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Evaluation and Redesign of Hazard Evaluation Tools for Hanover Insurance Group

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Evaluation and Redesign
of Hazard Evaluation Tools
for Hanover Insurance Group

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A Major Qualifying Project Report:

submitted to the Faculty of the

WORCESTER POLYTECHNIC INSTITUTE

in partial fulfillment of the requirements

for the Degree of Bachelor of Science

by

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Date: March 3rd, 2010

Approved:

_____

Professor Joe Zhu, Project Advisor

Abstract

This project redesigned The Hanover Insurance Group's fire sprinkler evaluation tool. By working closely with Hanover's Loss Consultants, we determined the necessary changes and modifications needed to produce an organized and user friendly software that integrates the functions of Microsoft Excel and Hydrograph to determine the adequacy of sprinkler systems. This newly designed tool helps Loss Consultants more efficiently gather and evaluate sprinkler data at a potential client's property.

Executive Summary

Our Major Qualifying Project was completed in association with The Hanover Insurance Group's Loss Control Department. We were assigned the task of creating new software that could easily and efficiently find the percent adequacy of any given sprinkler system, thus giving a Loss Control Consultant the necessary information to deem the dwelling of that sprinkler system as insurable or uninsurable. In order for us to achieve this goal, we became familiar with different types of sprinkler systems, sprinklers, water supplies, and types of fire prevention and protection that a specified building may need. In addition, we also had to familiarize ourselves with the equations and evaluation tools that Hanover Insurance Group is currently using to determine the adequacy of fire sprinkler systems.

The current system Hanover is using is a simple Microsoft Excel spreadsheet that has no organization, direction, or systematic approach to it (Figure 1). This system is often confusing and difficult to use. Hanover's current spreadsheet is not user-friendly, aesthetically pleasing, and is often the source for unnecessary errors. Hanover also uses a program called Hydrograph to find the adequacy of the sprinkler systems. This proves to be time consuming and sometimes problematic because Hydrograph is a separate program from the Excel spreadsheet, meaning that Loss Consultants must operate two programs simultaneously to get the information they need.

	A	B	C	D	E	F	G
1	Account Name						
2	Location Name						
3	Location Address						
4							
5	**Location Sprinkler Information**						
6	Sprinkler Type	Wet					
7							
8	Sprinkler Coverage %	100					
9	No Unsprinklered Areas						
10							
11	Sprinkler Heads (Size/Type)	Standard					
12	K-Factor	5.6					
13	Sprinkler Head Temperature Class	Ordinary					
14							
15	Height to top line sprinklers (ft.)	20.0					
16	Sprinkler Head Age (years)	13					
17	Sprinkler System Type	Pipe Schedule Ordinary Hazard		Go To Sprinkler Demand Requirement			
18	Leave Blank Go To Sprinkler Covg / Head						
19	Leave Blank Go To Sprinkler Covg / Head						
20	Leave Blank Go To Sprinkler Covg / Head						
21	Leave Blank Go To Sprinkler Covg / Head						
22							
23	Leave Blank Go To Sprinkler Covg / Head						
24	Sprinkler Coverage Per Head (sq.ft.)	120					
25							
26	**Sprinkler Demand Requirement**						
27	Occupancy Class (storage heights to 12 ft.)	Other	http://www.nfpa.org/codesonline				
28	Commodity Class (storage Heights > 12 ft.)						
29	Plastics						
30	Average Maximum Storage Height (ft.)	22.0		0			
31	Storage Configuration	Multiple Row Racks					
32	Shelves ?	Slatted Shelves					
33							
34	Aisle Width (ft.)						
35	Encapsulated Stock						
36	Top of Storage to Sprinkler Deflectors (ft.)						
37	Standard Used	Loss Control Bulletin					
38	Figure Number						
39	Density Curve						
40							
41		Complete Section Below					
42	Density Required (gpm/sq.ft)	0.200					
43	Operating Area (sq. ft.)	1,500					
44	Height Adjustment (Density)	100%	Density				
45	Dry Pipe System Adjustment (Area)	100%	Area				
46	Other Adjustment (Density)		No Additional Density Adjustmer				
47	Other Adjustment (Area)		No Additional Area Adjustment				
48	Total Adjustment (Density)	100%					
49	Total Adjustment (Area)	100%					
50							
51	After Adjustment(s)						
52	Density Required (gpm/sq.ft)	0.200					
53	Operating Area (sq. ft.)	1,500					
54	In-Rack Sprinklers	None					
55							
56	Hose Demand Combined (gpm) Use drop do	250					
57	Duration Requirement (Minutes)	60					
58				0.00			
59	**Water Supply Available**						
60	Primary Source Of Water	Public Main					
61	Gravity Tank Gallons						
62	Pressure Tank Gallons						
63	Suction Tank Gallons						
64	Pump: Use drop down: Select Pump Type or s	No Pump					
65	Pump Flow Rating (gpm)						
66	Pump Pressure Rating (psi)						
67							
68							
69	Private Water Supply						
70							
71	Date Of The Last Pump Test						
72		Location	Date	Static (psi)	Residual (psi)	Flow (gpm)	
73	Hydrant Test			78	56	1,234	
74	Hydrant Test Results						
75	Two Inch Drain Test					0	
76	Two Inch Drain Discharge Length	Short Discharge					
77							
78	No Pump			Churn	100%	150%	
79			psi				
80			flow	0			
81							
82	Can Six Step Method Be Used?	Yes					
83							
84	Water Supply Capabilities						
85							
86	Hose Streams (gpm) Available	873	Adequate Water for Hose		623 Surplus (gpm)		
87	Water Supply Adequate for Sprinklers?	Adequate					
88	No Private Water Supply						
89							
90	Sprinkler Protection Adequate ?						
91							
92	Comments: Type your comments here -->						

HSW v.1.2a 1-10-08 (Hanover Sprinkler Worksheet) © Copyright 2005-2007 Citizens & Hanover Insurance All Rights Reserved.

Sprinkler Worksheet | Water Supply Graph | 2" Drain Discharge | Water Supply Analysis | Pipe Sch

Figure 1: Hanover Insurance Group's Current Evaluation Tool

Our first redesign of the software was much improved when compared to that of the current spreadsheet. This program kept an Excel worksheet but used a new and improved data collection form, written in Visual Basic in the Developer section of Excel, which would communicate back and forth with Excel. The user interface of this model was an improvement on the original because it was labeled properly, the equations were organized in a logical manner, and the new system was overall more user-friendly as it employed the use of prompts and help options for the user. The first redesign consisted of tabbed pages which made the software easy to use and navigate through (Figure 2). This redesign also incorporated the function of Hydrograph and the percent adequacy into the evaluation tool, making the overall process easier, faster, and more efficient for the Loss Consultants using the program. However, our first redesign was not perfect. This program did not meet some of Hanover's requirements because it did not create an open dialog between the user and the program, there were no options to "save" or "create new" within the program and it was unable to resize itself properly as no scroll bars would appear cutting off vital parts of the program. Most importantly, the Visual Basic language that the program was coded in did not always allow for some calculations, resulting in error messages and program bugs. In response to these problems, our team created a second design for this program in hopes of eliminating all of short-comings of the first redesign.

Our second redesign is not only a tremendous improvement to the original spreadsheet

and the first redesign, but also exceeds the requirements and expectations of the Hanover

Insurance Group. Like the first redesign, this second software combines a data collection form

and Microsoft Excel; however it is coded in C# language instead of Visual Basic. Although Excel

and the new data collection form still communicate back and forth, they use a "middleman"

program to speak to both parties called Microsoft Visual Studio 2008. This redesign also

incorporates Hydrograph into the software, eliminating unnecessary steps when being used.

The graphical user interface (GUI) in this redesign is a further improvement on the previous

redesign. It is made up of tabbed pages making it easy to use and navigate through because all

the information and inputs are very organized (Figure 3). It is aesthetically pleasing and

professional in its appearance which is an upgrade from the original spreadsheet. This user

interface makes use of text boxes, multiple choice options, and "yes" or "no" questions and

answers. Sections of each tab are invisible or "grayed out" until certain inputs have been

chosen making the chance for error much smaller. This second redesign is better than the first

for several reasons. This version has a drop down "File" menu that allows the user to perform a

multitude of other tasks. There is a "Save/Save As" option which allows the user to save all

inputs and assign a file name. The user has the option of creating a new form under the "New"

option. There is an option to "Open in Excel", which gives the user the capability to print in

Excel format or just view in Excel. There is also an "Exit" option which allows the user to Exit the

program.
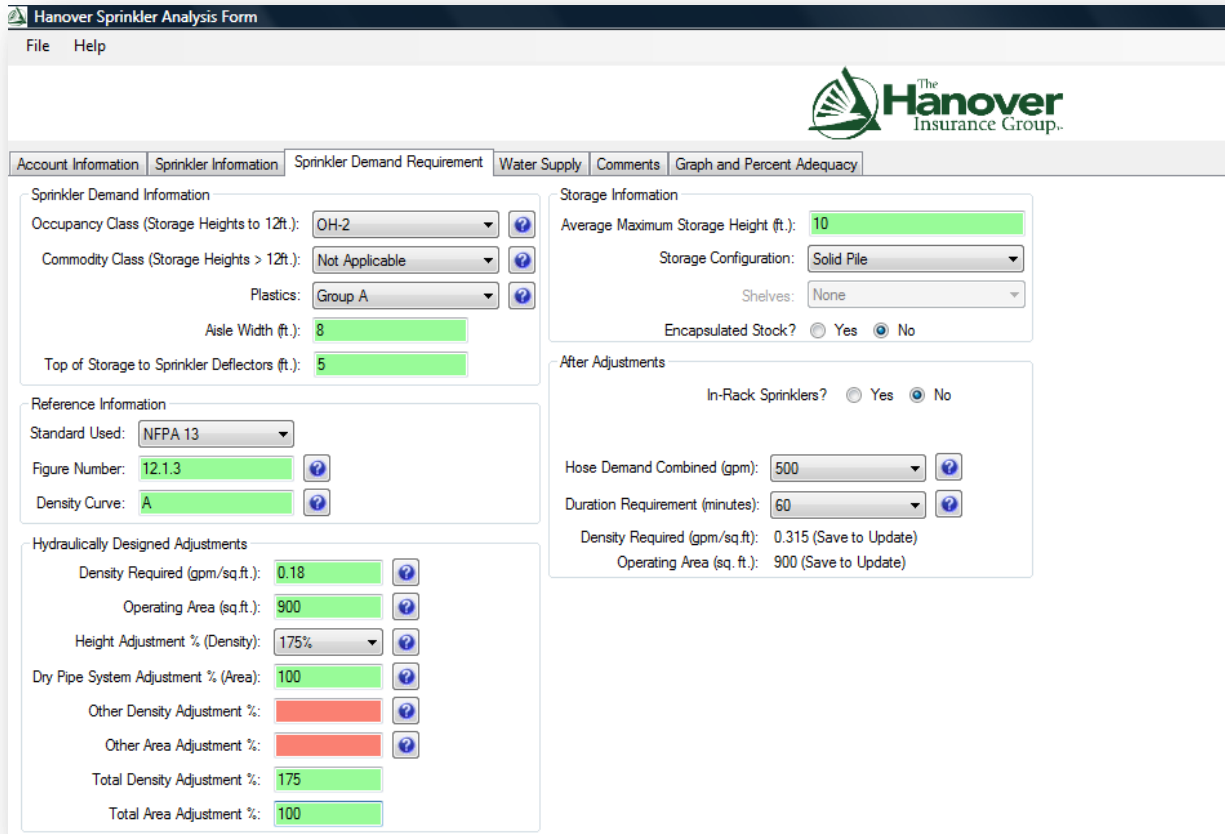
The new software we created for The Hanover Insurance Group meets all the requirements given to us. We designed and created a program that makes the analysis performed by Loss Consultants easier, faster, and more efficient. By combining the functions of the Excel spreadsheet and the Hydrograph software into one program we enabled the users to spend less time analyzing the adequacy of a sprinkler system and ensured far more accurate results. We created a user interface that looks professional and is aesthetically pleasing. The organization and tabbed pages of the interface allow for users to move through the program flawlessly and quickly, making the job easier, more efficient, and far more precise.

Acknowledgements

Our team would like to thank the Hanover Insurance group for giving us the opportunity to work on this project and contribute to the development of the company's professional evaluation tools. In particular, we would like to thank Christopher Beckman, Director of Property Loss Control, for his insight and guidance throughout our work on this project. We would also like to acknowledge Michael Billings, Vice President of Loss Control and Premium Audit, for his help regarding the inner workings of the company's evaluation software. Our team thanks Professor Milosh Puchovsky of the Fire Protection Engineering Department for his insight into the structure and function of fire sprinkler systems. We also thank Patrick Newell of the Computer Science Department, WPI Class of 2010, for his endless help in programming the sprinkler evaluation software. And finally, we would like to give a special thanks to our advisor, Professor Joe Zhu of the Management Department, for his help, guidance, support, and motivation throughout this project.

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1.0 Introduction

Hanover Insurance Group, established in 1852, is one of New England's leading insurance agencies which was originally formed to offer businesses protection against fire – one of the most common and deadly hazards of the time. Today, Hanover Insurance Group focuses on offering Property and Casualty products to their clients, business or personal.

A large part of Hanover's products pertain to evaluating and insuring their business client's properties. Some of their more popular Property products range from insuring a business's buildings, such as office areas, manufacturing areas and storage warehouses against hazards like fire, flood, and theft; as well as protection of other assets like company cars, records and documents, goods in transport, and business-liability protection. With these Property Insurance solutions, Hanover is able to aid businesses in adding value to their company, as well as reducing concerns of liability and loss.

Before fully committing to insuring a business property, Hanover's Loss Consultants must evaluate the property and determine a percent adequacy rating in accordance with their insurability standards. Their evaluation will determine what kind of hazards are present that need to be accounted for, and whether or not the business is eligible for insuring, and how much Hanover can insure them for. When evaluating an office property or warehouse, some of the biggest hazards that must be evaluated are fire hazards and the available protection against those hazards. Every building has its own kind of sprinkler system with different specifications, including the water sources, and what types of materials or number of people could be in the building at any given time. There are many different factors that the Loss Consultants must take

into consideration, which is why Hanover has developed a system for gathering this information.

Currently, Hanover Insurance's sprinkler evaluation system, a Microsoft Excel worksheet, is not working to its full capacity making it difficult for their Loss Consultants to use. If the Loss Consultants were able to better define the exact specifications of a property, while taking all factors into consideration and produce a more accurate percentage adequacy to Hanover's insurance standards, Hanover Insurance Group would be able to offer more competitive rates to their customers. This would be beneficial to both Hanover Insurance and the businesses they insure, and could potentially increase Hanover Insurance Group's success in the insurance industry.

Along with the sprinkler evaluation worksheet, Hanover's Loss Consultants use other methods of data collection and evaluation when considering different kinds of hazards at a business site. At this time, Loss Consultants do not use a uniform method of evaluating these hazards. A "Hazard Evaluation Tool" based on average ratings by the Loss Consultants could reduce time spent evaluating these hazards, and produce more uniform end results for the clients. Both of these improvements to the current evaluation methods used by Hanover's Loss Consultants could ultimately streamline their evaluation process.

2.0 Literature Review

One of the primary reasons that Hanover Insurance Group currently has problems with its fire sprinkler evaluation tool is that there are many factors associated with fire sprinklers, building codes, and property insurance. In order to better assess the problems presented in the current evaluation tool, we conducted research on the different types of sprinkler systems that a Loss Consultant might encounter; along with the National Fire Protection Association (NFPA) safety guidelines that Hanover must adhere to.

2.1 Types of Sprinkler Systems

There are many different types of sprinkler systems, all of which have various functions and detonation methods. Each sprinkler type must be installed according to building codes, standards, and regulations.

2.1.1 Wet Pipe Systems

Wet pipe sprinkler systems are the simplest and most common type of fire sprinkler in use. In this type of sprinkler system, the piping contains water at all times and is directly connected to a water supply that discharges water immediately upon sprinkler activation (Figure 4). Wet pipe systems are typically more reliable that other kinds of systems. (NFPA 12 p. 133)
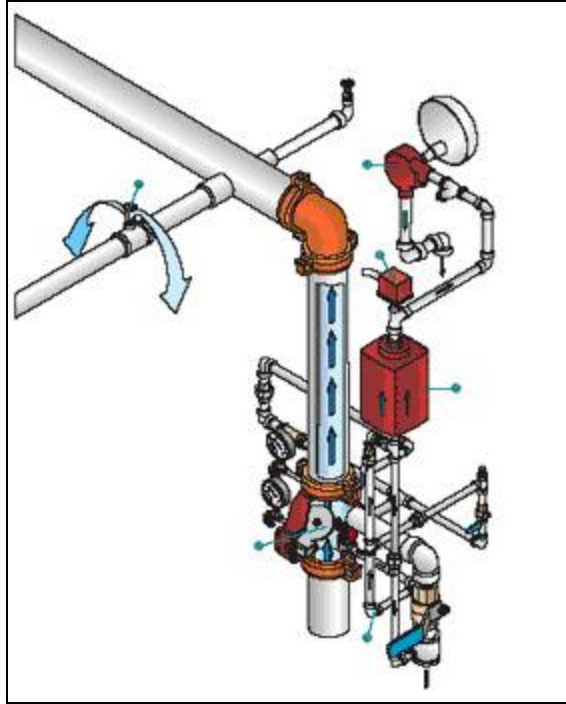
Figure 4: Wet Pipe Sprinkler System

2.1.2 Dry Pipe Systems

In a dry pipe sprinkler system, the piping is not filled with water, but instead is filled with either air or nitrogen that is constantly under pressure. When the sprinklers are activated by heat or smoke, the air pressure is reduced allowing water to enter the piping (Figure 5). Dry pipe systems are usually used in areas or buildings that are prone to freezing. They require more maintenance and attention than wet pipe systems. (NFPA 13 p. 135)
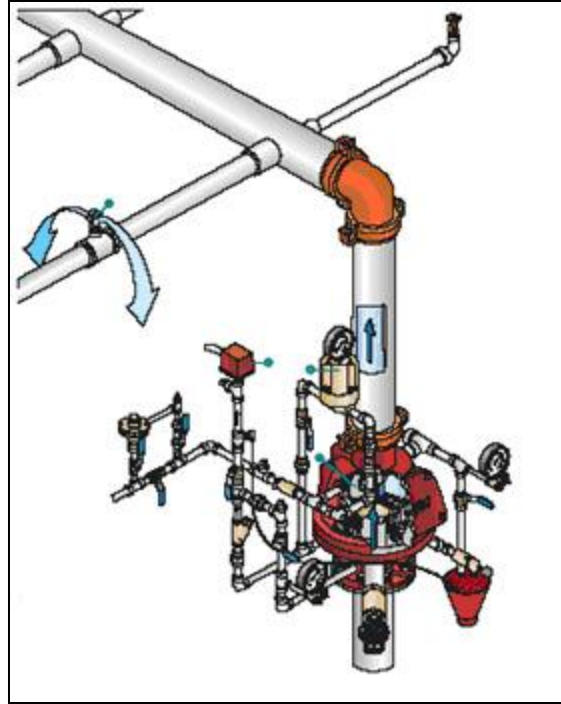
Figure 5: Dry Pipe Sprinkler System

2.1.3 Pre-action Systems and Deluge Systems

Another set of common fire sprinkler types are pre-action and deluge systems. These systems are much more complex than wet and dry pipe systems and require much more attention and maintenance (Figure 6). Failure to monitor these systems closely could result in an unreliable or malfunctioning sprinkler system. There are three basic types of pre-action systems. The single interlock system is a system that admits water to sprinkler piping upon detection of heat or smoke. The second type is called non-interlock system, which is a system that admits water to the sprinkler piping upon operation of detection devices or automatic sprinklers. Double interlock system is a sprinkler system in which water is admitted to the sprinkler piping upon operation of both detection and automatic sprinklers. (NFPA 13 p. 148)
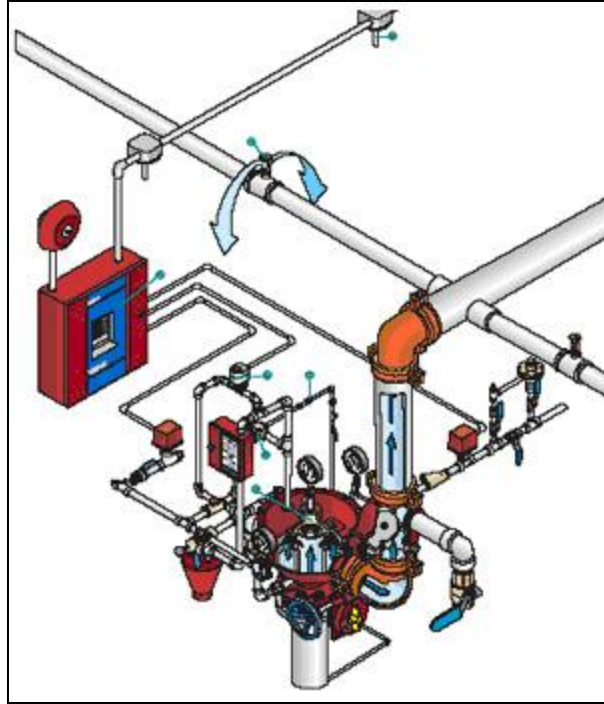
Deluge systems are normally used in highly hazardous areas. Deluge systems rely on supplemental detection to activate them, much like pre-action systems. (NFPA 13 p. 151)

2.1.4 Ultra-High-Speed Water Spray Systems

The ultra-high-speed system is a very sophisticated type of fire protection and is used to protect against explosive hazards. This sprinkler system is the cutting edge of fire protection technology, however it is also very difficult to install. This system is defined as one that can commence the initiation of discharge of water to a volatile commodity within 100 milliseconds of detection, measured from presentation of an energy source to the detector to flow of water from the nozzle being tested (Figure 7). This response level is required in cases where materials of very high heat and flames release are present. (NFPA 16-7)
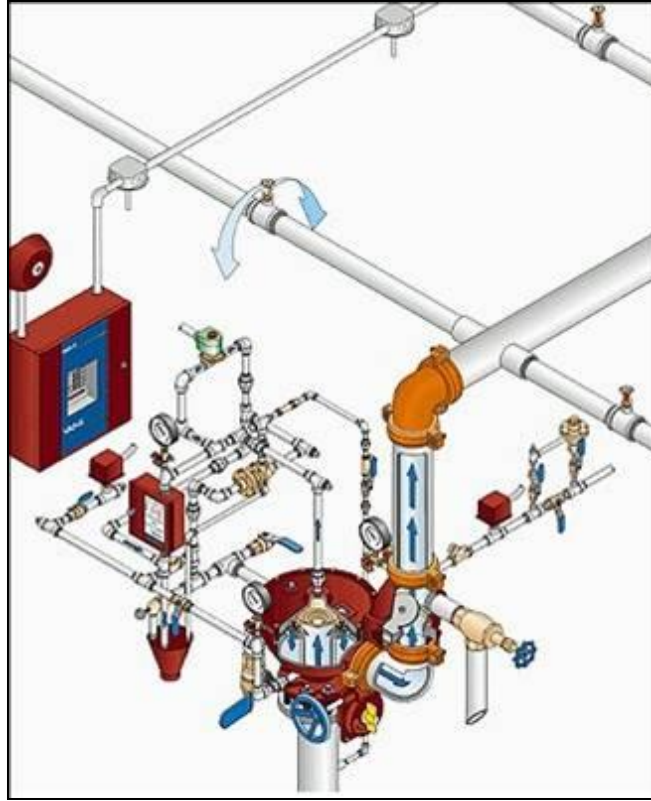
Figure 7: Ultra High Speed Sprinkler System

2.1.5 Water Mist Fire Suppression System

Water Mist Fire Suppression Systems are a newer technology that is currently being researched. The primary goals of this kind of system is to release less water while still extinguishing or preventing the spread of fire, a piping system that is lightweight , and a reduction in overall cost. . This system has objectives that it strives to meet. The first is to protect lives and property in a compartment, or section of from external fire threat. The second is to control fire temperatures in a compartment to prevent flashover and fire spread to adjacent compartments. The third objective is to use water to provide protection where there was no previous protection, such as aircraft passenger compartments. Another goal is to use

water where halon or carbon dioxide was previously used, such as fires in machinery rooms. The last objective is to provide freedom from sprinkler system design constraints with equivalent level of safety. Some system details include: low-pressure to high-pressure systems, sing- and twin-fluid systems, normally open nozzles, deluge-type systems, with separate detection system for activation, continuous discharge, and repeated short discharges (NFPA 16-8).

2.1.6 Standpipe and Hose System

Standpipe systems are fixed piping systems with associated equipment that transports water from a reliable water source to designated areas of a building where hoses can then be used for fighting fires. This kind of system can greatly improve efficiency in terms of manual fire-fighting and even in buildings with installed sprinkler systems. This kind of system plays a huge role in building fire safety and complements the sprinkler system. (NFPA 16-10)

2.1.7 Automatic Sprinkler Systems

The type of sprinkler system that this project mainly deals with is automatic sprinkler systems. Fire sprinkler systems are usually designed so that each individual sprinkler throughout the system can sense and react to heat from a source, such as a fire, and then dispense water over that source. The complexities of the relationship between fire and sprinkler systems have, in the past, been an obstacle in designing sprinkler systems using analytical design methods. Today, there is an ever-growing understanding for the measurement of performance characteristics in sprinkler systems and how those characteristics can be used to achieve fire protection goals. (NFPA 16-1)

Automatic sprinklers are thermo sensitive devices that react to predetermined temperatures by automatically releasing and distributing water in specified quantities and patterns over designated areas. The ultimate goal of this water distribution is to extinguish or contain a fire and prevent its spread. In automatic sprinkler systems water is fed to sprinklers by means of a piping system on which the sprinkler heads are placed at predetermined intervals along the pipes. (NFPA 16-2)

The operating elements of an automatic sprinkler system can be broken down into two categories: fusible sprinklers and bulb sprinklers (Figure 8 and Figure 9). Fusible sprinklers contain a metal alloy with a predetermined melting point. When the alloy fuses then the system begins to operate. Bulb sprinklers use a frangible bulb, in most cases made of glass, which contains a liquid that almost completely fills the bulbs except for a small air bubble that is trapped inside the glass. In case of a fire, when heat starts to expand the liquid, the air bubble disappears and pressure raises causing the bulb to shatter and the sprinkler to begin operating. (NFPA 16-2)

Figure 8: Bulb Sprinkler Head

Figure 9: Fusible Sprinkler Head

In addition to the different types of operating elements in automatic sprinkler systems, there are also different types of sprinkler heads. Recessed sprinklers are housed in a recessed hole in the ceiling. Flush-type sprinklers are used when appearance of the sprinklers is important. They are designed so that there is minimum projection of the working parts below the ceiling in which it is installed. When and if a fire does occur, the sprinkler heads will drop to a level below the ceiling and begin operation. Concealed sprinklers are somewhat like the flush-type sprinklers; however the entire sprinkler is housed in the ceiling and cannot be seen from the ground. In the event of a fire, the sprinkler drops down and begins operation.   Ornamental sprinklers are sprinklers that are decorated by plating or enameling to give a surface that blends into its surroundings. (NFPA 16-2)

2.2 Building and Factory Standards

The United States Department of Labor Occupational Safety and Health Administration, more commonly known as OSHA, has a set of standards that must be met for an operation and building to be used when it comes to fire protection. Maintenance, upkeep, and supervision of

fire protection must always be monitored in order for OSHA to approve the said operation or building. There are many requirements listed in this standard that cover design, testing, water supplies, and even specifics such as types of sprinkler heads. All automatic sprinkler designs used in an operation must provide the necessary discharge patterns and water flow for complete coverage in a workplace in order to comply with OSHA standards and it is the job of the employer to assure that only approved equipment is used in the automatic sprinkler system. It is also the job of the employer to make sure that proper maintenance is preformed on the system and that acceptance tests are run on it on a regular basis. Acceptance tests include the following: flushing of underground connections, hydrostatic tests in the piping system, air tests in dry pipe systems, dry pipe valve operation, and tests of drainage facilities. The employer must ensure that there is at least one water supply for every automatic sprinkler system, the water supply can last at least 30 minutes, and that the pipes of the automatic sprinkler system are protected against freezing and exterior surface corrosion.

OSHA also has standards specific to sprinklers. It is the duty of the employer to make sure that only approved sprinklers are being used throughout the system, that all sprinklers being used are up to date, and that all sprinklers are protected from mechanical damage. Finally, it is also stated that sprinkler systems holding more than twenty sprinkler heads should be alarmed upon activation. Sprinklers should also be spaced accordingly throughout the system to reach the maximum area covered by water discharge. (OSHA. Part #1910, subpart L, subpart title: Fire Protection, standard #: 1910.159, title: automatic sprinkler systems.)

2.3 Sprinkler Systems and Insurance

The insurance industry can be credited for expanding the use of sprinkler systems. Initial system use was justified by the significant reduction in property loss. This was evident in events of fire where there was a sprinkler system versus events of fire where there was no sprinkler system in place. Sprinkler systems also offer a high life safety benefit. (NFPA) Today, insurance agencies use the quality, performance, and adequacy of fire sprinklers systems as a measure of a client's insurability. In order to analyze and evaluate these factors, insurance agencies use various tools to ensure these measures are up to code.

2.4 Sprinkler Evaluation Tools

For the past several decades, the Hanover Insurance Group's Loss department has been using a complex Microsoft Excel spreadsheet as a tool to evaluate the risk associated with insuring a particular building. These risk evaluations are primarily based on the structure, function, and adequacy of the building's sprinkler system.

A Loss Consultants goes to the site of a potential client and examines the building, observing its condition, structure, and layout, along with the design and layout of the sprinkler system. The consultant records various information such as sprinkler type, size and location, sprinkler demand requirements, and water supply type, and inputs this data into the spreadsheet. The spreadsheet performs calculations and produces a graph that allows the consultant to see the risk associated with insuring this particular client. Along with the Excel spreadsheet, Hanover Insurance Group also uses a software program called Hydrograph to further evaluate the adequacy and performance of the sprinklers as well as the risk level associated with insuring a particular building.

The Microsoft Excel spreadsheet, which serves as the primary sprinkler evaluation tool, has many flaws in layout, design, and function. The spreadsheet is complex and consists of five different sheets, including a sprinkler data worksheet, a water supply graph, and a water supply analysis sheet (Figure 10). The "Sprinkler Worksheet" is the sheet where all the sprinkler data that is collected in the field is entered. This worksheet has a large volume of data entry fields – some of which are selected from a drop-down menu while others are entered manually. All of the entry points are linked by formulas which perform the necessary calculations to determine the risk factor of insurance. Having so many entry points linked by so many complex formulas can often lead to input errors, resulting in inaccurate outputs. In addition to that, the layout and interface of the spreadsheet is confusing and difficult to navigate. If the user is confused or misguided by the spreadsheet it can also result in sizable errors which may deem the final evaluation completely inaccurate.

Figure 10: Sprinkler Evaluation Spreadsheet

In addition to the design and user interface problems associated with the spreadsheet, it is also inconvenient for the Loss Consultants to use a second tool, the Hydrograph, to complete the sprinkler evaluation and determine the percent adequacy of the system. In order to address these issues, our team has designed a new evaluation tool for Hanover Insurance Group which is far more user friendly and combines the functions of the Excel spreadsheet and the Hydrograph program to determine whether or not a property is insurable.

3.0 Design and Methodology

The Hanover Insurance Group's Loss Control Department currently utilizes an Excel spreadsheet to enter, measure, and evaluate fire sprinkler safety requirements at a potential client's business site. A large part of the Loss Consultants' duties involve analyzing a potential client's fire safety sprinkler system. Before they can give a quote or insure a business, the consultants collect the required data pertaining to the current sprinkler system. It is important for the Loss Consultants to be able to efficiently and effectively collect this data to make sure they are insuring the business for the correct amount of coverage. Any potential miscalculations in the data could lead to an under- or over-estimation of pricing and level of coverage; which could have negative effects on both parties. Their current Excel worksheet is what Loss Consultants use on-site at a business to input the values they've collected. After they've gathered and input the necessary information, the spreadsheet makes calculations to determine whether or not the business passes Hanover's sprinkler capability requirements. In addition to this, the consultant also uses the Hydrograph program, which generates a graph and calculates the percent adequacy of the sprinkler system which determines whether or not the business qualifies to be insured. Currently, these combined methods do not produce results to the highest efficiency possible. Hanover Insurance decided that they would like these two evaluation tactics combined into a single software program to better accommodate their needs and increase productivity.

Before we started making any adjustments or alterations to the spreadsheet Hanover provided us, we needed to determine exactly the adjustments and changes they were looking for. To better understand our goals, we set up a meeting with Christopher Beckman, Director of

Property Loss Control. We knew Mr. Beckman would be able to provide us with the information we needed, as he is someone who dealt directly with the original evaluation tool in his job, and oversaw other consultants using this spreadsheet. After initiating a conference call with Chris, we were able to make a list of requirements for the new Sprinkler Evaluation software. Along with the integration of the sprinkler worksheet capabilities with the Hydrograph software, the overall Graphical User Interface (GUI) needed to be more efficient for the end users, and the software itself needed to be able to better calculate and evaluate all of the sprinkler specifications. With all of these improvements, the Loss Control Department will be able to more efficiently produce the results and percentages needed for fire sprinkler evaluation.

3.1 Problems with Current Evaluation Tool

The Microsoft Excel spreadsheet, Hanover Insurance Group's current primary method of fire sprinkler evaluation has numerous flaws and defects, making it difficult to use and hard to produce accurate results. The "Sprinkler Worksheet," the worksheet that collects all the input data, consists of over 100 data entry fields, some of which are selected from drop-down menus while others require manual entry. Some fields call for numerical entries while others require text input, and these requirements are not specified anywhere in the spreadsheet which can be very confusing especially for a new or inexperienced user (Figure 11).
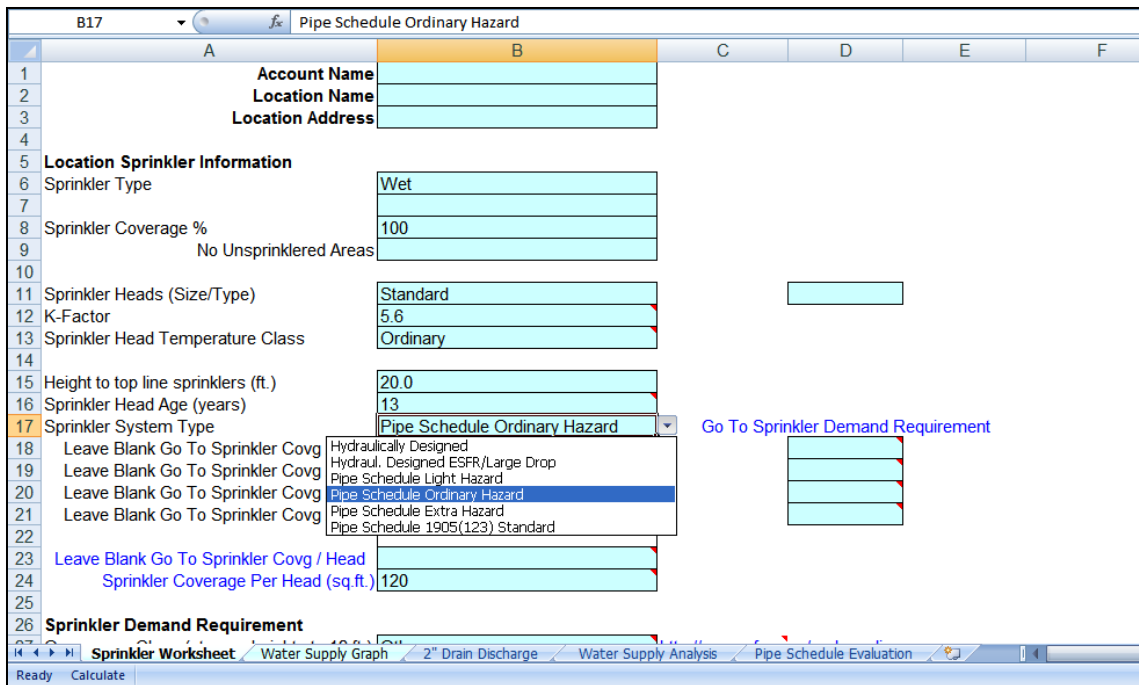
Figure 11: Original Sprinkler Evaluation Spreadsheet Input Fields

Each entry field, which requires an input, is a cell in the spreadsheet. However, these entry fields are surrounded by other cells which are blank, meaning they are not linked to a formula and do not call for an input. Some of the blank cells are not well marked to distinguish them from those cells that do require an input. This creates a great deal of confusion for the user and makes it very easy for the user to put the data into the wrong cell, creating significant errors in the calculations.

Some of the entry field cells are coded with a formula that calls to several other cells and uses that data to produce a result. However, some formulas in the current spreadsheet call to empty cells, deeming the calculations completely inaccurate. In addition, some cells in the spreadsheet appear to be blank but in reality are not. These cells are coded with a formula but

the formula is written in white font making it invisible and creating a whole new set of

opportunities for errors (Figure 12).
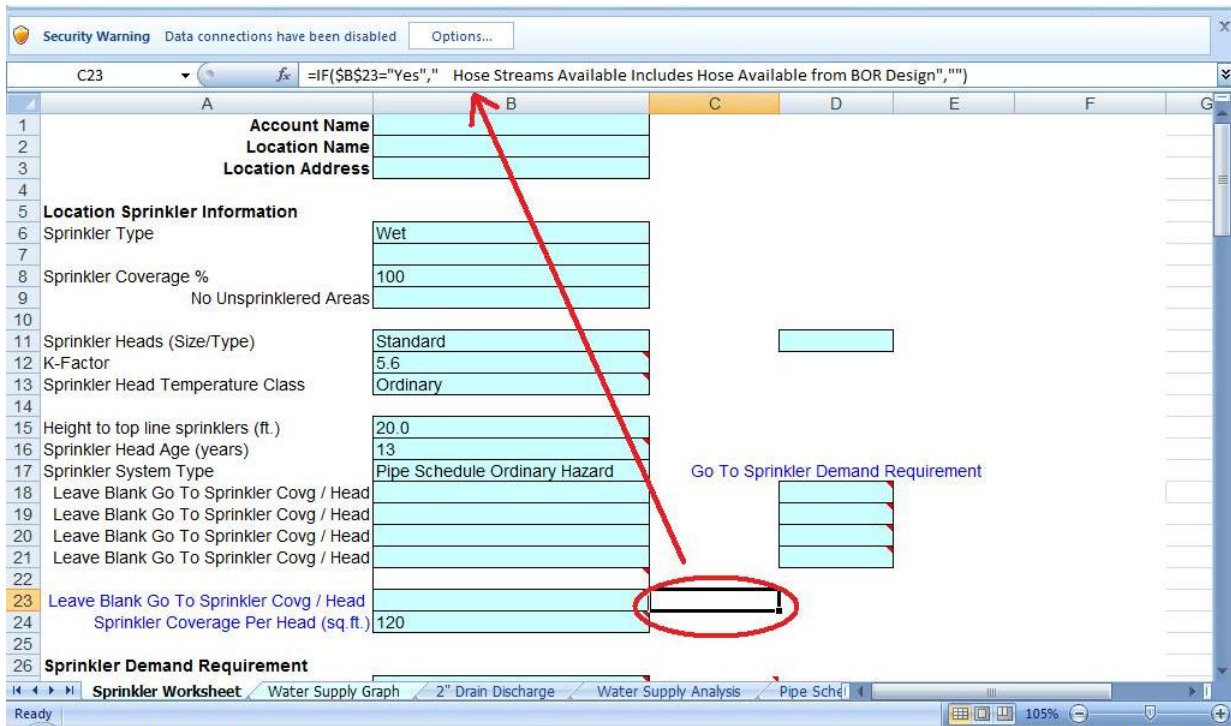
Figure 12: Original Spreadsheet – Blank Entry Fields

Furthermore, the Excel spreadsheet lacks in layout and interface design. It is sometimes

difficult to tell which text is just a heading and which text is a label to indicate the input data to

be entered in the corresponding cell. Blank cells make this especially difficult to decipher. Some

input box labels are also written in a different color font and it is not always apparent to the

user why that is and what he or she should do in these cases.

As mentioned before, the Excel spreadsheet is not the only tool Hanover Loss

Consultants have to use in order to fully evaluate sprinkler systems. In addition to the

spreadsheet, the consultants must use a separate software program called Hydrograph to

determine the percent adequacy of a sprinkler system. This is inconvenient for the Loss

Consultants and highly inefficient for the company as a whole.

In order to address the problems encountered with Hanover Insurance Group's sprinkler

evaluation spreadsheet, our team designed and created a new software that is far more

efficient and user friendly. We improved the graphical user interface, and combined the

functions of the Excel spreadsheet and Hydrograph software to create one integrated

evaluation tool.

3.2 First Redesign

Our first attempt at a redesign was conducted with the user interface, layout, and

organization in mind. This redesign was also created to integrate the functions of Microsoft

Excel and Hydrograph using Visual Basic for Applications (VBA) software.

3.2.1 Sprinkler Evaluation Software Development

One important objective that we wanted to accomplish in this project was to create a

more efficient software program to perform the calculations and data collection that Hanover

requires to complete their work. In Hanover's current system, they use Excel spreadsheets to

collect and organize their data, and then use this information to perform the calculations

necessary for the problem they are trying to solve.

Listed in the table below are the functions and equations that are used to compute any

of the calculations that are a part of the original Excel Sprinkler Worksheet and the new

Sprinkler Analysis Software. The table lists all of the formulas by name, and all of the variables

are listed with a description of what they stand for.

Formula Name	Variables	Formula
Recurring Symbols	**Q** – flow, in gallons per minute (gpm) **p** – pressure, in pounds per square inch (psi) **d** – internal diameter of pipe or orifice, in inches	
Flow through an Orifice	**c** – discharge coefficient	**Q** = $$29.84cd^2\sqrt{p}$$
Flow from a Sprinkler Head	**k** – discharge coefficient	**Q** = $$k\sqrt{p}$$
Hazen-Williams Friction Loss Equation	**P** - friction loss per foot of pipe, psi **C** - Hazen-Williams coefficient	**P** = $$\frac{4.52}{C^{1.85}d^{4.87}}\;x\;Q^{1.85}$$
Hazen-Williams "C" when Friction Loss is Known	**p** – friction loss, in psi, per foot of pipe	**C** = $$\left(\frac{4.52}{pd^{4.87}}\right)^{0.54}\;x\;Q$$
Normal Pressure	P_N – normal pressure P_T – total pressure P_V – velocity pressure	$P_N = P_T - P_V$
Velocity Pressure		P = $0.001123\frac{Q^2}{d^4}$
Flow Velocity in a Pipe	**v** – flow velocity, in feet per second	v = $0.4084\frac{Q}{d^2}$
Junction Point between a Sprinkler Demand Curve and the Water-Supply Curve	Q_J – flow at junction point Q_F – flow in flow test Q_D – design flow P_R – residual pressure, flow test P_S – static pressure, flow test P_D – design pressure, effective point P_E – height of design area, psi	**Q** = $$\left[\frac{P_S - P_E}{\frac{P_S - P_R}{Q_F^{1.85}} + \frac{P_D - P_E}{Q_D^{1.85}}}\right]^{0.54}$$
Junction Point between a Sprinkler Demand Curve and the Water-Supply Curve, after using previous equation	P_J = pressure at junction point	P_J = $$P_S - \left(\frac{P_S - P_R}{Q_F^{1.85}}\right)Q_J^{1.85}$$
Flow at any Pressure on a Water-Supply Curve	P – specified pressure P_S – static pressure, flow	**Q** =

	test P_R – residual pressure, flow test Q_F – flow in flow test	$Q_F \left(\dfrac{P_S - P}{P_S - P_R} \right)^{0.54}$
Pressure at any specified flow on a Water-Supply Curve	Q – specified flow	$P =$ $P_S - \left(\dfrac{Q}{Q_F} \right)^{1.85} x \, (P_S - P_R)$
Junction Point between Water-Supply Curve, less specified Hose-Stream Allowance, and Sprinkler, Demand Curve	Q – flow at junction point H – hose stream allowance	$\dfrac{P_D - P_E}{Q_D^{1.85}} x \, Q^{1.85}$ $+ \dfrac{P_S - P_R}{Q_F^{1.85}} x \, (Q + H)^{1.85} = P_S - P_E$
Associated Pressure after determining "Q" in previous formula		$P =$ $P_E + \dfrac{P_D - P_E}{Q_D^{1.85}} x \, Q^2$
Attainable Density	D_D = design density	$D_A =$ $D_D \, x \left(\dfrac{Q_J}{Q_D} \right)$
Percent Adequacy/Effective	D_R – density required	$\%A =$ $\left(\dfrac{D_A}{D_R} \right) x \, 100\%$

Figure 13: Table of Formulas

The last two functions, Attainable Density and Percent Adequacy/Effective are extremely critical to the Hanover Insurance Loss Control Department. The department analyzes these two functions and their solutions in order to create a suitable insurance policy for the company in question. If the Percent Adequacy/Effective is too low, then Hanover Insurance will not insure the client at that time.

Excel proves to be more of a problem, though, than it is of assistance. Not only is the old spreadsheet inefficient, but also not user-friendly. It does not provide prompts and/or help

to the user on how to operate the program which can be confusing and frustrating to the user. In addition to being difficult to use, this spreadsheet can also be the source of many errors, especially in cases where the spreadsheet is not labeled of organized effectively.

Hydrograph is a program that Hanover uses in addition to its Excel worksheet to display the percent adequacy of the sprinkler system that is being analyzed. This system, however, is extremely inconvenient to loss consultants because they have to use two separate programs to conduct their analysis.   Thus, it was a goal of ours to design and create a program which could combine these two functions, that of Excel and Hydrograph, so that the analysis process would be much more convenient and efficient for consultants to use. Margin of error would be smaller with the newly designed software because it would offer more organization and direction for the users. Our first redesign was a huge improvement compared to the original spreadsheet Hanover had been using. This first major different between the two was that this new software combined the functions of both the Excel spreadsheet and Hydrograph. This change alone saved the user time and was overall more convenient.

The most difficult part of creating the first software was the programming and coding. As stated earlier, the ultimate goal of this redesign was to be more user-friendly and efficient. Thus, we decided to keep an Excel worksheet and create a new data collection form that could communicate back and forth with Excel. This feature allowed for a more organized collection of the data in a way that was easier for the user to understand. This software was written in *Visual Basic* for Applications (VBA) (a widely used programming language) in the Developer section of Excel. VBA allowed for the communication between Excel and the new data collection form.

Our first redesign was better than the original spreadsheet that Hanover was using for many different reasons.   Firstly, our new software was more user-friendly. The information was organized so that a user could easily identify what information and data they are entering and dealing with. This redesign was also more efficient than the original, in that it combined the functions of both Excel and Hydrograph, which ultimately saves time and produces less user frustration.   The coding of this new software was done in Visual Basic, which allows the data collection form and Excel to talk to each other, eliminating any confusion the user may have when entering information into Excel, like the way the old system worked.

Although this first redesign of the software was much more efficient in comparison to the old spreadsheet Hanover was using, there was still much room for improvement. In our redesign, the options to "Save", "Open", and "Create New" were non-existent, making the program difficult to use in case of a mistake or returning to previous worksheets. Another fault in this new software was that it could not create an open dialog, and that the language used to code the software did not allow for some calculations to occur, which resulted in many error messages and bugs in the program. The last problem was more cosmetic. The software would not allow the user to resize the program to any screen size. When one tried, no scroll bars would appear, thus cutting off parts of the program. All of these issues rendered the redesigned software problematic, and when these problems were compounded with those of the user interface of this software, it became evident that this version may not be as user friendly as we had anticipated.

3.2.2 Graphical User Interface (GUI) Improvement

In order to address the problems pertaining to the user interface and layout of the Excel spreadsheet, our team drafted up several new designs that would be far more organized and user friendly (see Appendix B). The first design option allowed for each section of the spreadsheet to be accessed by its own designated button in a user form. There would also be a button for the water supply graph and percent adequacy, as well as "Save" and "Exit" buttons. The second design option was a user form that had all the sections of the spreadsheet stacked on top of one another, menu style, and when one of the sections was clicked on it would scroll open all the questions underneath it for the user to fill out. This option also included "save" and "exit" buttons. The third design option consisted of tabs, each section of the Excel spreadsheet having its own tab with the related question on it. This option included a tab for the graph and percent adequacy calculation. Each tab had its own "save" option and the option to click "next" or "back" to navigate to the following or previous tab. The last tab included the "exit" option.

We evaluated each of these design options based on layout, interface, user friendliness, organization, programming feasibility, and our ability to create it within our designated time frame. Based on these parameters we decided that the best option for Hanover Insurance Group is the third design option, the "tabbed" design. This design allowed us to create a new tool with a redesigned interface that would be far more efficient and user friendly for Hanover's Loss consultants.

Since the new sprinkler evaluation software is not in spreadsheet form there are no more empty or misleading cells to create confusion. The new tabbed design allows the user to enter inputs one section at a time, without being overwhelmed or confused by the volume of

data collection fields seen in front of him or her (Figure 14). The data entry boxes are clearly

distinguished in the new software and drop-down menus are clearly indicated where it is

appropriate. Unlike the original Excel spreadsheet, the formulas used to make calculations in

this new program are all coded into the software and cannot be seen, accessed, or tampered

with by the user. This eliminates a great deal of opportunity for error.
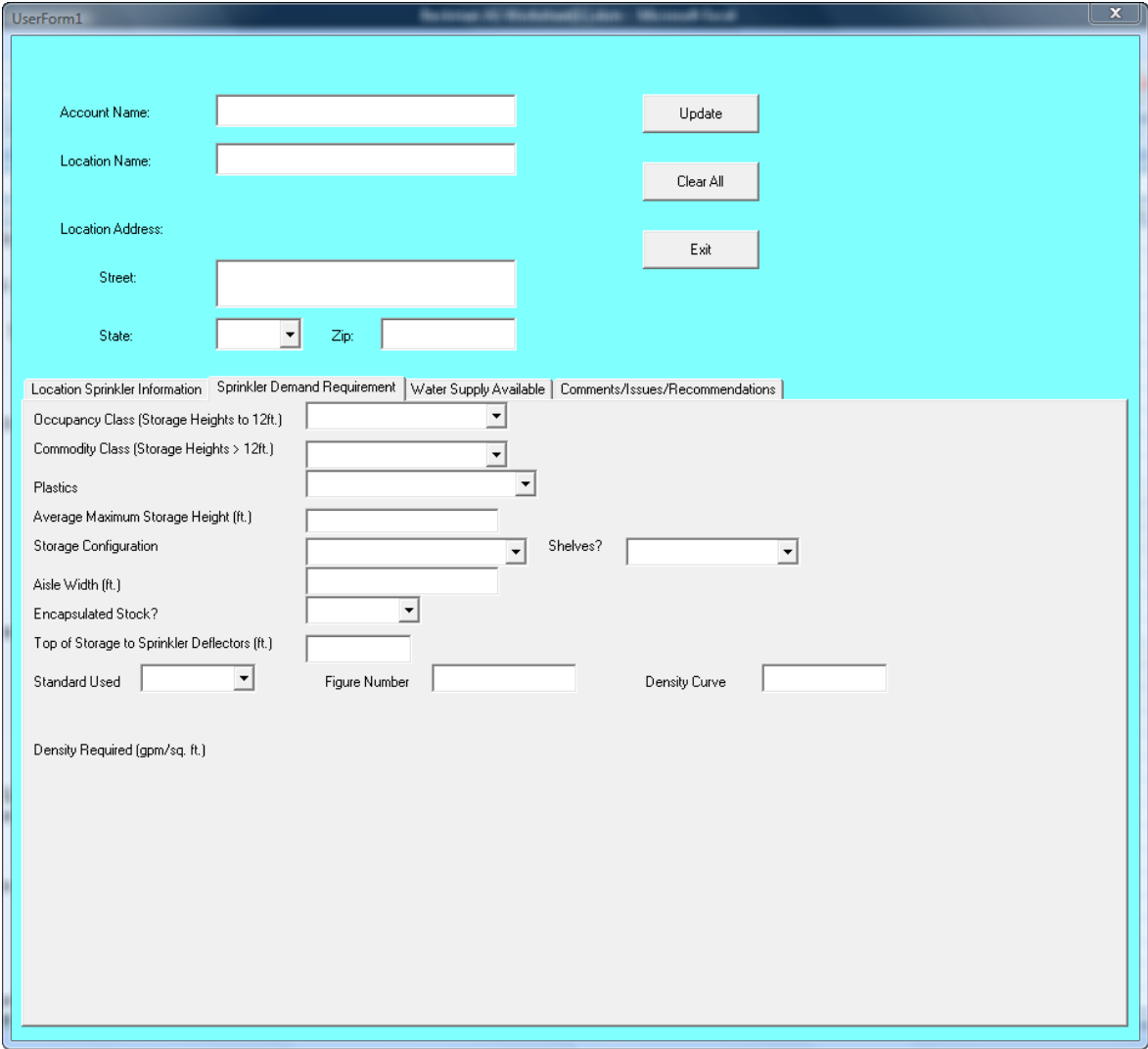
Figure 14: Image of First Redesign Software

The design, layout, and interface of this software are direct and easy to use. However,

coding the formulas in this software proved to be very difficult and led to an excessive number

of bugs. In addition, this user form did not appear professional enough for Hanover Insurance Group.

3.2.3 Excel Spreadsheet and Hydrograph Integration

One of our major objectives is the integration of the Hydrograph software into the new software evaluation tool. Currently, the Hydrograph software is a separate entity from the rest of the evaluation spreadsheet. This means that when a Loss Consultant finishes entering the necessary information from their consultation in the spreadsheet, only a pass or fail response is generated. In order to see to what percentage the client passes or fails the inspection, the Loss Consultant must then call up the Hydrograph Software and transfer the spreadsheet information into the separate Hydrograph software. The Hydrograph software then uses a combination of lines and points based on the Excel information to generate a percentage – which is the percentage to which the client meets or does not meet Hanover's sprinkler standards. Since the Consultant must call for this graph as a separate step in the process, it creates an unwanted step and inefficiency in their process. If the consultants were only to look at the Excel spreadsheet, which generates a pass or fail response, they could be missing out on potential clients, or over-insuring their existing clients. Since the information generated by the Hydrograph is vital to the Loss Consultants evaluation, a more efficient way to go about this process is to incorporate or merge the existing Excel spreadsheet and the Hydrograph data.

After our meetings with Chris Beckman, our first approach to this problem is to incorporate the graph into the new Graphical User Interface. Ideally, Hanover wanted one single program that generated a percent adequacy graph along with the pass/fail response

generated by the original spreadsheet. Using Visual Studio, we added a tab into our new

software program that will automatically generate a graph which displays the percent adequacy

(Figure 15).
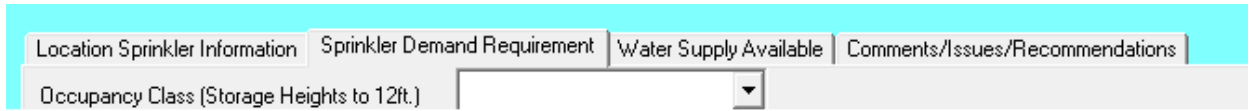
Figure 15: Tab Options in First Redesign

This new graph feature will automatically take the necessary information from the

user's inputs and produce a percentage to which the client will pass or fail the sprinkler

evaluation (Figure 16). With the addition of this feature to create one integrated software,

where the consultants also enter the initial information, it eliminates a step for them to call up

a separate program and the manual generation of the graph. Having both these features in one

consolidated program reduces the time spent as well as the difficulty of determining a

percentage.
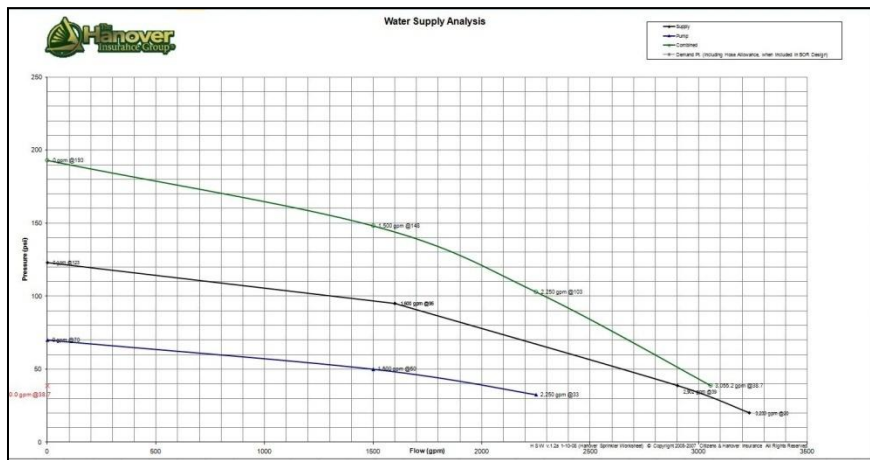
Figure 16: Water Supply Graph

Although the incorporation of the Hydrograph function into our new software was working correctly, it was not the best solution for this incorporation. While we were able to integrate the two tools into a more efficient program, we decided to take a second approach to our programming methods and were able to have a more efficient software program after our second redesign.

3.3 Second Redesign

Our second attempt at a redesign was based on the same general layout and user interface. The changes were focused on the software itself and how well it preformed the required tasks to accurate evaluate a sprinkler system. This redesign was created using Microsoft Visual Studio.

3.3.1 Sprinkler Evaluation Software Development

After close observation of the problems we encountered with our first software redesign, we created a much improved software program. This was a large endeavor for us to undertake, as we had to start from scratch in order to create feasible software that met the standards Hanover was looking for, while also designing something that is user-friendly.

The general idea of the second redesign had many of the same goals as the first: it should be more efficient and user-friendly, and should solve any previous problems that the Excel spreadsheet and the first redesign had. We wanted this software to have a data collection form that exchanged information with Excel, incorporated Hydrograph into the program, and we wanted a program that would aid users in the proper way to operate the program. In this second redesign we achieved all of these goals. Not unlike the first redesign,

this second software combined the functions of Excel and Hydrograph making the analysis of a sprinkler system easier, as it involves fewer steps to perform the analysis. This second software also makes use of a data collection form which aids the user in organizing the data and guides them in entering information.

The programming and coding that went into creating this second software is where the real differences can be found between the first and second designs. Although we used a data collection form to communicate with Excel, this new version is much more user-friendly. It prompts users to enter needed information, offers help if the user is confused, and refuses to let a user move on unless all required fields have been filled out, thus leading to more accurate results and less confusion by the user. This new software uses a "middleman" program called Microsoft Visual Studio 2008 to talk to the user and to the Excel spreadsheet, and is programmed in the coding language, C#.

This redesign is better than the original because our new software is more user-friendly. The information is organized so that a user can easily identify what information and data they are entering and dealing with. This redesign was also more efficient than the original in that it combined the functions of both Excel and Hydrograph, which ultimately saves time and produces less user frustration. The coding of this new software was done in Microsoft Visual Studio 2008 and in the C# Language which allows for the smooth communication between the user, data collection form, and Excel.

The second redesign is more successful than the first redesign. The C# Language allows for the user to be able to do much more in the data collection sheet such as "Save", "Create

New" forms, and ask for "Help" (via the use of Help buttons clearly marked beside each input text box). Also the new language does a tremendous job in aiding the user with direction and information they may need to fill out in performing their analysis. We have added color-coding to help with this. Each field is colored Red until the user types in the correct input. This second redesign is also more cosmetically pleasing than the first software we created because it makes use of more colors and is better organized.

3.3.2 Graphical User Interface (GUI) Improvement

In our second attempt to redesign Hanover Insurance Group's sprinkler evaluation tool and make improvements on our first redesign attempt, we kept the user interface design the same as in our first software creation, the "tabbed" design. The new software was still going to have a separate tab for each section of the spreadsheet, including tabs for the graph and percent adequacy (Figure 17). With the new software, this interface design still proved to be efficient, user friendly, organized, and easy to navigate through.
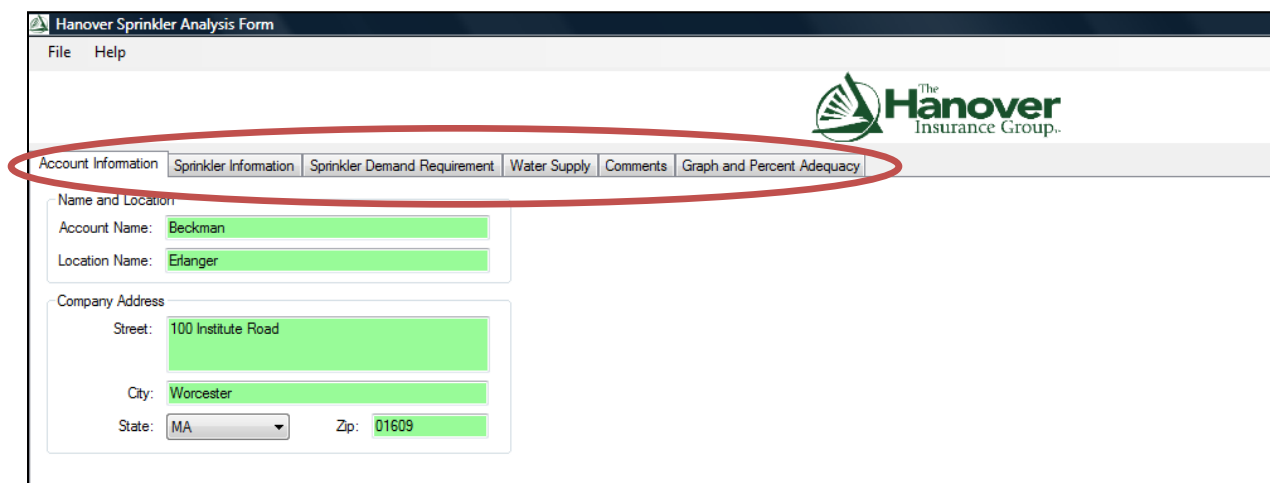
Figure 17: Second Redesign - Tabs

This redesign was an improvement on the first in its capability to eliminate even more opportunity for error. This design kept some of the input options "grayed out," or inaccessible to the user until particular options were selected, which triggered the appropriate grey fields to become active and available to the user. This reduces the opportunity for error by keeping the user's focus streamlined onto a particular section at a time. Unlike the first software we used, this new design had the added convenience of window resizing. The user can make the window smaller or larger at his or her own leisure, and when the window is resized, scroll bars automatically appear to allow the user to scroll up and down the user form, allowing for faster and easier navigation. Another added perk of this redesign is that it looks far more professional, clearly displaying The Hanover Insurance Group's company logo, allowing its appearance to correspond to the accuracy and integrity of this tool.

This new software also allowed our second redesign to reach high levels of organization and user friendliness. This new design contains a menu which allows the user to choose from options such as "Save" or "Save as…," "Open", "New", "Exit", and "Help", all equipped with their own programmed keyboard shortcuts (Figure 18). The "Help" option allows the user to access a help manual which answers a multitude of questions the user may have.
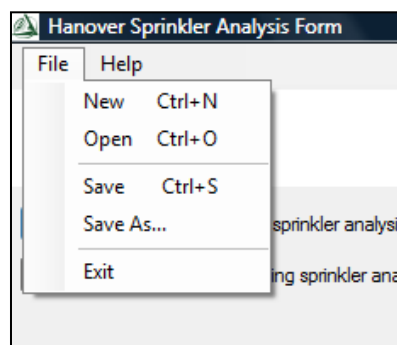
Figure 18: File Menu

This redesign demonstrates superior levels of organization, navigation, layout, and user friendliness. All of these factors will lead to higher efficiency, productivity, and accuracy for Hanover Insurance Group in evaluating fire sprinkler systems.

3.3.3 Excel Spreadsheet and Hydrograph Integration

In our second redesign of our software program, we had a better idea of how to incorporate the idea of the Hydrograph and percent adequacy. Using C# programming methods, we were able to create a more efficient GUI as explained in the process of our second redesign. As in our first redesign, we were able to incorporate the graph into our new software program. After a Consultant enters the sprinkler specifications into the program, the incorporation of the percent adequacy reading is built into the display and readily available.
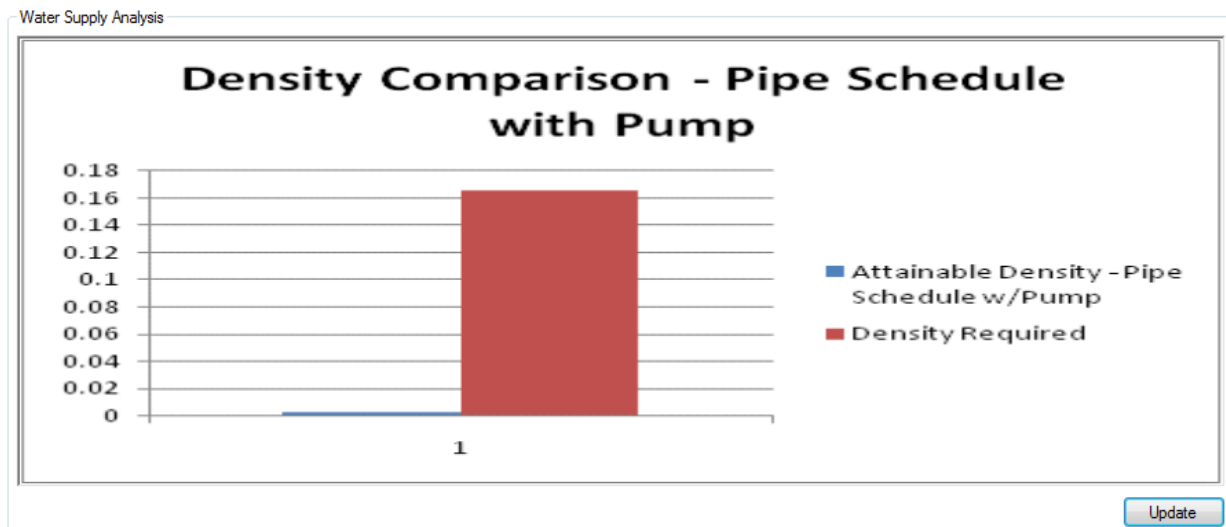
Since the graph is automatically generated from the user inputs, it eliminates the step for the Consultant to call up a second program and manually input information to generate a percent adequacy.

Now, when a Consultant travels to a site, entering data for a sprinkler evaluation, they can input the sprinkler specifications into our new software and produce a percent adequacy quickly and efficiently.

3.3.4 Final Software Workflow

Below is the flow of information from start to finish of the software as a Loss Consultant enters sprinkler data on site. This is from the user's perspective, and shows the different possible paths based on the types of sprinkler systems and other specifications at the site.
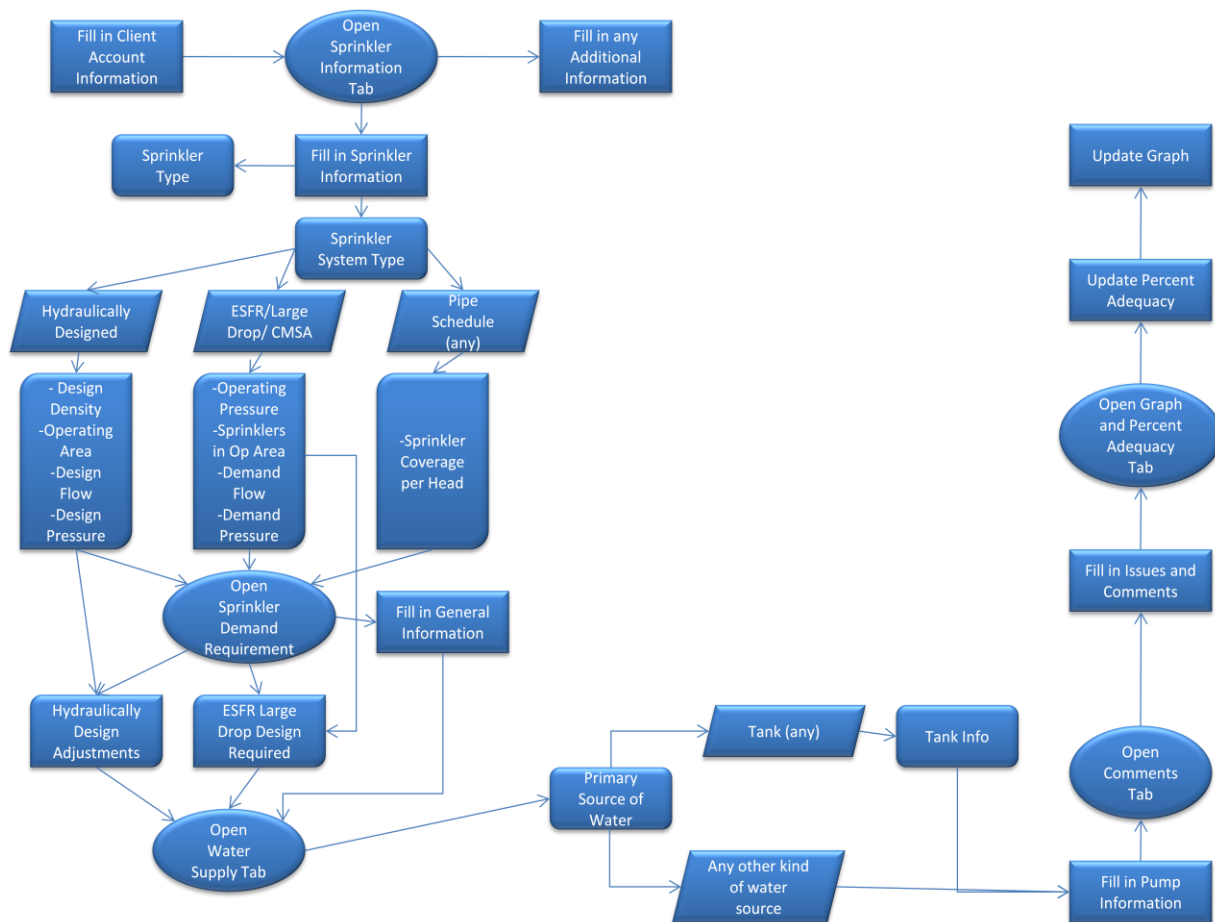
Figure 19: Example of Software Workflow from User's Perspective

3.4 Methodology Conclusion

We began our approach to this project by clearly defining our objectives. After clarifying our goals with Chris Beckman, one of our Hanover Insurance liaisons, we were able to determine the three major components our new software program needed: a more efficient software to perform the sprinkler evaluation, improve and create a more user friendly Graphical User Interface (GUI), and incorporate the Hydrograph software to create a combined tool. From these three major objectives, we defined what would be necessary to accomplish each with the best outcome. After making choices based upon the efficiency and usability of each design, we were able to produce one final design that captured all the changes Hanover Insurance requested.
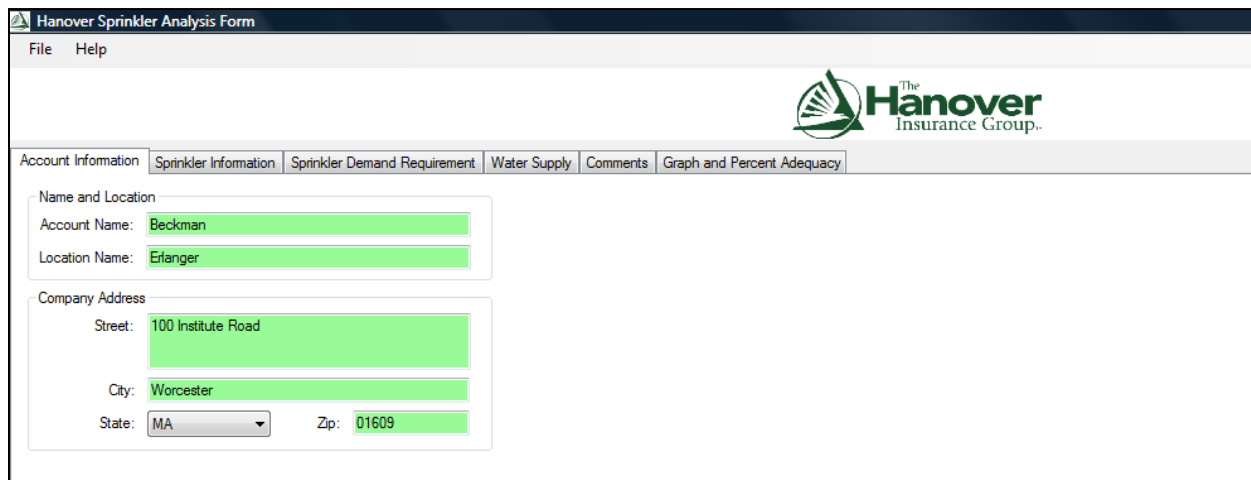
4.0 Analysis

In order to thoroughly analyze how the software processes data, test data and trials are used and recorded. We used a set of test data that will show all of the capabilities of the Hanover Sprinkler Analysis Software.

The first tab that is visible when the user opens a new analysis form is the Account Information Tab. We entered the following data into the input fields:

Account Name: Beckman
Location Name: Erlanger
Street: 100 Institute Road
City: Worcester
State: MA (selected from the drop down list)
Zip: 01609

Figure 20: Account Information – Test Data

Next, we moved to the next tab, the Sprinkler Information Tab. In this section, we entered the basic information about the actual sprinklers in use at the selected location, and any other additional information that is necessary depending on the sprinkler system type. We entered the following data into these input fields:

Sprinkler Type: Wet (selected from the drop down list)

Sprinkler Coverage: 100%
Sprinkler Heads: Standard (selected from the drop down list)
K-Factor: 11.2
Sprinkler Head Temperature Class: High Temperature (selected from the drop down list)
Height to Top Line Sprinklers: 20 ft.
Sprinkler Head Age: 13 years
Sprinkler System Type: Hydraulically Designed **

Max Hose gpm Available: 20 gpm
Is Hose Allowance Included?: No
Design Density: 0.2 **
Operating Area: 2000 **
BOR Design Flow: 420 **
BOR Design Pressure: 40 **

These starred fields change depending on what is selected in the Sprinkler System Type field. If

the Sprinkler System Type is "Hydraulically Designed ESFR/Large Drop/CMSA", then the four

starred fields will change to:

Minimum Sprinkler Operating Pressure
Sprinklers in Operating Area
BOR Demand Flow
BOR Demand Pressure

Similarly, if the Sprinkler System Type is equal to any of the four Pipe Schedule Systems, then

the only additional information that will be needed is the Sprinkler Coverage per Head (sq. ft).

Since our test data has the Sprinkler System Type equal to Hydraulically Designed, we will not

enter numerical data or selections for any other type of system.

Figure 21: Sprinkler Information - Test Data

At any time, the user may seek help in entering the correct data or explanations of definitions of certain fields. There are "?" boxes located beside certain input fields or drop-down boxes to help the user enter the correct data. This is an example of a help box that would pop up if the user were to need more information about the Sprinkler Head Age:
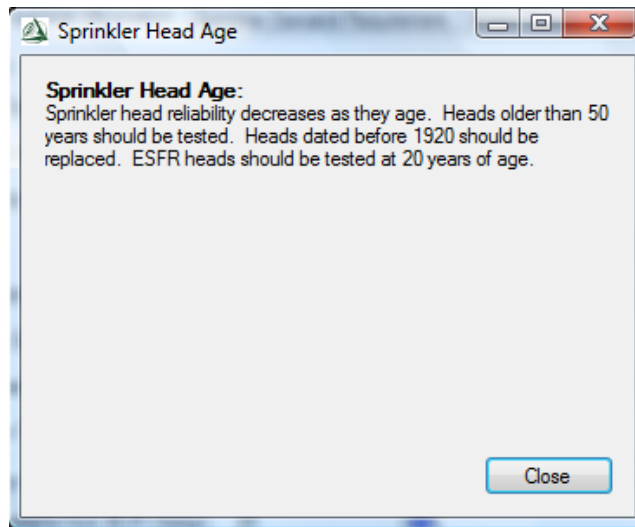
Figure 22: Help Box

Once the Sprinkler Information Tab has been completed in full, the user will move on to the next tab, Sprinkler Demand Requirement. Located in this tab are some very crucial calculations that the Loss Control Department at Hanover Insurance needs in order to help the Underwriters create specific insurance policies for their clients. In this tab, the user will be entering information about Sprinkler Demand, Reference Information, Storage Information, and information specific to the type of Sprinkler System that they had entered in the previous tab. For this analysis, we entered the following data:

Sprinkler Demand Information
        Occupancy Class: OH-2 (selected from the drop down list)
        Commodity Class: Not Applicable (selected from the drop down list)
        Plastics: Group A (selected from the drop down list)
        Aisle Width: 8 ft.
        Top of Storage to Sprinkler Deflectors: 5 ft.
Reference Information
        Standard Used: NFPA 13 (selected from the drop down list)
        Figure Number: 12.1.3
        Density Curve: A
Storage Information
        Average Maximum Storage Height: 10 ft.
        Storage Configuration: Solid Pile
        Encapsulated Stock?: No
Hydraulically Designed Adjustments **
        Density Required: 0.18
        Operating Area: 900
        Height Adjustment: 175% (selected from the drop down list)
        Dry Pipe System Adjustment: 100%
        Other Density Adjustment: *blank*
        Other Area Adjustment: *blank*
        **The Total Density and Area Adjustments are calculated fields and are not listed as input data.
After Adjustments
        In-Rack Sprinklers: No
        Hose Demand Combined: 500 (selected from the drop down list)
        Duration Requirement: 60 (selected from the drop down list)
        **The Density Required and Operating Area located in this section are calculated fields and are not listed as input data.

Figure 23: Sprinkler Demand Request - Test Data

Again, the starred fields will change depending on what is selected in the previous tab for Sprinkler System Type. If "Hydraulically Designed ESFR/Large Drop/CMSA" is selected for Sprinkler System Type, this section would have appeared in the Sprinkler Demand Requirement Tab instead of the Hydraulically Design Adjustments section:

Figure 24: Optional Information

Similarly, if the user chooses any of the Pipe Schedule Systems, then another section will be shown instead:

```
Water Supply Test Data:

STEP 1: GRAPH THE WATER SUPPLY
Static Pressure with No Flow:   <Static Pressure>
Residual Pressure with Water Flowing:   <Residual Pressure>
Water Flow:   <Water Flow>

STEP 2: REQ'D DENSITY DESIGN AREA
Required Density (gpm/sq.ft.):   <Density>
Required Design Area (sq.ft.):   <Area>

STEP 3: TOTAL WATER FLOW
Hose Stream Allowance:   0
(Density x Area x 1.1) = gpm:   <gpm>

STEP 4: PRESSURE AT REMOTE HEAD
K-Factor:   <K-Factor>
Sprinkler Protection Area (sq.ft.):   <Protection Area>
Ph = (Q/k)2 = (psi):   <Ph Calc>

STEP 5: TOTAL PRESSURE @ BOR
Height to Top Line Sprinklers (ft.):   <Height>
Pe = 0.433 x height = (psi):   <Pe Calc>
Pf = 30 - 50 psi (depending on required density):   <Pf Calc>
Pbor:   <Pbor Calc>

STEP 6: COMBINE FLOW AND PRESSURES
Required Flow (gpm):   <Req'd Flow>
Required Pressure (psi):   <Req'd Pressure>
```

Figure 25: Additional Optional Information

All of these fields are calculations based on a Pipe Schedule Water Supply Test administered by

the user. However, since one of the Pipe Schedule systems was not chosen on the previous

tab, these calculations are not displayed in full in this section currently.

Once the user has completed the Sprinkler Demand Requirement Tab, they will

promptly move on to the Water Supply Tab. This tab requires data inputs that describe the

clients water supply and any pumps they may have. It also includes specific Hydrant or Two-

Inch Drain Test data that the user can enter in to the appropriate fields when either of these

tests is necessary. Finally, this tab also includes the calculated Water Supply Capabilities,

including Hose Streams Available, Private Supply Duration Available, etc. The data that we used

to analyze this tab is shown below:

Water Source

       Primary Source of Water: Public Main (selected from the drop down list)

       Private Water Supply: No Private Water Supply (selected from the drop down list)

Pump Information

       Pump: Electric Booster Pump (selected from the drop down list)

       Select Pump Design: Horizontal Split Case Pump (selected from the drop down list)

       Pump Flow Rating: 1000 gpm

       Pump Pressure Rating: 40 gpm

       Pump Test: Test Not Available: Theoretical Calc (selected from the drop down list)

       Date of the Last Pump Test: Monday, February 22, 2010

Hydrant Test

       Location: Erlanger

       Date: Monday, February 22, 2010

       Static: 78 psi

       Residual: 56 psi

       Flow: 1234 gpm

Water Supply Capabilities **

       ** Water Supply Capabilities located in this section are calculated fields and are not listed as input data.

Figure 26: Water Supply Tab – Test Data

Once the user is satisfied with their inputs and the calculations, they are free to move

onto the Comments Tab. This includes free input space to enter any Comments or Pending

Issues/Recommendations that are necessary to help either the client or the Underwriters at

Hanover Insurance.
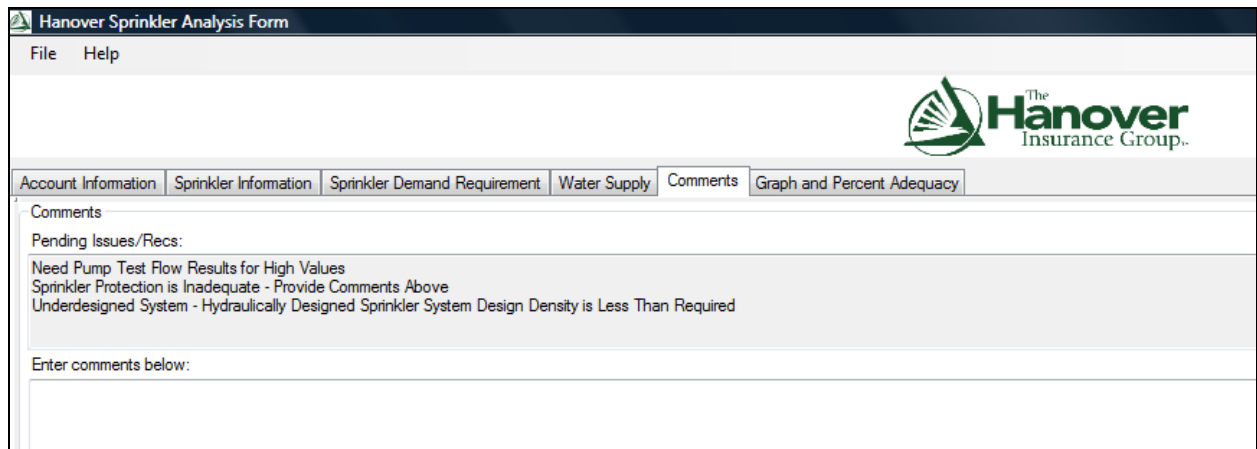
Figure 27: Comments Tab - Test Data

The last tab included in the Sprinkler Analysis Software is the Graph and Percent Adequacy Tab. This tab is vital to the Loss Control Department. They use this tab to decide whether or not Hanover Insurance should take on the company in question as a client. This would depend on their Percent Adequacy score. The closer the value is to 100% (or over 100%), the better the chance for the client to be taken on by Hanover. This tab also includes a bar graph to display the difference between the required Density and the density attained by the client.
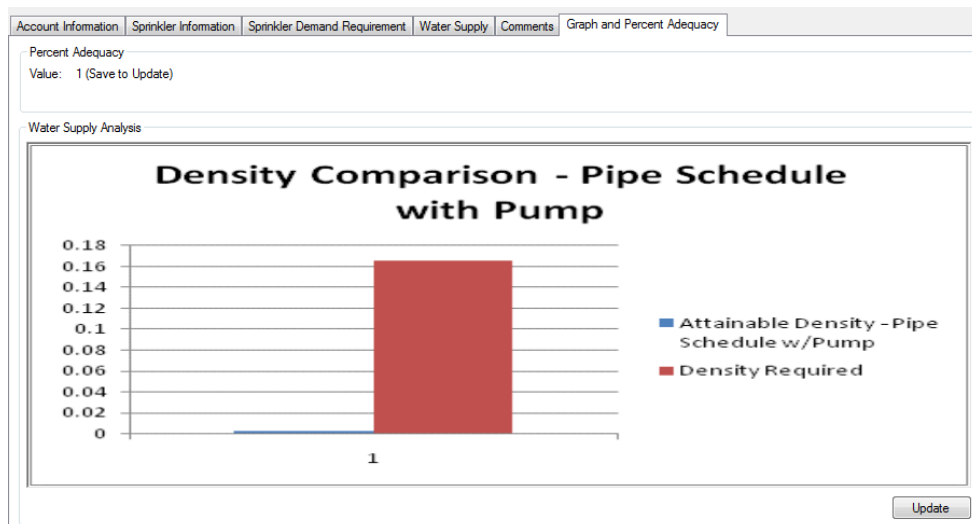
Figure 28: Graph and Percent Adequacy Tab - Test Data

This last tab concludes the data analysis of the Sprinkler Analysis Software. We have shown all of the input fields and the calculations that are included in the analysis form. This software is very easy to use, having all of the sections clearly displayed with their correct fields and efficient pop-up views. This software will greatly increase productivity and efficiency of the Loss Control Department.

5.0 Recommendations

We highly recommend that The Hanover Insurance Group incorporate our Sprinkler Analysis Software into their corporate information system. This will allow the Loss Control Consultants to access this program, whether in the office or on the road. We know that the use of this software will greatly increase productivity and efficiency, as well as increase the number of potential clients that are insured by The Hanover Insurance Group.

Our recommendations for future teams working on similar projects are to allow for more time for testing and analysis. This will allow the sponsor and team members to ensure that the project is working smoothly and carries out all of the functions required by the sponsor. In order to further guarantee this, teams should schedule frequent face-to-face meetings with the sponsor to make sure all objectives are clear, and that all parties are in agreement with the final set of goals.

In addition to fire sprinkler evaluation, The Hanover Insurance Group's Loss Control Department also analyses and evaluates other types of potential hazards pertaining to client's property. Currently, there is no unified method of checking, evaluating, and scoring any additional hazards that might be present at a client's property. A unified software program that could record, calculate, and output a score that portrays the importance and severity of each hazard and coordinates it with the client's insurability would all Hanover to continue to simplify their hazard evaluation methods and have a uniform system on which to base their insurability policies.

At this time, each Loss Consultant uses his or her own method of recording and scaling the significance of each hazard. With around thirty-five types of hazards that might be present at a site, Loss Consultants must rate each hazard present and assign a value which distinguishes how dangerous that hazard may be, and in turn, use that value to determine the company's overall insurability.

Our recommendation for the continuation of this project is to design a unified system of evaluating all hazards present at a potential client's business site. The first step to designing this type of tool would be to collect an overall rating of the thirty-five hazards from a group of Loss Consultants who deal with these hazards on a regular basis. The hazards should be rated on a scale that allows for a total evaluation making sure each hazard is accounted for, and how important it should be to the insurability process. Once a scale is determined, a software program should be created, either with Microsoft Office products or any other type of programming software that will allow for the input of hazards present and output a total rating for the Loss Consultant to use when determining insurability.

Summary

In our undertaking to create an improved sprinkler evaluation tool for The Hanover Insurance Group, our team conducted research and analysis of the company's current evaluation process and tools, and their primary objectives to determine the best solution to fit their needs. Our goal was to create a professional, organized, user friendly tool that would be able to determine the percent adequacy of any given fire sprinkler system. In order to achieve these goals we built a new software program based on the function of Hanover's current sprinkler evaluation tool using Visual Basic for Applications. This version proved to be an improvement on Hanover's original sprinkler evaluation tool; however, it still displayed a great deal of short comings. In response to the limited capabilities of our first redesign solution, our team created a second and far more successful redesign. We used Visual Basic Studio software and C# coding language to recreate the user form, producing significantly improved results. This software was easier to code, eliminating errors and making it far more user friendly. Upon evaluating this new software we were able to see the significant improvement it has made in terms of user interface, efficiency, accuracy, and precision. This software has demonstrated to be a far more valuable tool for the Hanover Insurance Group, increasing overall efficiency and productivity.

Appendix A

User Guide

Hanover Sprinkler Analysis Form

Table of Contents:

INTRODUCTION

Welcome to the Hanover Sprinkler Analysis Form! This form will help simplify your Water Supply Analysis data entry and calculations.

This User's Guide is basic, showing you how to navigate through the form and the various tabs. The Guide will help you to understand the functions and operations that are possible with the Analysis Form.

The Guide will help you with the following basic functions:

1. Installing the Hanover Sprinkler Analysis Form Software.
2. Creating a new, or opening a previous Water Supply Analysis Form.
3. Carrying out basic functions, such as Save/Save As, Open, and Exit.
4. Entering Data and seeking any extra help with inputs.
5. Updating outputs, such as calculations and graphs.

Thank You!

GETTING STARTED

When you open the Hanover Sprinkler Analysis Form software (see INSTALLING SOFTWARE), you will be greeted with a Welcome Page. This page gives you two options: NEW or OPEN.
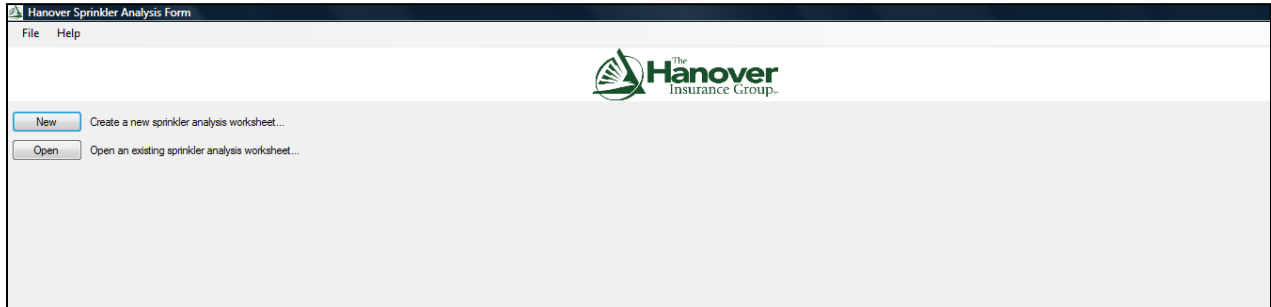
Create a New Analysis Form

To create a new Analysis Form, press the NEW button, and a "Save" window will pop up. This allows you to name your Form. This will then save the form in the same place where you have positioned the installer folder.

Once you have named your form and pressed Ok, then you are ready to begin. This creates a completely blank Analysis Form, where all of the fields are color-coded RED. This is because they are required input fields, and until you enter a correct input, they will remain RED. Once the correct input has been entered, the field will turn GREEN.
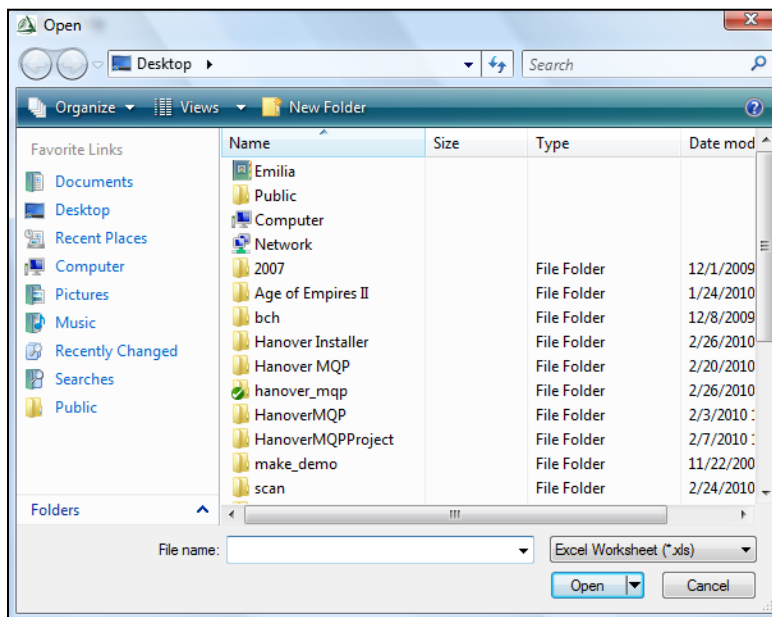
Open a Previous Analysis Form

To open a previous Analysis Form, press the OPEN button, and an "Open" window will pop up. This allows you to locate and open a form that you had previously created in the past.

Once you have located your form and pressed Ok, then you are ready to begin. Many of the fields will already be filled in. If the input fields are filled in with incorrect inputs, then they will be color-coded RED. Until you enter the correct input, they will remain RED. Once the correct input has been entered, the field will turn GREEN.

BASIC OPERATIONS

Save

There are two ways to Save your Analysis Form. The shortcut to saving your Analysis form is by using the keyboard save command. **Ctrl+S** will save your form at any time.

To locate the Save operation, you must open the File menu in the upper left corner and select Save from the menu list.

Save As

Save As is an option to Save and Relocate your Analysis Form. If you do not like the location of your saved Analysis Form, you can use Save As to move it to a more convenient location.

To locate the Save As operation, you must open the File menu in the upper left corner and select Save As from the menu list.

Open

To Open a previous Analysis Form, you can use the keyboard shortcut **Ctrl+O** to pop up an Open window, which allows you to search for your Analysis Form and Open it in the software.

To locate the Open operation, you can open the File menu in the upper left corner and select Open from the menu list.

Exit

To Exit the program, you can open the File menu in the upper left corner and select Exit from the menu list.

You can also press the RED "X" that is located in the upper right corner of the Analysis Form window.

ENTERING DATA

Inputting Data

Inputting Data into the Hanover Sprinkler Analysis Form is the same as entering data into any user form. There are text boxes that require manual entry of inputs, as well as combination boxes with an arrow on the left that releases a list of options to choose from.

Each required entry field will remain color-coded RED until a correct input is entered or chosen. Once the input is correct, the input field will turn GREEN.

Seeking Input Help

To seek help with some of the input fields, there are question mark boxes located to the right of those fields. When pressed, a help window will pop up with information to assist in entering the correct inputs.
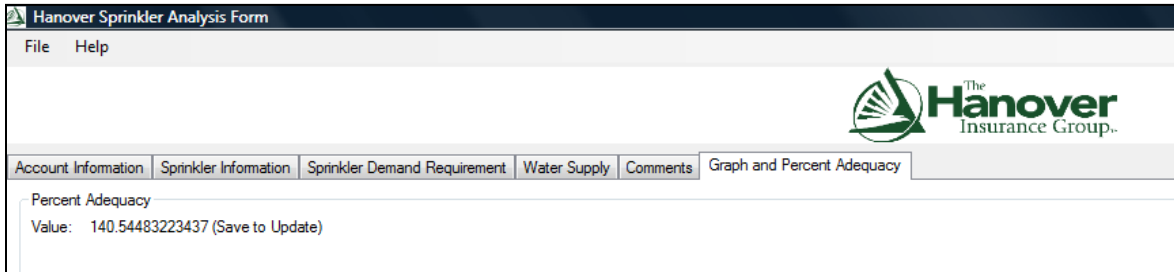
Once you are finished reading the help box, close it by pressing the RED "X" in the upper right corner of the help box window.
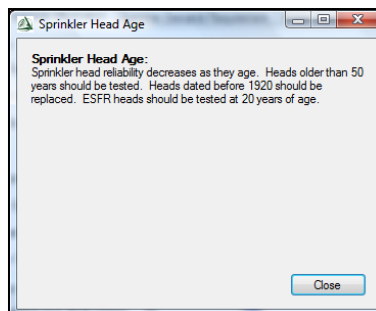
UPDATING OUTPUTS

Calculations

Within the Analysis Form, there are some calculations that include an instruction "Save to Update". To update these calculations, you need to save the Analysis Form. To do this, please refer to BASIC OPERATIONS – *Save*.

Graph

Located in the *Graph* tab in the Hanover Sprinkler Analysis Form, the Percent Adequacy Comparison Graph is updated by pressing the UPDATE button located underneath the graph.

Appendix B

Option 1:

Account Name

Location Name

Location Address

Location Sprinkler Information

Sprinkler Demand Requirement

Water Supply Available

Water Supply Graph

Percent Adequacy

Description: Each button, when clicked, takes user to each designated tab where inputs can be changed as needed.

Location Sprinkler Information

Sprinkler Type

Sprinkler Coverage %

Sprinkler Heads (Size/Type)

K-Factor

Sprinkler Head Temperature Class

Height to top line sprinklers

< Back   Save   Next Tab >

Option 2:

Account Name
Location Name
Location Address

Location Sprinkler Information

Sprinkler Demand Requirement

Water Supply Available

Water Supply Graph

Percent Adequacy

Location Sprinkler Info
Sprinkler Demand Requ.
Water Supply Available

Primary Source of Water
Gravity Tank Gallons
Pressure Tank Gallons
Suction Tank Gallons

Water Supply Graph
Percent Adequacy

Description: Each tab is clicked on by the user to be accessed and the tabs covering it scroll down to reveal it, or the tab itself scrolls up.

Option 3:

Account Name
Location Name
Location Address

Location Sprinkler Information

Sprinkler Type
Sprinkler Coverage %
Sprinkler Head (Size/Type)
K-Factor
Sprinkler Head Temp
Height to top line sprinklers
Sprinkler Head Age
. . . .

Location Sprin...	Sprinkler Dem...	Water Supply...	Water Supply Gra...	Percent Adequ...

Description: Each spreadsheet category is its own tab and can be clicked on to be accessed by the user.

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