, Roller Kit	07584-02	1
MASTERFLEX B/T, Rotor Assembly/with Rollers	108024-CR	1
Window	109467-CR	1
Shoulder Spacer Kit	109461-CR	6
Safety Switch Assy	109388-CR	1
Fuse - 8.0A, 3AG, (115V AC)		
Models 77111-10 and 77111-40	77500-27	1
Models 77111-60	77500-28	1
Fuse - T10A, (115V AC), Models 77111-00	77500-29	1
Fuse - T3.6A, (230V AC), Models 77111-07	77500-24	1
Fuse - T4.0A, 5 x 20mm, (230V AC),		
Models 77111-15, 77111-67 and 77111-47	77500-26	1
Controller (115V AC) for Model 77111-60	77111-10	1
Controller (230V AC) for Model 77111-67	77111-15	1
Motor (115V AC)		
Models 77111-60	109545-CR	1
Models 77111-10and 77111-40	109593-CR	1
Models 77111-00	109556-CR	1
Motor (230V AC)		
Models 77111-15 and 77111-47	109594-CR	1
Model 77111-67	109546-CR	1
Model 77111-07	109557-CR	1
Air Motor, Model 77111-80	108288-CR	
Motor Mounting Hardware	108688-CR	1
Retaining Ring Kit	07584-07	1
Cable, Control, Extension 20 ft.	108680	1
Line Cord - European, Models 77111-15, 77111-67, 77111-07 and 77111-47	50001-70	1

All MASTERFLEX *PERFECTPOSITION* B/T tubing formulations in sizes B/T 87 and B/T 91 can be used with this pump. Be sure tubing material matches application.

Accessories

Description	Part Number
Retaining Ring Tool	109852-CR
Cable, Interlock Extension, 25 ft.	109389
Mounting Bracket Digital Controller Models 77111-40 and 77111-47 only	77111-90
Remote Cable 77111-10, 77111-15, 77111-40 and 77111-47 ONLY	77300-32
Handheld Remote Controller 77111-10, 77111-15, 77111-40 and 77111-47 ONLY	07592-83
Footswitch Washdown 77111-10, 77111-15, 77111-40 and 77111-47 ONLY	07592-30

Cleaning

Keep the drive enclosure clean with mild detergents. Never immerse nor use excessive fluid.

Troubleshooting Models 77111-40 and 77111-47

Symptom	Cause	Remedy
A. Motor does not rotate. Display does not light.	A1. No power.	1. Check fuse and replace if defective.
		2. Check that unit is plugged into a live line.
		3. Check connection of power cord.
		4. Check the line cord for continuity and replace if defective.
		5. Return for servicing.
	A2. Defective remote control.	1. Place power switch in off position.
		2. Check that remote cable connector is inserted fully into the AC receptacle.
		3. If motor still does not rotate, select INT with the MODE control and press the STOP/START control.
		4. If the motor rotates, replace the remote control with similar unit. If motor will not rotate, return drive for servicing.
B. Motor does not rotate. Display lights.	B. MODE control not properly set.	1. Check that the MODE control is set to INT for operation with front panel control or to mA or V for operation with remote control.
		2. If motor still does not rotate, return for servicing.

Error Codes

If an error message is displayed, refer to the following list for possible corrective action you can take. If these do not correct the problem, contact your dealer.

Symptom	Cause	Remedy
"Err 1"	Changing speed reference too fast (motor undershoots).	Clear by pressing stop/start.
	No encoder pulses from motor.	Check all motor/encoder connections.
"Err 2"	Changing speed reference too fast (motor overshoots).	Clear by pressing stop/start.
	Motor over-speed.	Check all motor/encoder connections.
"Err 4"	Bad PROM.	Return unit for repair.
"Err 5"	Bad zero crossing detector or crystal.	Return unit for repair.
"Err 6"	Bad EEPROM data, operator parameters set to default values.	Avoid fast switching of power to the unit.
"Err 7"	Bad EEPROM data, A/D span cal, span cal set to default.	Return unit for repair.
"Err 8"	EEPROM write/verify error.	Return unit for repair.

Section 5 Specifications

Models 77111-10 77111-12 77111-15 77111-17 77111-40 77111-47

Output:

Speed:	11 to 321 rpm
Torque output, Maximum:	1440 oz-in (104 kg•cm)
Speed regulation:	
Line	±0.25% F.S.
Load	±0.25% F.S.
Drift	±0.25% F.S.
Display:	Four-digit, seven segment LED
Remote outputs:	
Voltage speed output	(0–10V DC)
Current speed output	(0–20 mA or 4–20 mA)
Tach output	(TTL, 128 to 7680 Hz)
Motor running output	(N.O. & N.C. contact closure)
Tubing Compatibility:	Sizes B/T 87 or B/T 91
Flow Range:	up to 10 GPM (37.85 LPM)

Input:

Supply voltage limits:	
77111-40	90 to 130 Vrms @ 50/60 Hz
77111-47	200 to 260 Vrms @ 50 Hz
Current, max.:	
77111-40	6.5A
77111-47	3.3A
Remote Inputs:	Start/Stop, CW/CCW, PRIME (contact closure)
Voltage input	(0–10V DC)
Current input	(0–20 mA or 4–20 mA)

Construction:

Dimensions (L × W × H):	
77111-10, 77111-15	9 in × 11 in × 4 1/2 in (229 mm × 279 mm × 114 mm)
77111-12, 77111-17	28.25 in × 15.88 in × 15.13 in 718 mm x 403 mm x 384 mm
Weight:	
77111-10, 77111-15	9.4 lbs (4.3 kg)
77111-12, 77111-17	89.0 lbs (40.37 kg)
Enclosure Rating:	IP 56 (NEMA 4) Per IEC 60529

Models 77111-10 77111-12 77111-15 77111-17 77111-40 77111-47 (continued)

Environment:

Temperature, Operating:	32° to 104°F (0° to 40°C)
Temperature, Storage:	–49° to 149°F (–45° to 65°C)
Humidity (non-condensing):	10% to 90%
Altitude:	Less than 2000 m
Pollution Degree:	Pollution Degree 3 (Sheltered locations)
Chemical Resistance:	Exposed material is painted aluminum, plastic and vinyl

Compliance:

115V: UL508C, UL778
CSA C22.2 No. 14, C22.2 No. 108
230V (for CE Mark):
EU Low Voltage Directive (EN61010-1),
EU EMC Directive (EN61326) and
EU Machinery Directive (EN809)

Models 77111-60 and 77111-67

Output:

Pump Speed:	12 to 321 rpm
Torque output, maximum:	1100 oz-in (104 kg•cm)
Tubing compatibility:	Sizes B/T 87 or B/T 91
Flow Range:	Up to 10 GPM (37.85 LPM)

Input:

Supply voltage limits:	
Model 77111-60	90 to 130 Vrms @ 60 Hz
Model 77111-67	200 to 260 Vrms @ 50 Hz
Current, max:	
Model 77111-60	6.5A
Model 77111-67	3.3A

Construction:

Dimensions (L × W × H):	
Models 77111-60, -67	27.63 in × 15.88 in × 16.75 in 701 mm × 403 mm × 426 mm
Weight: Models 77111-60, -67	89 lbs (40.4 kg)
Enclosure Rating:	
Models 77111-60, -67	IP56 per IEC 60529

Environment:

Temperature, Operating:	0°C to 40°C (32°F to 104°F)
Temperature, Storage:	-20°C to 60°C (-4°F to 140°F)
Humidity: (non-condensing)	10% to 90%
Altitude:	Less than 2000 m
Pollution Degree:	Degree 3 per EN 61010-1 (Sheltered Locations)
Chemical Resistance:	Exposed material is painted aluminum, plastic and vinyl

Compliance: 115V: UL778, CSA C22.2 No. 108
230V: (for CE Mark)
EU Low Voltage Directive (EN61010-1)
EU EMC Directive (EN61326)
EU Machinery Directive (EN809)

Model 77111-80

Output:

Pump Speed:	35 to 321 rpm
Torque output, maximum:	1100 oz-in (104 kg-cm)
Tubing compatibility:	Sizes B/T 87 and B/T 91
Flow Range:	up to 10 GPM (37.8 LPM)

Input:

Compressed air:	24 cfm (0.68 m3/min) @ 100 psig

Construction:

Dimensions (L × W × H):	27.63 in × 15.88 in × 15.13 in 701 mm × 403 mm × 384 mm
Weight:	63 lbs (28.5 kg)
Enclosure Rating:	IP56 per IEC 60529

Environment:

Temperature, Operating:	1°C to 40°C (34°F to 104°F)
Temperature, Storage:	–10°C to 65°C (–14°F to 149°F)
Humidity: (non-condensing)	20% to 80%
Altitude:	Less than 2000 m
North American Rating:	Class I, Division 2, Groups A, B, C, & D, T6
ATEX Rating:	CE ⟨Ex⟩ II 3 G c IIC T6
Group:	II (Non-mining equipment)
Category:	3 (No ignition source)
Zone:	2 (Infrequent exposure)
Type of Atmosphere:	G (Gas)
Gas Group	IIC (Hydrogen/Acelylene)
Method of Protection:	"c" (Non-electrical equipment construction)
Temperature Classification:	T6 (85°C max. surface temperature)
Chemical Resistance:	Exposed materials are powder coated aluminum, CRS, plastic, and vinyl
Compliance (for CE mark):	EN809 (EU Machine Directive)
	EN13463-1 and EN13463-5 (EU ATEX Directive)

Models 77111-00 and 77111-07

Output:

Pump Speed:	
Model 77111-00	321 rpm
Model 77111-07	271 rpm
Torque output, maximum:	1100 oz-in (104 kg-cm)
Tubing compatibility:	Sizes B/T 87 or B/T 91
Flow Range:	Up to 10 GPM (37.85 LPM)

Input:

Supply voltage limits:	
Model 77111-00	90 to 130 Vrms @ 60 Hz
Model 77111-07	200 to 260 Vrms @ 50 Hz
Current, max:	
Model 77111-00	8.0A
Model 77111-07	4.0A

Construction:

Dimensions (L × W × H):	27.63 in × 15.88 in × 15.13 in 701 mm × 403 mm × 384 mm
Weight:	88 lbs (39.9 kg)
Enclosure Rating:	IP65 per IEC 60529

Environment:

Temperature, Operating:	0°C to 40°C (32°F to 104°F)
Temperature, Storage:	-10°C to 60°C (-14°F to 140°F)
Humidity: (non-condensing)	10% to 90%
Altitude:	Less than 2000 m
Pollution Degree:	Degree 3 per EN 61010-1 (Sheltered Locations)
Chemical Resistance:	Exposed material is painted aluminum, plastic and vinyl

Compliance: 115V: UL778, CSA C22.2 No. 108
230V: (for CE mark)
EU Low Voltage Directive (EN61010-1)
EU EMC Directive (EN61326)
EU Machinery Directive (EN809)

Models 77111-50 and 77111-55

Output:	
Pump Speed:	35 to 321 rpm
Torque output, maximum:	1100 oz-in (104 kg-cm)
Tubing compatibility:	Sizes B/T 87 or B/T 91
Flow Range:	Up to 10 GPM (37.85 LPM)
Input:	1750 rpm maximum 1/2 hp (0.37 kW) 293 oz-in minimum NEMA 56C motor for 77111-50 or IEC 72 71-14F130 frame for 77111-55
Construction:	
Dimensions (L × W × H):	27.63 in × 15.88 in × 15.13 in 701 mm × 403 mm × 384 mm
Weight:	63 lbs (28.5 kg)
Enclosure Rating:	IP65 per IEC 60529
Environment:	
Temperature, Operating:	1°C to 40°C (34°F to 104°F)
Temperature, Storage:	–10°C to 65°C (–14°F to 149°F)
Humidity: (non-condensing)	20% to 80%
Altitude:	Less than 2000 m
Chemical Resistance:	Exposed materials are powder coated aluminum, CRS, plastic, and vinyl
Compliance (for CE mark):	EN809 (EU Machine Directive)

Section 6 Warranty, Product Return and Technical Assistance

Warranty

Use only MASTERFLEX precision tubing with MASTERFLEX pumps to ensure optimum performance. Use of other tubing may void applicable warranties.

This product is warranted against defects in material or workmanship, and at the option of the manufacturer or distributor, any defective product will be repaired or replaced at no charge, or the purchase price will be refunded to the purchaser, provided that: (a) the warranty claim is made in writing within the period of time specified on this warranty card, (b) proof of purchase by bill of sale or receipted invoice is submitted concurrently with the claim and shows that the product is within the applicable warranty period, and (c) the purchaser complies with procedures for returns set forth in the general terms and conditions contained in the manufacturer's or distributor's most recent catalog.

This warranty shall not apply to: (a) defects or damage resulting from: (i) misuse of the product, (ii) use of the product in other than its normal and customary manner, (iii) accident or neglect, (iv) improper testing, operation, maintenance, service, repair, installation, or storage, (v) unauthorized alteration or modification, or (b) post-expiration dated materials.

THIS WARRANTY IS THE EXCLUSIVE REMEDY OF THE PURCHASER, AND THE MANUFACTURER AND DISTRIBUTOR DISCLAIM ALL OTHER WARRANTIES, WHETHER EXPRESS, IMPLIED, OR STATUTORY, INCLUDING WITHOUT LIMITATION, WARRANTIES OF MERCHANTABILITY AND FITNESS FOR A PARTICULAR PURPOSE. NO EMPLOYEE, AGENT, OR REPRESENTATIVE OF THE MANUFACTURER OR DISTRIBUTOR IS AUTHORIZED TO BIND THE MANUFACTURER OR DISTRIBUTOR TO ANY OTHER WARRANTY. IN NO EVENT SHALL THE MANUFACTURER OR DISTRIBUTOR BE LIABLE FOR INCIDENTAL, INDIRECT, SPECIAL OR CONSEQUENTIAL DAMAGES.

The warranty period for this product is two (2) years from date of purchase.

Product Return

To limit charges and delays, contact the seller or Manufacturer for authorization and shipping instructions before returning the product, either within or outside of the warranty period. When returning the product, please state the reason for the return. For your protection, pack the product carefully and insure it against possible damage or loss. Any damages resulting from improper packaging are your responsibility.

Technical Assistance

If you have any questions about the use of this product, contact the Manufacturer or authorized seller.

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B/T® PerfectPosition™ Pump Tubing for 77111- and 77110-Series Rapid-Load® Pump Heads

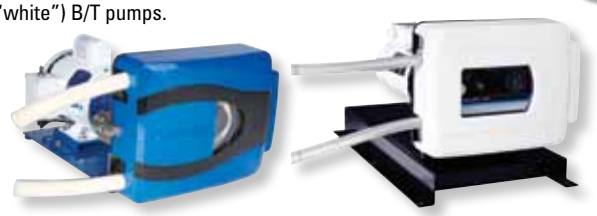
- Ensure optimal performance from your Masterflex pump
- PerfectPosition tubing retention marks indicate the exact placement of tubing in the pump head to provide the best performance and life of the tubing
- Custom extruded to fit 77111-series and 77110-series Masterflex B/T pumps and pump heads
- Engineered for long life in peristaltic pump applications

These Masterflex B/T tubing sizes 87 and 91 are optimized to provide better performance in higher-pressure applications. Each tubing size is manufactured to extremely close tolerances that match our B/T pump heads. These tight tolerances ensure accurate, repeatable flow, and long tubing life. Plus, the PerfectPosition tubing retention marks indicate the best placement of the tubing within the pump head.

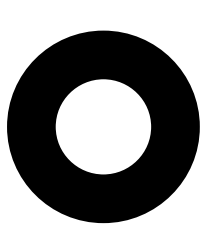
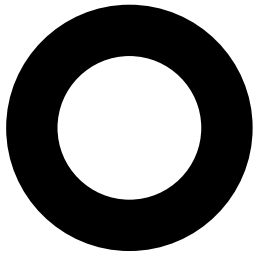
Choose from a variety of tubing formulations below to allow for optimal performance in the most challenging applications. For detailed formulation descriptions and specifications, see pages 1182–1185.

MORE information!

B/T PerfectPosition tubing sizes B/T 87 and B/T 91 are compatible with both the 77110-series ("blue") and 77111-series ("white") B/T pumps.



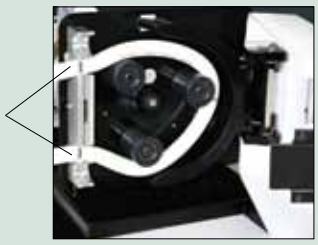
Specifications

	B/T PerfectPosition™ pump tubing	
Tubing cross sections	 B/T 87	 B/T 91

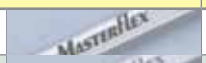
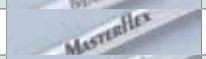
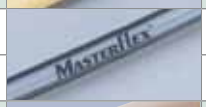
Pump tubing size	PerfectPosition™ pump tubing	
	B/T 87	B/T 91
Inside diameter (nominal) Hose barb size	0.5" (12.7 mm) ½" (12.7 mm)	0.75" (19.0 mm) ¾" (19.0 mm)
Flow range (approximate)† with 12 to 321 rpm drive	0.67 to 17.7 LPM (0.17 to 4.7 GPM)	1.4 to 37 LPM (0.4 to 9.8 GPM)
Maximum pressure‡	40 psi (2.7 bar)	35 psi (2.4 bar)
Maximum vacuum‡ Suction lift‡	26" Hg (660 mm Hg) 29 ft H_2O (8.8 m H_2O)	

†Determined under the following conditions: 0 psi at inlet, 0.5 psi at outlet; water temperature at 72°F (22°C). ‡Actual performance varies depending on tubing formulation—values shown are for firm tubing.

PerfectPosition indicator marks confirm proper loading and ensure optimal performance.



Ordering Information

Pump tubing formulation			B/T PerfectPosition pump tubing	
			B/T 87	B/T 91
Silicone (platinum-cured)	10 ft (3.0 m) per pack		**SN-96510-87 /pk**	**SN-96510-91 /pk**
Silicone (peroxide-cured)	3 ft (0.9 m) per pack		**SN-96406-87 /pk**	**SN-96406-91 /pk**
BioPharm silicone (platinum-cured)	3 ft (0.9 m) per pack		**SN-96424-87 /pk**	**SN-96424-91 /pk**
BioPharm Plus silicone (platinum-cured)	3 ft (0.9 m) per pack		**SN-96444-87 /pk**	**SN-96444-91 /pk**
Puri-Flex™ NEW	10 ft (3.0 m) per pack		**SN-96419-87 /pk**	**SN-96419-91 /pk**
C-FLEX®	10 ft (3.0 m) per pack		**SN-06424-87 /pk**	**SN-06424-91 /pk**
PharMed® BPT	25 ft (7.6 m) per pack		**SN-06508-87 /pk**	**SN-06508-91 /pk**
	3 ft (0.9 m) per pack		**SN-95668-87 /pk**	**SN-95668-91 /pk**
PharmaPure®	25 ft (7.6 m) per pack		**SN-06435-87 /pk**	**SN-06435-91 /pk**
Chem-Durance® Bio	25 ft (7.6 m) per pack		**SN-06442-87 /pk**	**SN-06442-91 /pk**
Norprene® food (A 60 F)	25 ft (7.6 m) per pack		**SN-06402-87 /pk**	**SN-06402-91 /pk**
	3 ft (0.9 m) per pack		**SN-06403-87 /pk**	**SN-06403-91 /pk**
Tygon® LFL	25 ft (7.6 m) per pack		**SN-06429-87 /pk**	**SN-06429-91 /pk**
	3 ft (0.9 m) per pack		**SN-06430-87 /pk**	**SN-06430-91 /pk**
GORE® Style 400 NEW	2.24 ft (0.7 m) per pack		—	**SN-06439-91 /pk**