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# Evaluation of operating parameters for tank rinsing systems

Jesse L. Davis

To the Graduate Council:

I am submitting herewith a thesis written by Jesse L. Davis entitled "Evaluation of operating parameters for tank rinsing systems." I have examined the final electronic copy of this thesis for form and content and recommend that it be accepted in partial fulfillment of the requirements for the degree of Master of Science, with a major in Biosystems Engineering Technology.

William E. Hart, Major Professor

We have read this thesis and recommend its acceptance:

Fred D. Tompkins, C. Roland Mote, James B. Wills

Accepted for the Council:
Carolyn R. Hodges

Vice Provost and Dean of the Graduate School

(Original signatures are on file with official student records.)

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Date December 3, 1992

# EVALUATION OF OPERATING PARAMETERS FOR TANK RINSING SYSTEMS

A Thesis

Presented for the

Master of Science

Degree

The University of Tennessee, Knoxville

Jesse L. Davis

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# ABSTRACT

An experimental apparatus was designed to quantify the effectiveness of commercially available tank rinse nozzles to adequately clean residues from inner surfaces of sprayer reservoirs. A laboratory scale test stand was constructed to perform two specific functions: 1) provide mounting and support for typical sprayer tank mounting brackets; and 2) house two independent fluid delivery systems.

A multi-position frame was designed to accept mounting brackets for four tank sizes. Design considerations included rapid and easy exchange of various tanks and still provide support for the mass of tank and fluid. Two fluid delivery systems were designed and assembled to facilitate the testing of sprayer tanks. One fluid delivery system was devoted to transferring concentrated trace solution (10000 parts per million ionic bromide) between a separate storage reservoir and test tanks. A 1136-L [300-gal.] polyethylene tank served as a storage vessel for the test solution. The ionic bromide tracer was used to contaminate interior surfaces of test tanks. The transfer system was used to move the concentrated chemical into test tanks. After filling a test tank, the solution was transferred back to the storage reservoir. A second fluid delivery system supplied clean rinse water to a tank rinsing nozzle centrally located inside a test tank. Clean water was stored in an auxiliary 114-L [30-gal.] cone tank mounted on the test stand. Two separate fluid delivery systems were utilized to avoid potential rinse water contamination, which would ultimately alter rinsate sample concentration.

Two commercial tank rinsing nozzles (Spraying Systems Company model 27500-E ¾-18 TEF and Lechler, Inc. model 5E) were evaluated. Three operating parameters (pressure, rinse sequence, and rinse volume) were varied to evaluate performance of these two nozzles. Nozzle operating pressures were set according to manufacturers recommendations. The Spraying

Systems nozzle was operated at 138, 207, 276, and 345 kPa [20, 30, 40, and 50 psi] for all tank sizes (190, 380, 760, 1136 L cylindrical and elliptical [50, 100, 200, and 300 gal.]). The Lechler nozzle was tested only on the 380-L [100-gal.] tank at pressure of 207, 276, and 345 kPa [30, 40, and 50 psi]. Two rinse volumes (5 and 10 percent of tank capacity) and three rinse procedures (single, double, and triple) were evaluated at each pressure. For the single rinse procedure, the tank was rinsed once with the total rinse volume. In the double (triple) rinse procedure, the tank was rinsed twice (thrice) with half (one-third) of the total rinse volume. All rinse tests were replicated a minimum of three times.

Rinsate samples were collected in disposable paraffin lined paper cups to prevent cross contamination between samples. Rinsates were drained between each rinse cycle. An Orion model 290A portable pH meter was used to measure rinsate sample concentrations. The meter, equipped with an ion specific bromide electrode and its corresponding double junction reference electrode, enabled direct concentration measurement ranging from 0.0000 to 199000 parts per million.

Rinse sequence was statistically significant ($\alpha$=0.05) in reducing rinsate concentration for all tank sizes tested. Rinse volume and tank size were also shown to have an effect. Operating pressure had little impact on rinsate concentration. Tank geometry and nozzle type were not significant ($\alpha$=0.05) factors in this study.

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# CHAPTER I

# INTRODUCTION

## Background and Statement of Problem

Crop protection chemicals are used extensively in production agriculture. The United States Department of Agriculture (USDA, 1992) projects 219 million kilograms [482 million lb.] of active ingredients (a.i.) will be applied to major field crops in 1992. While having numerous advantages, disadvantages are also associated with agricultural chemical use. The most widely recognized issue is their impact on the environment, specifically the potential for surface water and groundwater contamination. Results of a five year survey conducted by the Environmental Protection Agency (EPA, 1990) estimate 10.4 percent of community water systems and 4.2 percent of rural domestic wells contain at least one pesticide above survey minimum reporting limits. Specific reporting limits for each of the 126 pesticides and pesticide degradates were established by EPA. Of all analytes investigated, nitrate was the most commonly detected substance (reporting limit of 0.15 milligrams per liter). Analytes of dimethyl tetrachloroterephthalate acid (DCPA) metabolites and atrazine were the two most frequently detected pesticides. Reporting limits for DCPA and atrazine were 0.10 and 0.12 micrograms per liter, respectively. Another EPA report (EPA, 1988) cited nonpoint sources, which includes runoff from farm land, as a major source of water pollution. Nonpoint sources are responsible for 65 percent of contamination in impaired rivers, 76 percent in impaired lakes, and 45 percent in impaired estuaries (EPA, 1988). However, Ehart (1988) stated another problem exists - the safe and legal disposal of excess spray material and leftover rinsates.

Principals of sprayer application, utilizing hydraulic pressure to force liquid spray materials through nozzle tips are essentially the same as they were 70 years ago (Spurrier, 1990).

Surveys by Rider and Dickey (1982) and Grisso et al. (1988) found only 25-30 percent of applicators were applying within 5 percent of their intended rate. Grisso et al. (1988) noted chemical misapplication is costly and can potentially damage the environment or crop. Improper application can also result in excess spray material requiring disposal. Ehart (1988) noted wastes from mixing, loading and cleaning operations pose the greatest challenge for pesticide applicators. Taylor et al. (1988) reported that a typical custom applicator in Illinois may generate 41635 L [11000 gal.] of rinsates during a single season. Even if applied correctly, where the tank is *empty* after application, Rester (1988) estimated an average of 23 to 38 L [6 to 10 gal.] of field strength material would remain in a system. Jones et al. (1991) remarked that 0.91 kg [2 lb.] of atrazine would cause 303 million liters [80 million gal.] of water to exceed the drinking water national health advisory level of 3 parts per billion, which emphasizes the consequences of improper disposal techniques mentioned by Brown (1986). Currently, there are no inexpensive, simple and safe methods available for disposing of pesticide waste solutions. Incineration is the only approach presently available that eliminates the pesticide from the environment (Hetzel, 1991). McQueen (1992) indicated incineration at an EPA approved/operated site will cost $350 per 208-L [55-gal.], excluding transportation. Rinsate and waste reduction appears to be more appropriate and cost effective than waste disposal (Spurrier, 1987).

**Objectives**

Research efforts were directed toward determining optimal operating parameters of tank rinsing nozzles to reduce agricultural sprayer rinsates. Three specific objectives were outlined. The first objective was to develop an accurate and repeatable procedure to detect tracer chemical concentrations. A technique requiring minimal time to verify rinsate chemical content was sought. An optimal set of operating parameters (pressure, flow rate, rinse sequence) was the second objective. Defining a single parameter set which would adequately remove residues from all tank sizes evaluated was desirable. The third objective was to determine the total volume of water required to satisfactorily clean a reservoir of a given size.

# CHAPTER II

# LITERATURE REVIEW

## Applicator Safety

Dover (1985) stated application methods are designed for convenience, economy, and efficacy, not to minimize exposure to workers during mixing, loading, application and cleaning. Often, disposing of pesticide containers, unused diluted pesticide and rinsate from cleaning the container or equipment poses risks to the user or the equipment (Dover, 1985). Hock (1987) felt exposure could be reduced if not eliminated by utilizing: a) adequate personal protective equipment; b) technologically superior application equipment and techniques, and; c) improved and economically affordable disposal processes. Only by physically separating the person from the pesticide can exposure be reduced or eliminated (Dover, 1985). Brazelton and Akesson (1987) noted California law first required the use of closed mixing systems in 1973 which resulted in a reduction of pesticide related illness reports. A study conducted by Olson et al. (1991) of callers to Minnesota Regional Poison Control Centers revealed 99 percent of all pesticide calls were reported as unintentional poisonings. Further, 99 percent were associated with acute exposure. Of those exposed to herbicides, 45 percent were dermal. Jacobs (1982) stated the attractiveness of the closed system concept lies in its potential superiority over other methods that might be used to reduce the impact of pesticide exposure on mixer/loaders. Mueller (1989) reported on a National Cancer Institute study which found lung cancer high among commercial pesticide applicators. Applicators with 20 or more days per year of exposure to herbicides had 6 to 8-fold increased risk, over the average farmer, in getting non-Hodgkin's lymphoma.

## Regulatory Issues

### *Definition of a Hazardous Waste*

As specified in the code of federal regulations (40 CFR parts 261-276), a substance is deemed a hazardous waste if it exhibits any characteristics of 1) ignitability, 2) corrosivity, 3) reactivity, or 4) toxicity. Agricultural chemicals appearing on the list of hazardous wastes generally exhibit the characteristic of toxicity. One must consider inert as well as active ingredients when determining if a particular pesticide is regulated as a hazardous waste. To illustrate this point, two common crop protection chemicals (2,4-D and atrazine, Table 1) have been selected for examination. Technical grade atrazine is not regulated; although formaldehyde which is an inert ingredient of some atrazine formulations, is listed. Therefore, atrazine formulations containing formaldehyde as an inert ingredient are considered a hazardous waste. The active ingredient of 2,4-D appears on the list of toxic substances. Thus, atrazine must be handled as a hazardous waste like 2,4-D; although for different components.

Table 1. Examples of Hazardous Waste Herbicide Ingredients

| Common name | Ingredient | Chemical abstracts name | Chemical abstracts number | Hazardous waste number |
|---|---|---|---|---|
| 2,4-D | Active | Acetic Acid (2,4-dichlorophenoxy) | 94-75-7 | U240 |
| formaldehyde | Inert | same | 50-00-0 | U122 |

### *Generators of Hazardous Waste*

Three categories of hazardous waste generators exist: 1) conditionally exempt; 2) small quantity; and 3) large quantity. Conditionally exempt generators include those who generate less than 100 kg [220 lb.] of hazardous or 1 kg [2.2 lb.] of acutely hazardous material in one calendar month. Small quantity generators (SQGs) are individuals who generate greater than 100 kg [220 lb.] but less than 1000 kg [2200 lb.] of hazardous material in a calendar month. Large quantity generators are those who produce more than 1000 kg [2200 lb.] per month. Most farmers would fit into the SQG classification, while commercial applicators will more likely be large quantity generators.

*Storage and Transportation*

SQGs are allowed to accumulate material on-site for 180 days without a permit (270 days if material must be transported further than 322 kilometers [200 miles]), provided the quantity accumulated never exceeds 6000 kg [13200 lb.]. Generators are required to complete a Uniform Hazardous Waste Manifest (Figure 1) before transporting/disposing of the material. A generator is responsible for retaining a copy of each manifest for a period of three years or until he receives a signed copy from the designated facility which received the waste (this signed copy must be retained for three years). Additionally, a record of test results and waste analysis must be kept for three years from the date the waste was last sent to on-site or off-site treatment, storage or disposal. Cost of disposal will vary depending on the waste, distance to disposal site, and method of disposal. Eckerman (1992) noted paying $1000 per 208-L [55-gal.] for a commercial/licensed hazardous materials handler to transport his waste. Kreuger (1988) cited the cost to be as high as $3000 per 208-L [55-gal.]. According to the United States Code (1988), civil penalty fines for non-compliance with hazardous waste transportation laws can reach $10000 per violation (for a continuing violation, each day constitutes a separate offense). Criminal offenses (upon conviction) carry fines up to $25000 per day, a maximum five year prison sentence, or both (United States Code, 1988).

UNIFORM HAZARDOUS WASTE MANIFEST

1. Generator's US EPA ID No.

Manifest Document No.

2. Page 1 of

3. Generator's Name and Mailing Address

A. State Manifest Document Number

B. State Generator's ID

4. Generators Phone (     )

5. Transporter 1 Company Name

6. Use EPA ID Number

C. State Transporter's ID

D. Transporter's Phone

7. Transporter 2 Company Name

8. Use EPA ID Number

E. State Transporter's ID

F. Transporter's Phone

9. Designated Facility Name and Site Address

10. Use EPA ID Number

G. State Facility's ID

H. Facility's Phone

| 11. US DOT Description (Including Proper Shipping Name, Hazard Class, and ID Number) | 12. Containers No. | Type | 13. Total Quantity | 14. Unit Wt/Vol. | I. Waste No. |
|---|---|---|---|---|---|
| a. | | | | | |
| b. | | | | | |
| c. | | | | | |
| d. | | | | | |

J. Additional Descriptions for Materials Listed Above

K. Handling Codes for Wastes Listed Above

15. Special Handling Instructions and Additional Information

16. GENERATOR'S CERTIFICATION: I hereby declare that the contents of this consignment are fully and accurately described above by proper shipping name and are classified, packed, marked, and labeled, and are in all respects in proper condition for transport by highway according to applicable international and national government regulations.

If I am a large quantity generator, I certify that I have a program in place to reduce the volume and toxicity of waste generated to the degree I have determined to be economically practicable and that I have selected the practicable method of treatment, storage, or disposal currently available to me which minimizes the present and future threat to human health and the environment; OR, if I am a small quantity generator, I have made a good faith effort to minimize my waste generation and select the best waste management method that is available to me that I can afford.

Printed/Typed Name | Signature

GENERATOR

17. Transporter 1 Acknowledgement of Receipt of Materials

Printed/Typed Name | Signature | Date: Month | Day | Year

18. Transporter 2 Acknowledgement of Receipt of Materials

Printed/Typed Name | Signature | Date: Month | Day | Year

TRANSPORTER

19. Descrepancy Indication Space

20. Facility Owner or Operator: Certification of reciept of hazardous materials covered by this manifest except as noted Item 19.

Printed/Typed Name | Signature | Month | Day | Year

FACILITY

**Figure 1.** Uniform Hazardous Waste Manifest (EPA Form 8700-22).

*Exemption*

At present, farmers are not required to comply with federal hazardous waste regulations provided pesticide containing materials are used on their own farm consistent with label disposal instructions (Code of Federal Regulations, 1991). Kreuger (1988) expressed that this exemption was quite narrow and quite specific. Excess spray material and wash waters could be sprayed over an area allowed by label directions or used as make-up water in future tank mixes. It does not mean that a farmer can bury or dump waste pesticides anywhere on his property (Kreuger, 1988).

**Rinsate Management**

Past disposal practices identified by Brown (1986) included washing excess spray and rinse water into drains and sewers, or allowing them to run off into adjacent drainageways. Not only were these methods unsafe, they were illegal. A survey of 400 Illinois farmers, regarding their disposal of surplus tank mixes and dilute solutions, revealed 71 percent held the material in containers until it could be applied on an appropriate crop, 4 percent used an approved landfill, and 32 percent utilized an evaporation pit or other method (Anonymous, 1987). Chemical applicators must develop effective waste management programs to reduce the amount of waste requiring disposal. The Midwest Plan Service (MWPS, 1991) offers many suggestions to reduce the volume of containers and liquids that a farmer must properly manage (Appendix D). Many symposiums have explored alternative methods for the disposal of dilute spray mixtures. Broder and Cole (1987) identified two approaches to pesticide waste reduction: 1) involved rinsate reduction and in-field rinsing; 2) the other involved recycling of rinsates as diluent in subsequent batches. Current application technology wisdom favors applying any diluted spray material as well as wash water for the sprayer, back onto the crop or treated area

(Akesson, 1987). Disposal techniques listed in Table 2 as proven technologies were investigated in the literature. Three rinsate reduction methods, regardless of whether they were a proven technology, are also explored.

## Disposal Methods

### *Carbon Filtration*

Treatment of pesticide laden waste water by carbon filtration involves passing the liquid through a bed of carbon, thus removing the contaminant by adsorption. Generally, some form of flocculation or pretreatment process is required to remove suspended solids which could cause blockage of the granular carbon media. Advantages include unit mobility and being an accepted technology to treat other forms of waste water. Blockage caused by solids and the ultimate disposal of carbon as a hazardous waste can be cited as disadvantages.

Hall et al. (1992) evaluated a *SENTINEL®* carbon filtration water effluent treatment plant. The *CARBO-FLO®*, a flocculation and filtration system, was designed to treat 1000-L [264-gal.] of dilute material in approximately three hours. Three chemicals, permethrin, alachlor and atrazine were examined separately and as a three-way tank mix. Experiments were conducted with 500-L [132-gal.] of each dilute mixture. Individual samples, analyzed on a Varian gas chromatograph (model 3600), had initial concentrations of 237.5, 5100 and 795 parts per million (ppm) for permethrin, atrazine and alachlor respectively. Failure of the flocculation process blocked a carbon filter while treating atrazine. Filter blockage was caused by having 0.54 percent a.i., 0.04 percent greater than recommended. However, filter replacement had no adverse effect on the final outcome. Conclusions drawn from these experiments were: 1) the *CARBO-FLO®* system removed greater than 99.99 percent of pesticide from water; 2) initial pesticide concentration must not exceed 0.5 percent a.i.; 3) formulation and a.i. type make a

Table 2. Categorization of Disposal Technique Technologies

| Technology | Category | | |
|---|---|---|---|
| | Proven Technology[1] | Technology Transfer[2] | Emerging Technology[3] |
| **Physical/Chemical Treatment & Recycling** | | | |
| 1. Pesticide Rinse water Recycling | X | | |
| 2. Granular Carbon Adsorption | X | | |
| 3. UV-Ozonation | | X | |
| 4. Small-Scale Incineration | | | X |
| 5. Solar Photo-Decomposition | | | X |
| 6. Chemical Degradation | | X | |
| **Biological Treatment & Land Application** | | | |
| 1. Evaporation, Photo-degradation & Bio-degradation in Containment Devices | X | | |
| 2. Genetically Engineered | | | X |
| 3. Leach Fields | X | | |
| 4. Acid & Alkaline Trickling | | | X |
| 5. Organic Matrix Adsorption & Microbial Degradation | | | X |
| 6. Evaporation & Biological Treatment with Wicks | | | X |

Source: Work Group Results. In: *Pesticide Waste Disposal Technology; Pollution Technology Review No. 148.* James S. Bridges and Clyde R. Dempsey, Eds.., Noyes Data Corporation, Park Ridge, NJ. pp. 161.

1. Technology is currently being utilized on a commercial basis to treat and dispose of dilute pesticide wastewaters. (i.e., proven technology).

2. Technology is being utilized commercially to treat other types of waste and offers promising opportunities for pesticide wastewater. (i.e., technology transfer opportunities).

3. Technology is not being utilized commercially but experimental data indicates it is a promising candidate technology for pesticide wastewater, (i.e., emerging technology).

difference in system efficiency; and 4) flocculation process appeared less important than filtration for pesticide removal.

A *CARBOLATOR 35B®* treatment unit was tested by Dennis and Kobylinski (1983). Pilot-scale studies were conducted with seven pesticides: baygon, diazinon, dursban, dimethoate, ronnel, malathion, and 2,4-D ester. Three concentrations (20, 60, and 100 ppm) were formulated in 1514-L [400-gal.] batches for each a.i. A pilot-scale study demonstrated an extraction efficiency of 95 percent or greater for all seven pesticides. Further, two separate field tests verified system dependability. Addition of an in-line cartridge filter to remove suspended solids was necessary during field testing. Since this unit was assembled from commercial items, the authors expressed that the *CARBOLATOR 35B®* offers an economical method for SQGs to treat wastes.

Nye and Way (1988) investigated the problem many users have with carbon filtration treatment, the inability to flocculate waste water. To get pesticides to mix with water: solvents, emulsions or other compounds are added, which causes flocculation problems. Aluminum or ferric salts followed by the addition of hydroxide were found to provide the most consistent results.

## *Evaporation Ponds*

Evaporation ponds are above or inground containment facilities used for treating dilute pesticide rinse waters. Construction can be a concrete pit, a lined lagoon, or a soil filled bed. Seiber (1988) explains that they operate by water and chemical volitization, and the residual water becomes progressively more enriched in less volatile chemicals. Entry of rainfall or runoff water can occur if proper precautions are not taken. Groundwater contamination resulting from a container leak is a concern. Low operating cost, of a constructed system, is an advantage.

However, the accumulation of secondary residues, which will have to be dealt with eventually, could be considered a negative aspect (Seiber, 1988). Further, unless chemical reagents can be developed to degrade the toxicants, Seiber feels the negatives outweigh the positives.

Winterlin et al. (1984) monitored 10 lined evaporation beds at the University of California field stations for possible buildup and decay of deposited pesticides. It was noted that these beds had been in use many years prior to conducting studies. Typical beds (6 m x 12 m x 1 m) were lined with butyl rubber and backfilled with 31-46 cm [12-18 in.] of soil. Leach lines in the backfilled soil provided subsurface feeding of waste water to the bed. Most beds were covered with a corrugated fiberglass roof which provided protection from rainfall while still permitting sunlight to enter. One ton of hydrated lime [$Ca(OH)_2$] was incorporated into the soil of most beds to increase pesticide degradation. Soil samples were analyzed by gas chromatography. When used as designed, high pesticide residues tended not to build up after 6-10 years of use, however, residues did concentrate in the top 0-3 cm [0-1 in.] of soil. Lime accelerated degradation of some pesticides. For safety, monitoring beds at least once per year was suggested. This system proved to be an economical on-site disposal method according to the authors.

Baker and Johnson (1984) constructed a pit at the Iowa State University Agronomy-Agricultural Engineering Research Center to relate pesticide volitization to water evaporation. The pit was lined with two sheets of black polyethylene, then backfilled with 122 cm [48 in.] of soil and 46 cm [18 in.] of crushed rock. Depth to water surface was monitored and liquid samples were collected through vertical tiles placed in the pit. Evaporation from May to July averaged 2 mm [0.08 in.] per day, while the period of August to December only had a 0.4 mm [0.002 in.] per day loss. Based on average values, it was estimated the pit could successfully evaporate 20-30000 L [5284-7926 gal.] per year. The authors noted possible volitization problems with pesticides having high vapor pressures.

Junk et al. (1984) evaluated the degradation of pesticides in a water-soil system. Fifty-six plastic garbage containers (110-L [29-gal.]), used as a containment device, were partially buried in open ground. Six pesticides (atrazine, alachlor, 2,4-D, trifluralin, carbaryl, and parathion) were assessed in these receptacles. Pesticides were mixed with 60-L [16-gal.] of water and 15 kg [33 lb.] of soil before being placed in containers. Trials were conducted at two concentrations (0.4 and 0.02 weight percent of a.i.) for each pesticide. Samples from each container were collected over a 68 week period. Experimental results indicated this strategy provided satisfactory containment, volitization should be insignificant (the volatile trifluralin was not lost), and alachlor and atrazine were found to be persistent in soil.

*Leach Fields*

Seiber (1988) explains leach fields are an extension of the soil lined evaporation bed concept. Leach lines are embedded into the soil (61-122 cm [24-48 in.] below grade) to distribute waste water back into the field for subsequent weathering. A potential for surface and subsurface water contamination exists because the system is not isolated from groundwater.

Spittler et al. (1984) installed Chemical Control Centers (CCCs) on small fruit farms (8-121 hectares [20-300 acres]) in cooperation with the United States Department of Agriculture Soil Conservation Service (USDA/SCS). Facilities consisted of a catch basin, leach lines and some form of pesticide storage. Of primary concern in locating a CCC was the availability of a moderately-well drained soil in which to install leach lines. Water and soil samples were taken from nearby water sources at three CCCs and analyzed. Water samples were examined for captan, difolatan, carbaryl, methylparathion, permethrin, and azinophosmethyl. Conclusions suggested that pesticides did not leach into groundwater, in fact, they migrated less than 46 cm [18 in.] from leach lines during five years of operation. Analysis of soil samples revealed no adverse environmental effects (gauged from reduction in soil arthropod population).

## Rinsate Reduction Methods

### *Direct Injection*

Direct injection is a rinsate reduction technique which has drawn considerable attention. Howard (1988) described direct injection as a system which introduces a chemical concentrate directly into the carrier volume at some point before discharge from the spray nozzle. Roth (1988) noted a direct injection system is essentially two systems - a diluent system and a pesticide concentrate system. Diluent and concentrated chemicals are stored in separate reservoirs. Akesson (1987) pointed out this technology reduces washdown requirements of application machines to a minimum, since the spray tank would contain only clean water. Dover (1985) suggested injection systems could be automatically flushed, spraying the rinsate over the crop during the last few minutes of operation.

Several researchers have constructed and evaluated systems for both liquid and dry pesticide formulations. Three methods of injecting concentrated material into the diluent stream have been tested; 1) upstream of system pump; 2) downstream of system pump; and 3) at the nozzle body.

Vidrine et al. (1975) constructed a sprayer model to evaluate the performance of a variable concentrate method to deliver a constant application rate. A positive displacement pump was used to convey pesticides. The diluent and pesticide circuits merged at the spray boom. Two problems were identified with the use of this method: 1) pesticide deposition variability was greater than by conventional methods and 2) transient errors in pesticide application rate resulted from changes in operating speed.

Larson et al. (1982) and Kuhlman et al. (1986) developed a system to inject chemical concentrates into the diluent stream near spray nozzle tips. Laboratory studies were conducted on four nozzle injection designs to determine which provided the most uniform test chemical (Rhodamine B) distribution. A Hesston 500 swather was fitted with a spray system for field tests. A John Blue (FA-500) positive displacement pump metered and delivered chemical concentrates to nozzle assemblies. To provide an output proportional to ground speed, the concentrate pump was coupled to a ground-driven wheel. Chemicals were applied at 0.125 L/min [0.003 gal./min] or 2.34 L/ha [0.25 gal./acre]. Flow dividers were necessary to maintain equal pressure and flow to each nozzle assembly. Distribution and strength of chemicals were variable. In an effort to reduce variability, a small quantity of diluent was added to the discharge side of the chemical pump which increased flow to individual nozzles. Preliminary tests suggested modifications practically eliminated variability problems. However, pump redesign may be necessary to increase high pressure water flow for better concentrate control by travel speed.

Reichard and Ladd (1983) built a direct injection and transfer system that allowed the operator to remove chemical concentrates from their shipping container. Travel speed did not affect application rate since a piston pump was used to meter pesticides. The concentrate was injected into the diluent stream on the high pressure (downstream) side of the system pump. Delivery rate was altered by manually adjusting the pump stroke length.

Koo et al. (1987) wrote a simulation model to evaluate various existing and new injection sprayer designs. The model was validated by instrumenting a spray boom to measure actual time delays. Rhodamine B (a fluorescent dye) was used as a tracer chemical.

Experimental results showed a sizable time delay associated with injecting chemicals directly into the spray boom. Delays up to 20 seconds were observed for the experimental setup. The simulation model proved to be accurate enough for use in predicting application errors for typical field situations. The authors noted the only way to eliminate delays would be to inject concentrates directly at each nozzle body.

Budwig et al. (1988) evaluated the mixing effectiveness and response time of a commercial chemical injection system. A Raven SCS 700 injection metering pump dispensed a chemical concentrate into diluent stream before being passed through an in-line mixer. A laser beam was used to detect the potassium permanganate [$KMnO_4$] tracer for time lags. Steady state samples were analyzed by spectrophotometer. The chemical injection system had large delay times in typical wet boom sprayers, therefore it would be unacceptable for spot spraying and speed change applications.

Tompkins et al. (1990) investigated three metering methods for direct injection systems. Additionally, three injection points were evaluated; 1) Upstream of system pump; 2) Downstream of system pump; and 3) at the nozzle body. Two piston and one peristaltic pump were used to meter a potassium bromide tracer into the diluent stream. All pumps were evaluated on the low pressure (upstream) side of the system pump. Only piston pumps were utilized to inject the tracer on the high pressure (downstream) side. Upstream injection of concentrate provided a chemical distribution equal to tank mixing, although, large transient times were reported. Transient times were reduced and concentration variations were increased when injecting downstream. Direct nozzle body injection reduced transient time, but a non-uniform distribution resulted.

Miller and Smith (1992) incorporated a direct nozzle injection system into a conventional boom sprayer. The chemical concentrate was introduced into the diluent stream through a metering orifice upstream of the nozzle tip. A fluorescent dye/water mixture was used as a test chemical and conveyed by a rotary gear pump. Tests were conducted on a laboratory spray table. Thorough mixing was provided by injecting a concentrated chemical parallel to the nozzle center line. No problem of disparate nozzle-to-nozzle concentration was found. To obtain desired results, the authors stated the system must be coupled to a control system. Injection pressure variation with ground speed changes gave significant errors at low flow rates. A more practical approach, utilizing a positive displacement pump to adjust flow, was suggested.

Peck and Roth (1975) constructed an induction system based on studies described by Nelson and Roth (1973). This system was capable of introducing either a wettable powder (WP) or an emulsifiable concentrate (EC) liquid into the boom supply line. The ground-driven metering system could deliver WP at rate from 0.28-13.44 kg/ha [0.25-12 lb./acre] or a liquid concentrate at 0.56-28 L/ha [0.86-43 gal./acre]. A screw feeder was used to meter WP while a peristaltic tube pump was used to meter liquids. The system used a manifold distribution system. A lag time, due to the nature of mixing and distribution systems, was noted. The authors defined lag time as: the elapsed time from the instant of speed change to the instant that the application rate reaches a value of 95 percent of the equilibrium rate.

Gebhardt et al. (1984) designed and tested a drag-body type flowmeter for use in a direct injection system. Five pesticides were evaluated in the unit. The flow rate of treflan was the only pesticide that the flowmeter could accurately predict. The authors noted the necessity to calibrate the meter for a particular pesticide.

Cho et al (1985) experimented with a spraying system that injected two chemicals into carrier volume simultaneously. Tests revealed uniformity at various nozzles was poor, however, was no worse than conventional sprayers.

Hare et al. (1969) developed a dust-metering unit to apply solid pesticide formulations. Dry materials were dispensed into a centrifugal-type fan intake by a spring auger. Point of dust entry into the fan intake was cited as a critical factor to achieve equal distribution to all nozzles. The unit satisfactorily applied many dust formulations from 0.3-17.8 kg/ha [0.33-20 lb./acre]. The author noted delivery rate is dependant on driven speed, density and physical characteristics of the dust.

Harrell et al. (1973) constructed a system to mix dry pesticides with diluent. The metering unit described by Hare (1969) was electrically driven. Some initial mixing was performed by the pump before reaching the in-line mixer. Four laboratory runs were conducted. Runs 1 and 3 bypassed the in-line mixer, while runs 2 and 4 utilized the mixer. Results were not significantly different as compared to conventional sprayers. Laboratory tests were performed to compare pumps. Roller pumps using an in-line mixer had a high coefficient of variation (CV), while bypassing the mixer resulted in a low CV. Similar results were observed when using a piston pump. Of the three pumps, the centrifugal pump provided the most uniform mixture. Laboratory and field tests demonstrated the experimental sprayer (with centrifugal pump) could be used in place of a conventional sprayer to mix dry pesticides with water.

Nelson and Roth (1973) constructed an induction system that continuously metered, mixed and delivered wettable powders into a boom supply line. A screw feeder metered bulk materials and a jet pump (venturi) was used to mix WP. Slurries were formed in a mix tank. System performance was evaluated using two WP formulations in laboratory studies. Two factors (metering rate and venturi turbulence level) were varied and compared to a conventional sprayer. The induction system did not disperse suspensions as well as did the conventional system tested. Wettable powder properties such as: particle size, presence of wetting agents and dispersants may affect performance of the induction system.

Hart and Gaultney (1989) designed a prototype system to continuously meter and mix dry flowable pesticide formulations with a liquid carrier. A variable volume metering/crushing (VVMC) unit metered materials and reduced particle sizes. Mixing of dry formulations with water was accomplished by construction of a plexiglas solid-to-liquid interface. Ten formulations were evaluated in this system. Preliminary tests showed dispersion times could be decreased by reducing the particle size of packaged materials. However, the unit was not compatible with all dry flowable formulations evaluated.

Hart and Gaultney (1991) constructed a near-constant volume metering/crushing screw to improve output characteristics and particle size distribution over a broader range of dry flowable formulations as compared to the VVMC previously tested. The system was modified to increase exposure to the metering screw. Metering rates were less than those of the VVMC and the new design failed to overcome the limitations of the previous system.

Due to materials being in separate tanks and entailing no hand mixing, operator safety is increased by eliminating exposure to concentrated chemicals. This strategy is environmentally sound because there is no excess tank mix to dispose of. Transient time (due to changes in ground speed) and uniformity of distribution (inadequate mixing of concentrate and carrier) have been cited as drawbacks (Hughes and Frost, 1985; Tompkins et al., 1990). However, Gebhardt et al. (1984) believes direct injection holds promise if flow rate can be measured and controlled. Spurrier (1987) suggests these systems may warrant further development and field application.

*Rinsate Recycling*

Pesticide rinse water recycling is a volume reduction technique where rinsates are collected, stored and subsequently used as a dilution agent in future tank mixes. Aerial applicators in Louisiana (60 percent) have constructed recycling facilities for their operation

(Rester, 1988). By using a sufficient number of storage tanks to segregate rinsates, possible phytotoxicity problems can be avoided (Taylor et al. 1988). Although operation size will dictate the number of tanks required, Tennessee Valley Authority (TVA, 1991) suggested most facilities would need three to four 1893-L [500-gal.] tanks. One should keep in mind labeled use, compatibility and dilution rate when segregating rinsates. Taylor et al. (1988) noted rinsates added to tank mixes should be no more than 5 percent (by volume) of total makeup water. The authors suggested a 5 percent blend would add no more than one to two percent of a.i. per tank mix for most chemicals. The midwest, where few crops are grown, is well suited to recycling. When the number of crops grown increases, the practicality of rinsate recycling decreases (Taylor et al., 1988). TVA (1991) estimates a system would cost approximately $2500. Design considerations and construction plans are available from Midwest Plan Service (1991).

*Tank Rinsing*

Wesley et al. (1988) evaluated the effectiveness of fresh water to clean an enclosed pesticide mixing and loading system. Approximately 20-L [5.25-gal.] of field strength chemical was used to contaminate a 95-L [25-gal.] unit, then transferred to a holding tank. Clean water, applied through overhead flood nozzles and a hand held nozzle, was circulated through the system for one minute. Four rinse cycles of 20-L [5.25-gal.] each were performed, with each being transferred to separate tanks. Chemicals toxic to soybeans and cotton were tested in this system. Bioassays were used to asses rinsing effectiveness. Rinsates from each of the four cycles were applied to plants in the fourth to sixth leaf stage. Two rinse cycles proved adequate to remove 2,4-D from the system. No evidence of injury to cotton plants, from rinsates three and four, were found. Rinsates three and four of dicamba caused minor injury to soybeans, however, this injury was not expected to affect yield potential.

Beasley (1988) described an in-field sprayer rinsing system which could be incorporated into an existing sprayer. The author described two variations which implemented either a gravity flow or a pressure delivery system. Both gravity flow and pressure flow options utilized a garden hose and hand held nozzle to rinse the tank. Clean rinse water, supplied from an auxiliary reservoir, allowed the operator to manually rinse the sprayer tank. Rinsate material could then be applied back over the crop or treated area. A limitation of this system was the potential for the operator to come into direct contact with pesticides during rinsing.

Evans (1992) constructed a tank rinsing system for a commercial floater applicator. Two stainless steel flood nozzles (Spraying Systems Company, model ½K-SS60) were modified (Figure 2) and mounted inside the 6056-L [1600-gal.] spray rig tank. A 190-L [50-gal.] clean rinse water reservoir (Figure 3), fabricated to fit within spray boom framework, was pressurized with 241 kPa [35 psi] of air. After completing the spray operation, all 190-L [50-gal.] of rinse water was dispensed into the sprayer tank as a single rinse. Rinsate material was applied back over the area previously treated (usually end rows). Data were not collected to determine cleanliness, however, no phytotoxicity problems were reported. Evans estimated his facility treats approximately 4047 hectares [10000 acres] per year and generated only 3785-L [1000-gal.] of rinsates requiring disposal.

Jeffrey (1991) developed a flush nozzle for use in a tank washing system. Performance of the original nozzle design, a fixed 360° dispersion plate, proved unsatisfactory. Two nozzles placed in a 600-L [160-gal.] tank failed to completely remove the water soluble emulsion applied to reservoir sidewalls. Nozzle modification resulted in a rotary angled swash plate with a 40 liter per minute [10.5 gal./min] flow rate. The author noted two nozzles should be adequate for tank sizes up to 2000-L [530-gal.]. Residue tests, using a manganese solution as a tracer, were performed on the isolated tank and the entire sprayer system (Figure 4). Swabs were used to

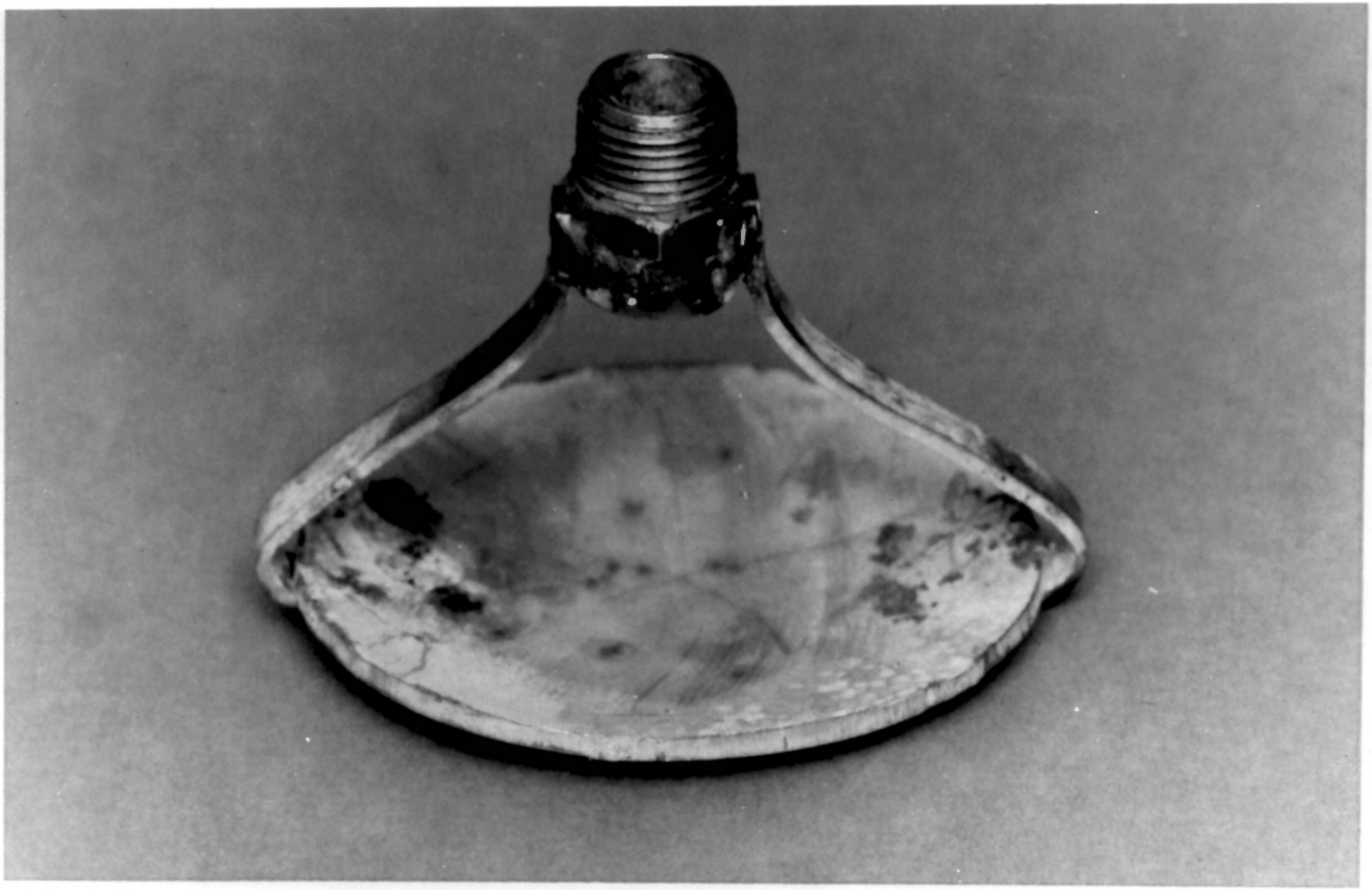


**Figure 2.** Stainless steel flood nozzle (Spraying Systems model ½K-SS60) modified by Evans (1992) for use as a tank rinsing nozzle in a commercial floater applicator.

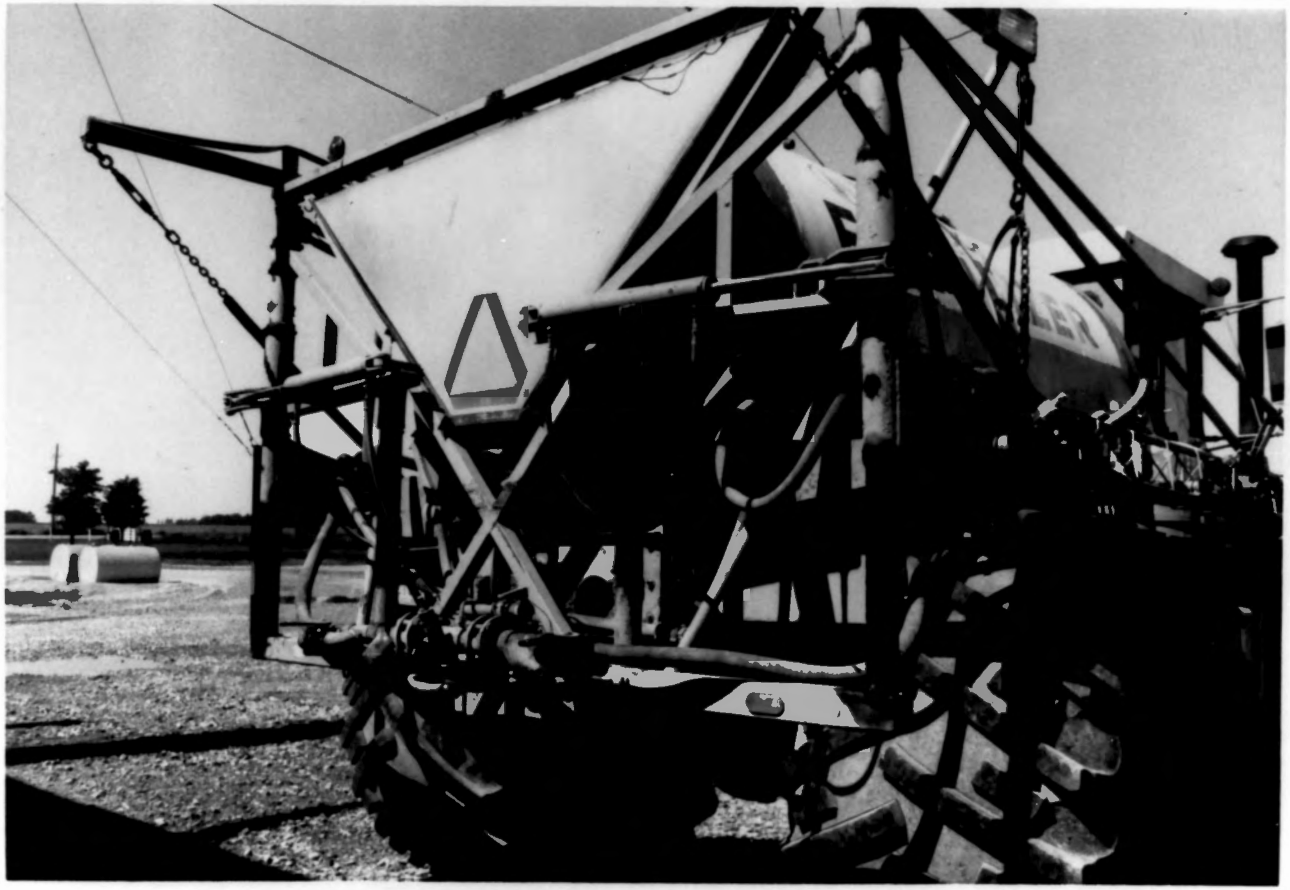


**Figure 3.** Auxiliary clean rinse water reservoir fabricated to fit within spray boom framework used by Evans (1992) as part of commercial floater applicator tank rinsing system.

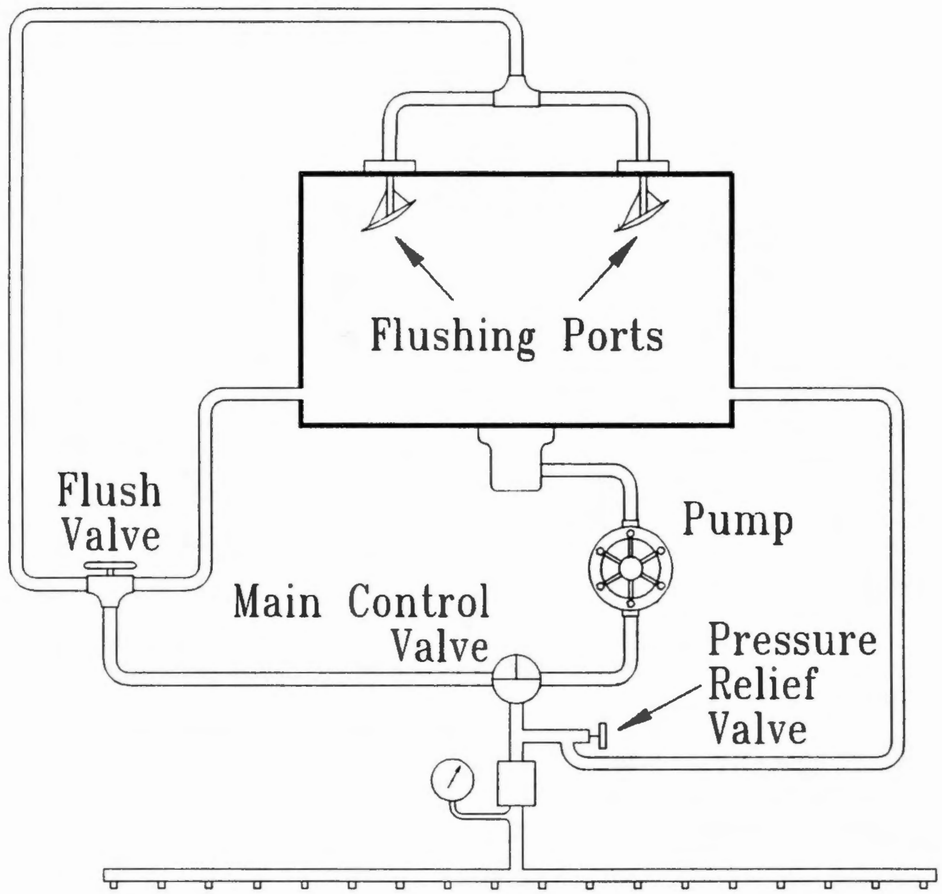



**Figure 4.** Schematic of sprayer tank rinsing system evaluated by Jeffery (1991).

determine level of contamination. Two rinse cycles, using 40-L [10.5-gal.] aliquots of clean water, were executed for a period of two minutes in isolated tank tests. System trials were performed on a sprayer with an 800-L [210-gal.] tank and 12-meter [40-ft.] boom. Experiments determined tank and plumbing capacity should be considered when selecting a rinse volume. Two or more small rinses yielded better results than one large rinse.

**Potassium Bromide as a Trace Chemical**

Several researchers have successfully used potassium bromide as a trace or test chemical. The bromide ion has been used extensively as a tracer in studies of pesticide mobility through soil (Jury et al., 1986; Weintraub et al., 1986; Starr and Glotfelty, 1990; Rice et al., 1991).

Potassium bromide (KBr), a white granular material (colorless crystal or powder), has a specific gravity of 2.75. One gram will readily dissolve in 1.5 ml of water, and the aqueous solution is pH neutral (Windholz et al., 1976). Tompkins et al. (1991) described the chemical as being relatively inexpensive, readily available, and capable of being handled without significant personal hazard, although, Windholz et al. (1976) indicated that large doses could cause central nervous system depression and prolonged intake may cause mental deterioration and acne-form skin eruptions. The material, having therapeutic applications as a sedative and anticonvulsant, is used to manufacture photographic papers and plates (Windholz et al., 1976).

Tompkins et al. (1991) used a solution containing 28.3 grams [1 ounce] of KBr per liter [0.25 gal.] of distilled water as a chemical concentrate for direct injection studies. After injecting the concentrate into a direct injection or conventional spray mix, the resulting solution had an approximate concentration of 0.6 grams per liter. A field conductivity meter (Cole-Parmer Instrument Company) was used to measure samples over a range of 0.05 to 1.0 grams per liter. Conductivity meter measurement reliability was verified by ion chromatography.

Hart et al. (1991) surface applied an aqueous solution of KBr to field plots to assess incorporation uniformity of an L-tine rotary tiller. A 350 kilogram per hectare [312 lb./acre] rate was applied, allowed to dry for 1 hour, then incorporated to a depth of 15 cm [6 in.]. Treated soil samples were tested for the bromide ion on a Dionex 2000i ion chromatograph. Although extract efficiency was reported to be 85-89 percent, chromatographic procedure was time consuming. A less complicated method for detecting bromide concentration was described by Bruce et al. (1985). This investigation dealt with infiltration of bromide in soil. Extraction and filtration of the soil sample proceeded measurement of bromide concentration with an ion specific electrode.

# CHAPTER III

# MATERIALS AND METHODS

An experimental apparatus was designed to determine optimal operating parameters of tank rinsing nozzles in an effort to reduce sprayer rinsates. A concentrated tracer solution was transferred from a separate storage reservoir into various capacity sprayer tanks to contaminate interior surfaces. Residues were left inside tanks after the tracer solution was drained. Rinse nozzles were operated under several conditions to evaluate their ability to remove residues. Rinsate samples were collected and analyzed to establish the level of tracer. A benefit of dilute rinse water is that it can legally be applied over a previously treated area, whereas concentrated solutions cannot. Additionally, cross-contamination (phytotoxicity) problems are reduced when the sprayer tank is cleaned prior to switching chemical types.

## Test Stand

A laboratory scale test stand was constructed to perform two specific functions: 1) provide mounting and support for typical sprayer tank mounting brackets; and 2) house two independent fluid delivery systems. A multi-position frame was designed to accept mounting brackets for four tank sizes. Design considerations included rapid and easy exchange of various tanks and still provide support for the mass of tank and fluid. One fluid delivery system was devoted to transferring a concentrated test solution between a separate storage reservoir and a test tank. A 1136-L [300-gal.] tank served as a storage vessel for the test solution. Utilization of a storage reservoir permitted reuse of the test solution. The transfer system was used to move the concentrated chemical into a test tank, thereby contaminating the interior sidewalls. After filling the tank, the solution was transferred back to the storage reservoir.

Originally, an existing preassembled pump/motor configuration (Figure 5) was used to transfer fluid between the storage reservoir and test tanks. The system consisted of a Dayton 745 W [1 HP] electric motor and a Hypro roller pump (model N6310) connected through a v-belt drive. A Browning sheave (model AK61H) and bushing (model H 5/8) combination was fitted to the pump shaft. Another Browning sheave (model AK28) was attached to the motor shaft. Pump output was estimated by using equation 1 to determine rotational speed, then matching this speed to the pump curve.

$$N_1 D_1 = N_2 D_2 \quad (1)$$

where:

$N_1$ = Driver Speed (Motor RPM)

$N_2$ = Driven Speed (Pump RPM)

$D_1$ = Driver Sheave Diameter (Motor)

$D_2$ = Driven Sheave Diameter (Pump)

This sheave arrangement resulted in a rotational pump speed of approximately 792 revolutions per minute (rpm) which provided a 58.3 L/min [15.4 gal./min] flow rate at 0.0 kPa [0.0 psi]. The system functioned properly, however, transfer time proved to be unreasonably long.

A second fluid delivery system was designed to supply clean rinse water to a tank rinsing nozzle positioned inside a test tank. Clean water was stored in an auxiliary 114-L [30-gal.] cone tank mounted on the test stand. The two separate fluid delivery systems were utilized to avoid potential rinse water contamination, which would ultimately alter rinsate sample concentration. A Hypro roller pump (model N7700), matched with a Browning 40 tooth gearbelt

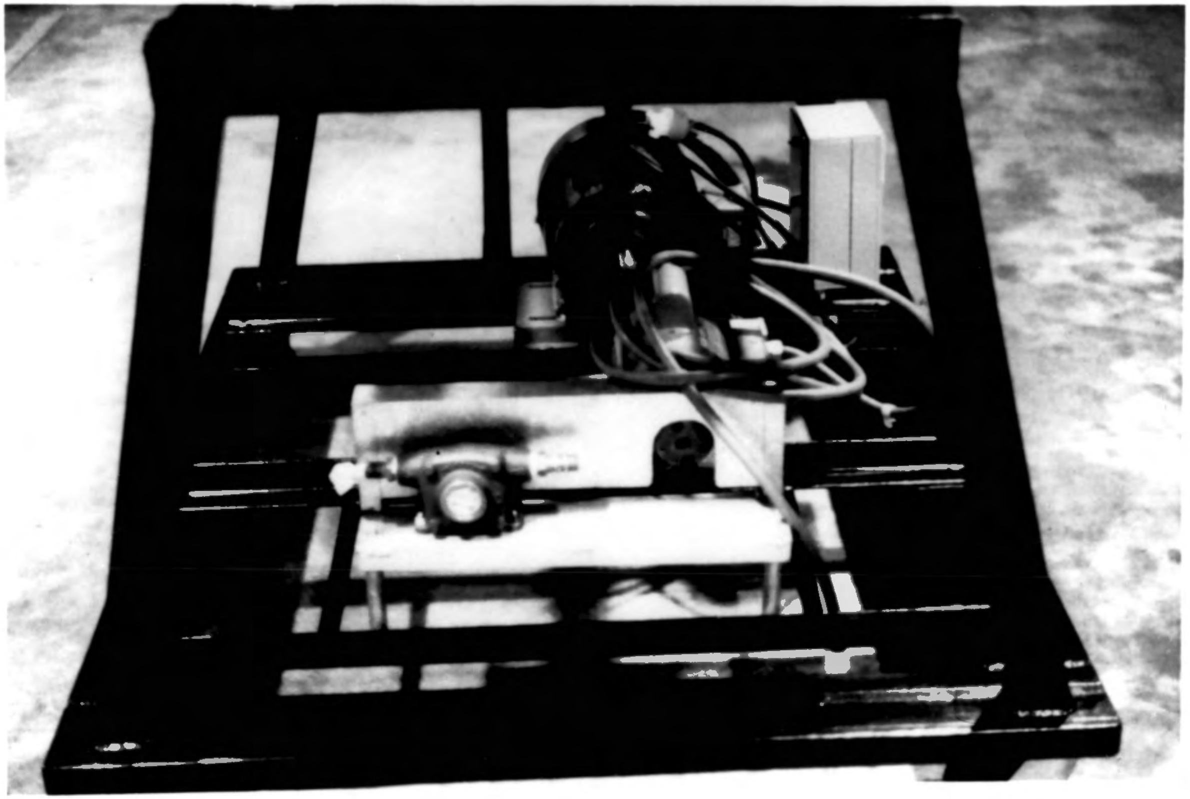


Figure 5. Original pump and motor combination used as the fluid transfer system.

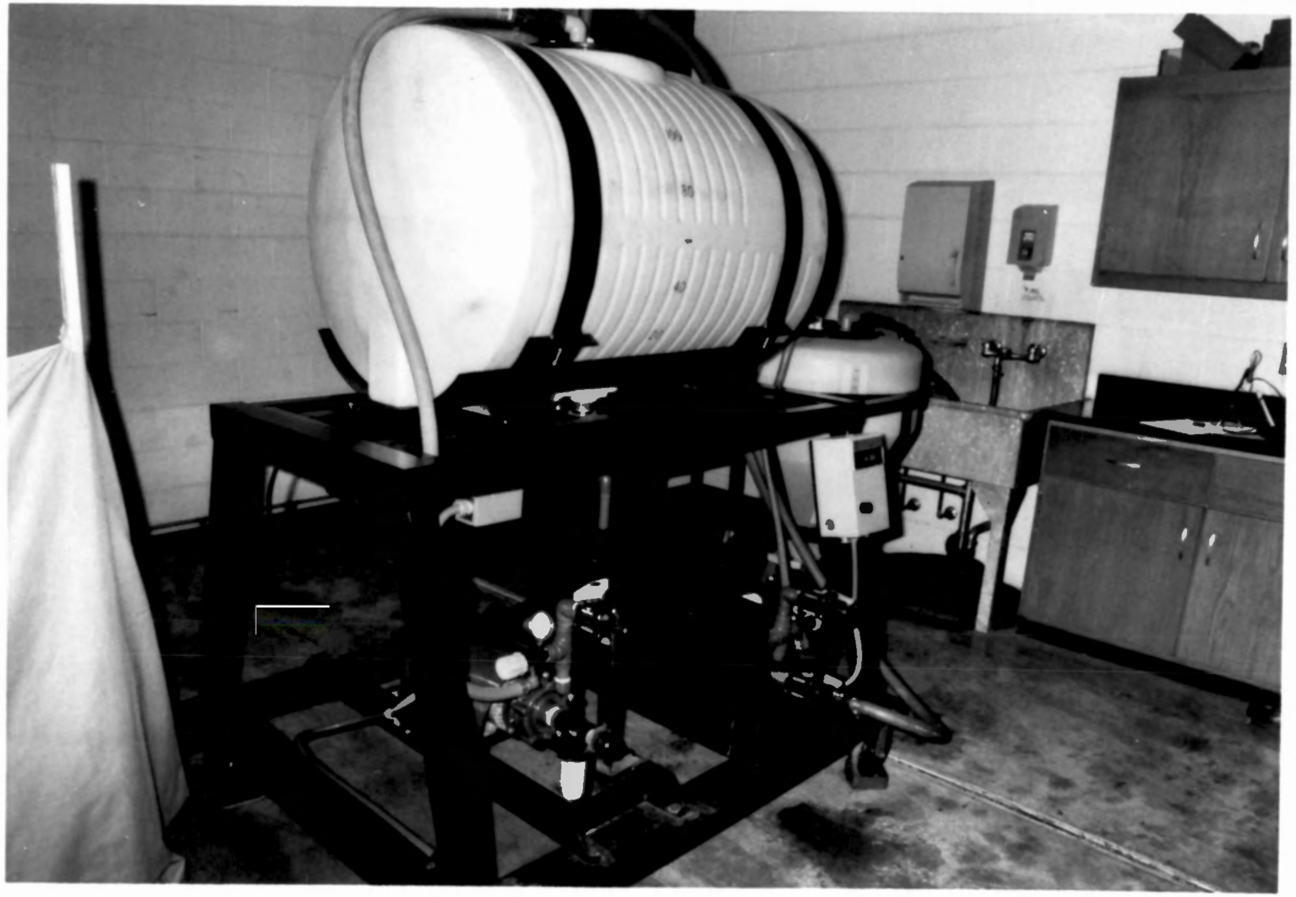


Figure 7. Assembled and operational test stand showing basic framework and caster wheels mounted to channel iron base.

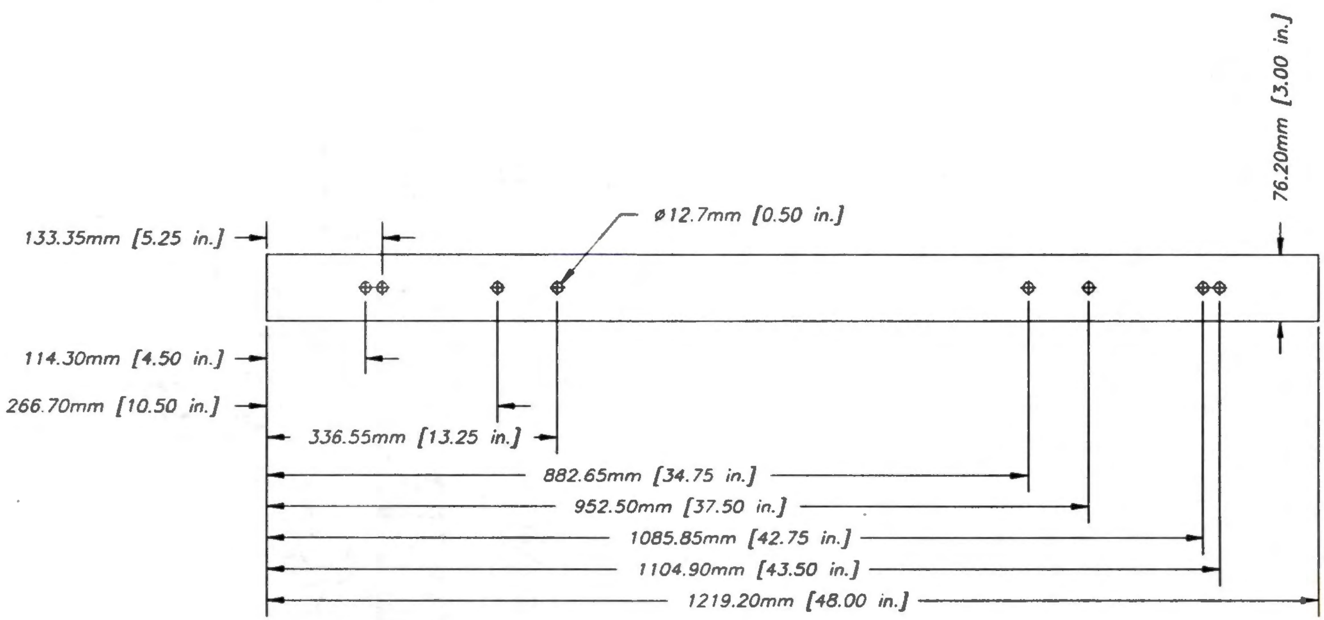



**Figure 8.** Mounting rails designed to accommodate various sprayer tank brackets.

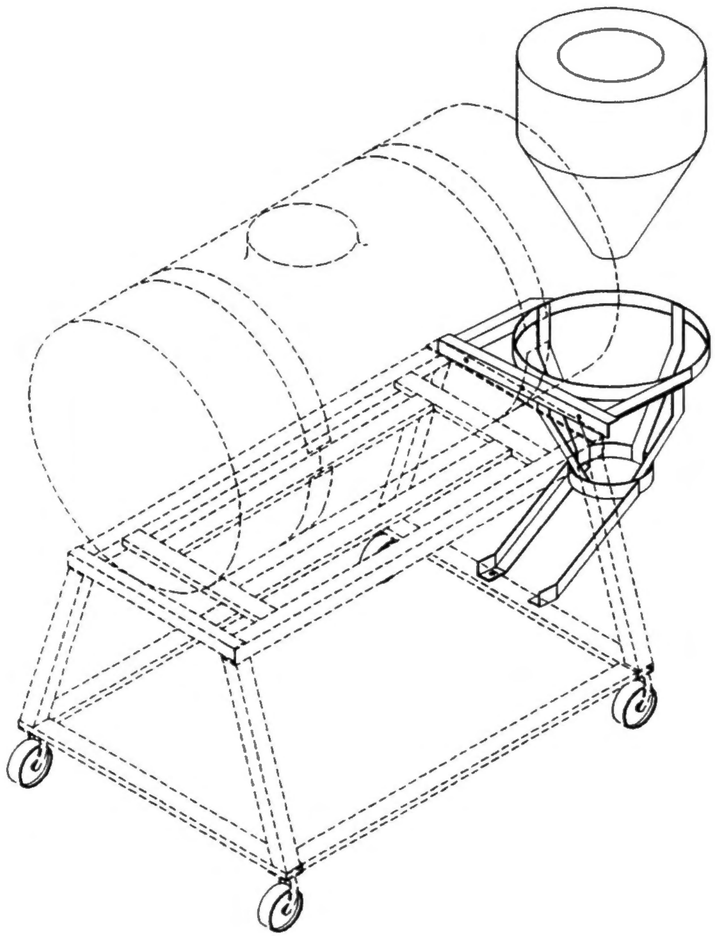


Figure 9. Design and placement of cone tank cradle on test stand.

*Test Tanks*

All sprayer test tanks and the storage reservoir were constructed from polyethylene. Each tank was equipped with a center fill opening and two drain outlets centrally located in the tank bottom. Each of the two underside tank ports were utilized. One port, fitted with a valve and quick-disconnect coupler, allowed rapid changes in fluid circuitry. Transfer and drain hoses were interchanged on this port. A ball valve and drop tube assembly (petcock) was added to the second port. The petcock permitted liquid sample extraction without disconnecting transfer/drain hoses.

*Plumbing Components*

Plumbing components incorporated into both fluid delivery systems were manufactured from non-corrosive materials. Pump housings and internal mechanical components were the only corrosive material which came into direct contact with fluids. Non-corrosive components were selected to limit possible contamination of test fluids. Rigid tubing, elbows, tees, crosses, hose barbs and bushings were schedule 80 polyvinyl chloride (PVC). Strainer housings, ball valves, pressure relief valves, and quick disconnects were polypropylene. Reinforced rubber hoses were used to link pumps to tanks. Test tanks and the storage reservoir were polyethylene. Polypropylene quick-disconnect fittings (Figure 10) were attached to hoses, tanks, and fluid delivery systems to simplify fluid circuit changes. Each fluid delivery system included a line strainer, pressure regulator valve and a glycerine filled pressure gauge. Pump outlet ports were plumbed with manual ball valves and quick disconnect fittings.

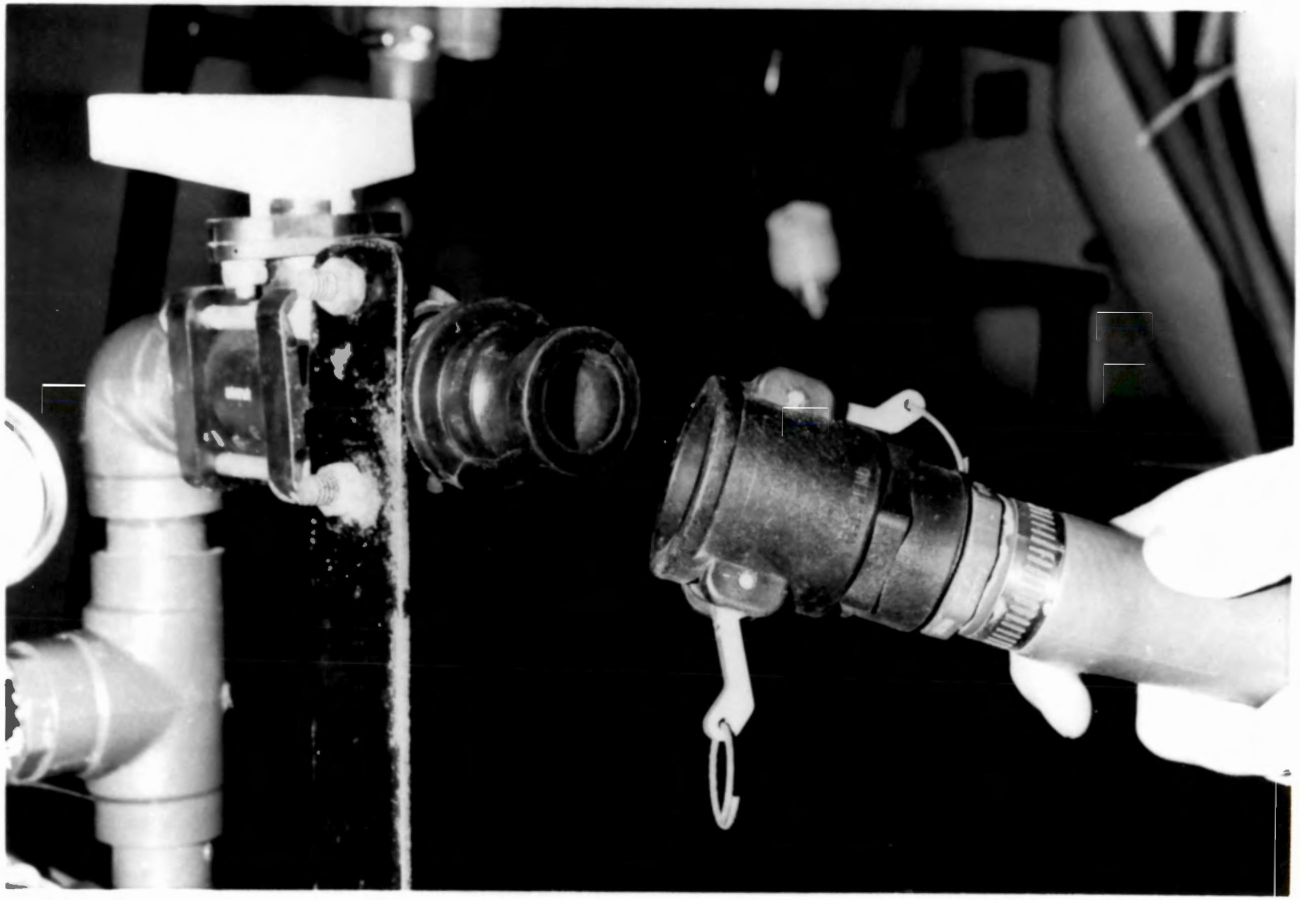


**Figure 10.** Polypropylene quick-disconnect fittings added to hoses, tanks, and fluid delivery systems to simplify fluid circuit changes.

*Tank Lid Modification*

Since tank diameter varied with capacity, vertically centering rinse nozzles within tanks was a consideration. Three tank lids were altered in a similar fashion to permit vertical adjustment of rinse nozzles. Due to its unique small diameter, the 190-L [50-gal.] tank lid required modification. Conversely, for its larger lid diameter, the 1136-L [300-gal.] elliptical tank lid was also modified for nozzle position adjustment. Finally, a third lid interchangeable between remaining tank sizes, was also adapted.

Tank lid required original lid cores to be retrofitted with 6 mm [0.25 in.] plexiglas inserts. The outer portion of lids were preserved intact to maintain lid/tank mating threads. A hole, drilled through the plexiglass center, accepted a 25.4 mm [1 in.] schedule 80 PVC support tube. This tube, bored so a 19 mm [0.75 in.] schedule 80 PVC nozzle drop tube would slip inside, was braced by attaching a slip ring to either side of the plexiglass. Slip rings, constructed from flat PVC stock, fitted tightly around the support tube. Two locking collars were fabricated from a schedule 40 coupling. Collars, specifically added to provide more threading material, were located at each support tube end. Holes were tapped through both collar and support tube so 0.25 in. x 20 thumb screws would lock the nozzle drop tube in place. Slip rings were secured to the support tube with PVC cement. Four #12x24 machine screws attached plexiglass core to the original lid. Clear silicone, placed at lid-plexiglass and plexiglas-support tube joints, provided a watertight seal. Two additional holes were tapped in the plexiglas to incorporate a vent and a transfer pump bypass line. Figure 11 illustrates the components described above. The three modified tank lids are illustrated in Figure 12.

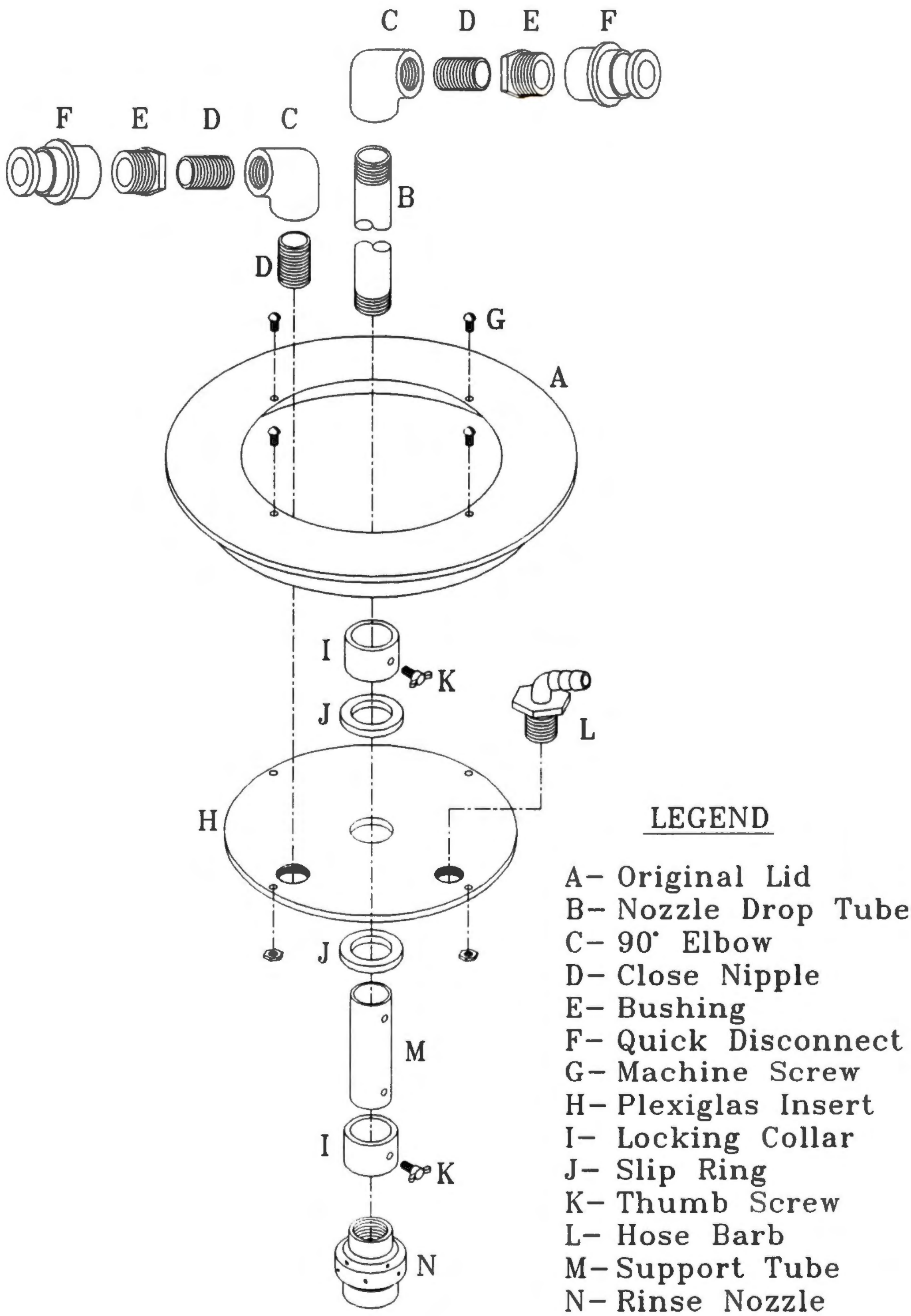



**Figure 11.** Exploded view of tank lid modification components.

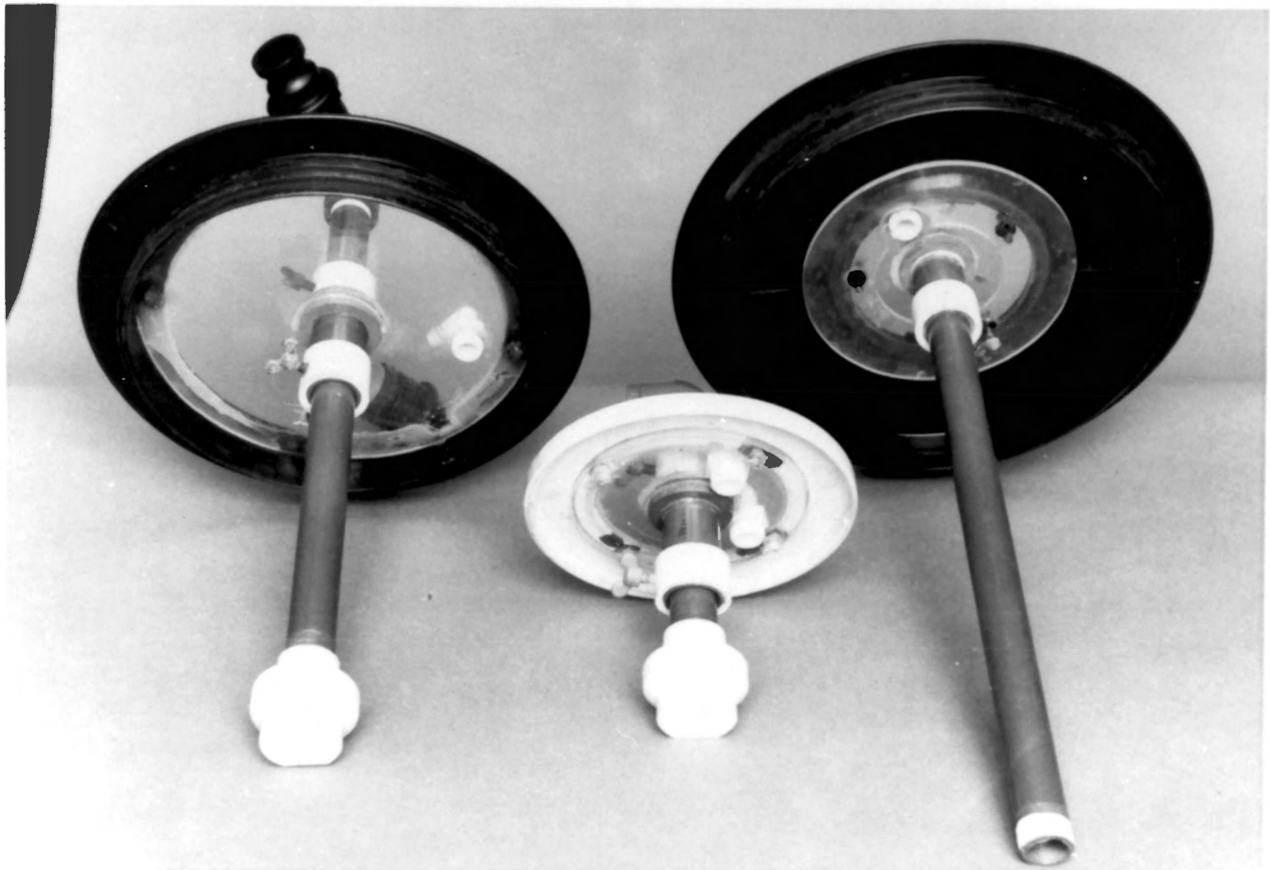


Figure 12. Modified tank lids for vertical adjustment of rinse nozzles.

**Test Chemical Preparation**

*Calibration Standards*

*Mallinckrodt* analytical reagent grade potassium bromide crystals were used to formulate aqueous tank mix solutions and calibration standards. Calibration standards were formulated using a serial dilution method. Bromide ion concentrations for calibration standards were expressed as milligrams per liter or parts per million. Five one-liter concentrations (10000, 1000, 100, 10 and 1 ppm) were prepared. During formulation of calibration standards, potassium bromide reagent weights were determined with an analytical balance (*Sartorius* model B 120 S) to the nearest 0.0001 gram. In order to determine the correct amount of KBr to yield a specific bromide ion concentration, one must consider the relationship between individual atomic weights of potassium and bromide. For every mole (119 mg per liter) of KBr, the bromide constitutes 67.15 percent, which equates to 79.909 mg of bromide. Knowing one milligram per liter is equivalent to one part per million, a 10000 ppm bromide standard was calculated in the following manner:

$$\frac{119.00 \text{ mg KBr}}{x \text{ ppm Br}^-} = \frac{79.909 \text{ mg Br}^-}{10000 \text{ ppm Br}^-} \Rightarrow x$$

$$x = \frac{148919.94 \text{ mg KBr}}{\text{L}} \cdot \frac{\text{gram}}{1000 \text{ mg}} = \frac{14.89 \text{ g KBr}}{\text{L}} \Rightarrow \frac{10000 \text{ Br}^-}{\text{L}}$$

where: atomic weight of potassium bromide (KBr) = 119.00

atomic weight of potassium (K) = 39.102

atomic weight of bromide (Br) = 79.909

x = parts per million of bromide

Therefore, 14.89 g of KBr crystals were amassed and transferred into a 1000 ml flask containing approximately 500 ml of distilled water. The flask was inverted several times to guarantee crystals dissolving into solution. Additional distilled water was then added to attain 1000 ml total volume, thus yielding one liter of 10000 ppm bromide. One-hundred milliliters were retained for subsequent dilution, while the remaining 900 ml were stored in a one liter brown glass bottle. Blending the 100 ml portion retained with 900 ml of distilled water formed a 1000 ppm standard. Repeating this retention process continued until the five concentrations previously mentioned had been obtained. Standards were stored at room temperature out of direct light. By preparing fresh standards weekly, degradation and bacterial growth problems were eliminated.

*Tank Mix Solutions*

An aqueous solution of KBr with an initial concentration of 10000 ppm was prepared as a test chemical. The two ingredients used to formulate this solution were tap water and *mallinckrodt* analytical reagent grade potassium bromide crystals. Depending on test tank size, approximately one-half the water volume required for a given tank was dispensed into the 1136-L [300-gal.] storage reservoir. Given the large quantity of water and potassium bromide employed, the same precision observed for generating calibration standards was not exercised in developing tank mixes. The required mass of KBr crystals was converted to english units and weighed on a platform scale to the nearest 0.25 lb. Pre-weighed KBr crystals were dissolved in a 11-L [3-gal.] plastic bucket of hot water, then poured into the storage reservoir. Since larger tanks required several thousand grams of potassium bromide, many repetitions were necessary to dissolve all crystals. Once all potassium bromide crystals were dissolved, the remainder of the water was added. Although potassium bromide crystals and water were not measured precisely, tank mix concentrations were monitored with a calibration meter and adjusted as needed. Prior to analyzing the solution, it was recirculated with the transfer system for approximately five minutes. Initial tank mix concentrations were determined to be within ±500 ppm of the required 10000 ppm concentration. Initial concentrations were adjusted by adding more KBr crystals or diluting the solution with clean water. To increase concentration, a small volume of solution was extracted and additional crystals were added. The mixture was returned to the storage reservoir, recirculated, and analyzed. Replacing an aliquot of the tank mix with clean water decreased the concentration. After reaching the desired 10000 ppm concentration, the tank mix was allowed to equalize with the ambient temperature overnight. By permitting the solution to stand overnight, temperature fluctuations were kept to a minimum throughout a day's testing.

**Detection Equipment**

*Description*

An Orion model 290A portable pH meter (Figure 13) was used to measure rinsate sample concentrations. The meter, equipped with an ion specific bromide electrode (Orion model 94-35) and its corresponding double junction reference electrode (Orion model 90-02), enabled direct concentration measurement ranging from 0.0000 to 19900 ppm. Sample temperatures (°C) were collected using a temperature sensor which was incorporated into an Orion Triode™ pH electrode (model 91-57BN). Utilizing these three probes simultaneously simplified gathering concentration and temperature values. A 4.5 digit liquid crystal display (LCD) panel displayed both values concurrently. The operator had the flexibility to specify one, two or three significant digits for concentration display. An internal calibration, with up to five-points, could be performed directly with the meter. A low-level scale for detecting bromide

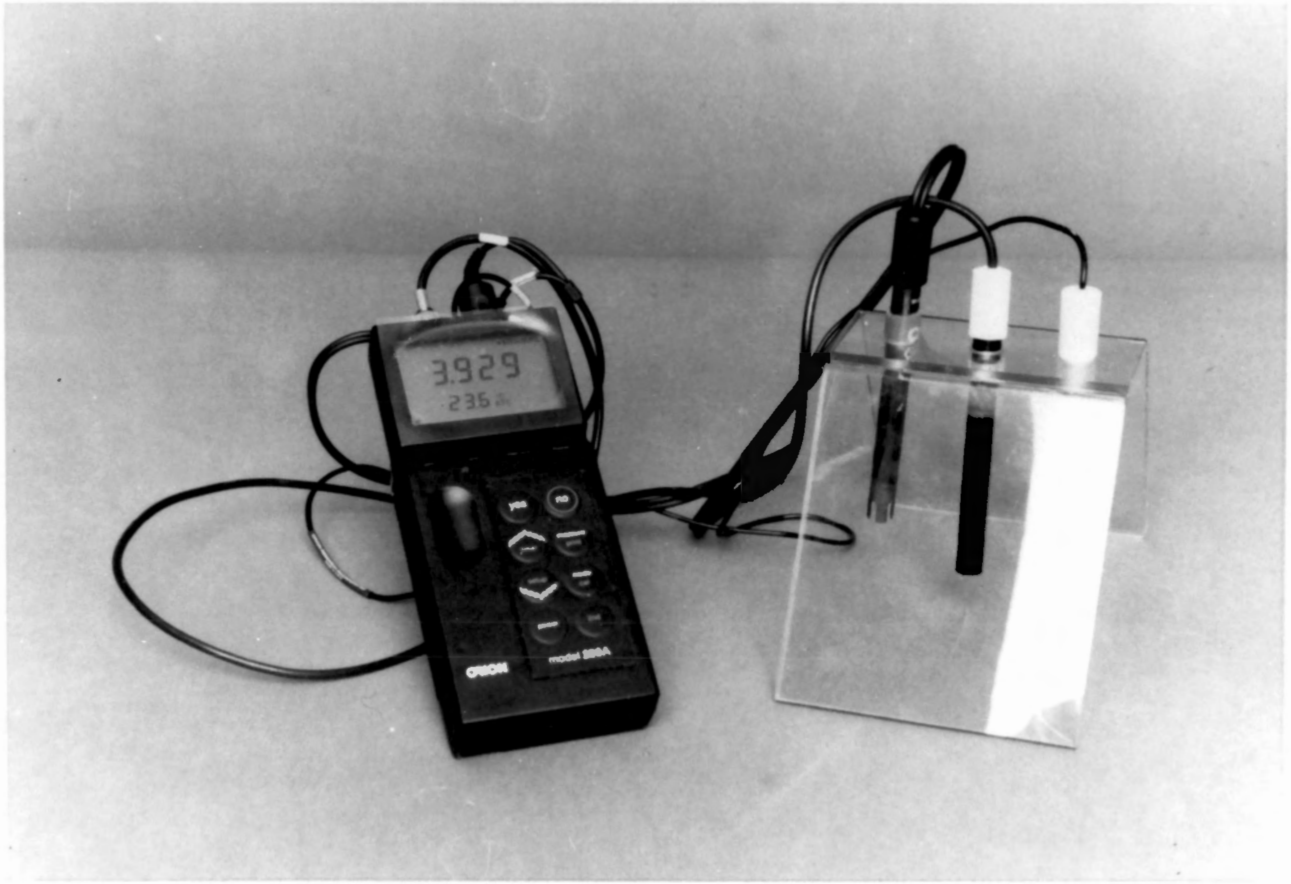



**Figure 13.** Orion 290A portable pH meter equipped with bromide ion specific, double junction reference, and pH electrodes.

concentrations less than 0.2 ppm was not used for this project. The meter manufacturer stated relative accuracy was ±0.5 percent of reading.

*Meter Setup*

Prior to meter calibration, the 290A internal setup routine was initiated to verify concentrations would display three significant digits and display *hold* was toggled on. Display *hold* reduced data transcription errors by retaining stabilized values until the operator indicated he was ready to proceed with another measurement. To resume analyzing, the *measure* key was pressed.

Following completion of the meter setup routine, all probes were inspected for essential periodic maintenance. A soiled bromide probe sensing membrane caused drift, loss of low-level response and poor reproducibility. Polishing strips (Orion Cat #948201) were used to clean the membrane and restore performance. An inner (Orion Cat #900002) and an outer filling solution (Orion Cat #900003, 10% $KNO_3$) were required by the double junction reference electrode. Only one solution (Orion Cat #900011, 4M KCl saturated with AgCl) was needed for the pH electrode.

*Meter Calibration*

Calibration of the 290A was accomplished by using laboratory standards discussed earlier. After agitating standards by manually shaking bottles, 100 ml aliquots of each concentration were dispensed into paraffin lined paper cups. Standards were treated with 2 ml of an Ionic Strength Adjuster (ISA, Orion Cat #94001, 5M $NaNO_3$), as recommended by the bromide electrode manufacturer, to assure all samples had approximately equal ionic strength. Solutions were mixed using a magnetic stir plate with a rpm dial setting of three (approximately

225 rpm), given a range of one to five, for all samples. Insertion of a magnetic stir bar preceded samples being placed on a stir plate. Meter calibration protocol demanded the lowest concentration be tested first, then continued in ascending order until all five standards had been recorded. Probes were positioned approximately 25.4 mm [1.0 in.] below liquid surface. After establishment of a concentration value, it was manually adjusted to display actual calculated sample concentration. Probe slope was determined, and maintained internally, by the meter following the final calibration standard measurement. Only the bromide specific and double junction reference electrodes were used to calibrate the meter.

## Rinsate Samples

### *Operating Parameters*

Two commercial tank rinsing nozzles (Spraying Systems Company model 27500-E ¾-18 TEF and Lechler, Inc. model L5E) were evaluated. Three operating parameters (pressure, rinse sequence, and rinse volume) were varied to evaluate performance of these two nozzles. Nozzle operating pressures were set according to manufacturers recommendations. The Spraying Systems nozzle was operated at 138, 207, 276, and 345 kPa (20, 30, 40, and 50 psi) for all tank sizes tested. The Lechler nozzle was tested only on the 380-L [100-gal.] tank at pressures of 207, 276, and 345 kPa (30, 40, and 50 psi). Two rinse volumes (5 and 10 percent of tank capacity) and three rinse procedures (single, double, and triple) were evaluated at each pressure. For the single rinse procedure, the tank was rinsed once with the total rinse volume. In the double (triple) rinse procedure, the tank was rinsed twice (thrice) with half (one-third) of the total rinse volume. All rinse tests were replicated a minimum of three times.

*Rinse Water Measurement and Application*

Clean rinse water from the auxiliary cone tank was measured visually. The volume of water being dispensed through the system was gauged from graduations (1.9-L [0.5 gal.] increments]) molded into the polyethylene tank. The manual ball valve plumbed ahead of the nozzle was opened prior to rinse system operation. Water level in the cone tank was noted before switching the system motor on. After dispensing the desired volume of water, the manual ball valve was closed and the motor was switched off simultaneously. The valve was closed to eliminate dispensing additional water while the system pump came to a complete stop.

*Collection*

Rinsate samples were collected using the following procedure. Prior to testing, the test chemical solution was agitated to ensure a homogeneous mixture. Recirculating fluid, while still in the storage reservoir, for five minutes through the transfer pump provided adequate agitation. Rinse system pressure was set according to predetermined test operating parameters. Rinse water accumulated while adjusting system pressure was gravity drained prior to contaminating the test tank with concentrated KBr solution. The ionic solution was transferred to the test tank where it remained until approximately 450 ml was extracted to purge the petcock (Figure 14). A 100 ml sample of solution was then withdrawn and concentration measured to quantify initial concentration. All samples were collected in disposable paraffin lined paper cups to prevent cross contamination between samples. Once an initial tank mix sample had been collected, the solution was transferred back into the storage reservoir. Excess material remaining in the tank after the transfer process was gravity drained. Closing of valves preceded dispensing a predetermined volume of rinse water into the tank. After purging the system by removing and discarding the first 450 ml of rinsate, a 100 ml sample was taken for analysis. Rinsates were

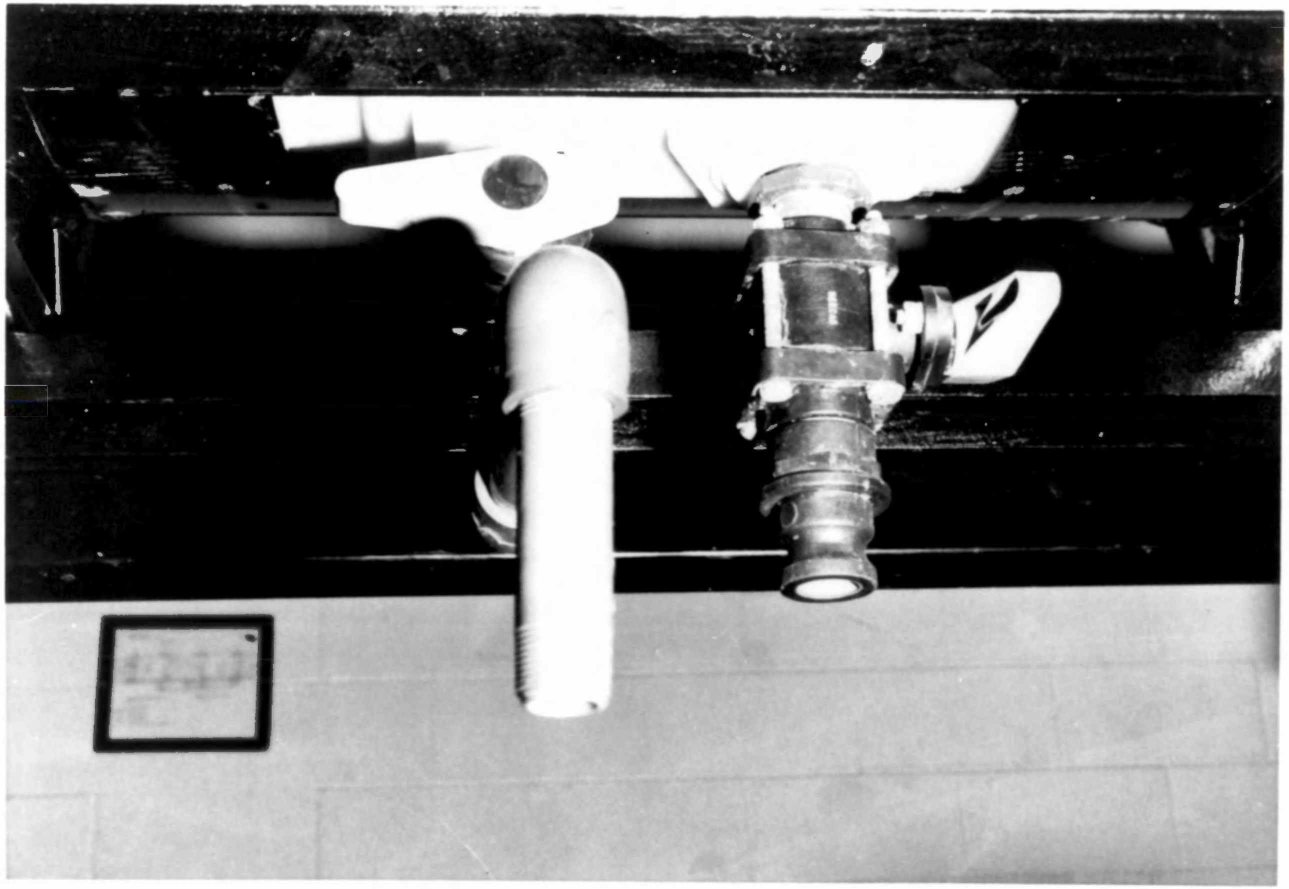


**Figure 14.** Petcock mounted on the bottom of test tank used to extract rinsate samples.

drained between each rinse cycle and the number of rinse cycles performed depended on preset test parameters. System operating pressure was changed only after the final rinsate sample had been collected from a particular test sequence.

*Concentration Measurement*

Rinsate samples were treated and analyzed in a manner consistent with calibration standards. Two milliliters of ISA were added to each sample with a 10 ml pipet. A magnetic stir bar was placed into a sample before being set on the stir plate. Specimens were mixed at 225 rpm and probes were placed approximately 25.4 mm [1.0 in.] below the liquid surface. After a stable reading was achieved and the meter display locked, concentration and temperature values were recorded. Probes were rinsed with distilled water, blotted dry, and placed in a storage rack between measurements. Owners manuals stated storing probes in ambient air for short time periods was permissible. All samples of a given sequence were analyzed before collecting subsequent samples. As recommended by the manufacturer, probe slope was checked for drift every two hours. Fresh calibration standards (1 ppm and 10 ppm) were used to detect drift. If the concentration reading for either standard varied by more than 1 ppm, the meter was recalibrated.

## Statistical Data Analysis

The General Linear Model (GLM) procedure was used for data analysis. A model was constructed using the fixed effects (operating parameters) as independent variables along with all interaction combinations. Additionally, a four-way interaction of the fixed effects was used as an error term. Since the data were from an unbalanced design (each fixed effect having a different number of levels), it was necessary to estimate the concentration means. The leastsquares mean option in GLM produced estimates of what the concentration means would be if factor levels were balanced. A new variable (lconc, equation 2) was defined in the *SAS®* program to stabilize low rinsate concentration value variance. This new variable was defined as:

$$\text{lconc} = \log(\text{conc}+1) \tag{2}$$

where: lconc = new variable

log = natural log

conc = original rinsate concentration

# CHAPTER IV

# RESULTS AND DISCUSSION

A preliminary study was conducted to establish baseline performance data for test equipment. Specifically, preliminary testing served four functions: 1) determined accuracy and repeatability of detection equipment to analyze rinsate concentrations; 2) defined operating parameter ranges necessary to clean tracer chemical residues from interior tank surfaces; 3) aided in the development of a standardized method to collect/detect rinsate samples; and 4) provided an opportunity to correct test apparatus problems prior to conducting actual tests. Performance of the Spraying Systems tank rinsing nozzle was evaluated in the 190-L [50-gal.] tank. A tank mix containing six grams of potassium bromide per liter of water (4030 ppm) was formulated for initial studies. Data from these tests (Appendix A) were not statistically analyzed.

## Detection Equipment

The Orion 290A meter (and probes) proved to be a reliable device for detecting rinsate concentration. No difficulties were experienced. Although, the bromide-specific-electrode-sensing-membrane required routine cleaning. It was necessary to clean the sensing membrane once per week to reduce potential problems of slope drift, loss of low level response and poor reproducability. Rinsate samples were analyzed in less than one minute, using a clean sensing membrane. The bromide ion specific electrode was checked for drift every two hours as per manufacturers recommendations. The meter was recalibrated if drift was detected. It was only necessary to recalibrate the meter at the beginning of each day and at four hour intervals during operation. Data transcription errors were reduced by using the meter's display *hold* feature.

**Operating Parameters**

Little documented research data regarding tank rinsing and no information relating to the specific detection equipment used for this project was found in the literature. Thus, preliminary tests were required to quantify the effectiveness of the rinsing nozzle. Initially, operating pressure was held constant (276 kPa [40 psi]) while rinse volume and rinse sequence were varied. Rinse volumes ranged from 6 to 20 percent of total tank volume. The rinse water volume was dispensed in equal aliquots of 2, 3, and 5 rinse sequences. Triple rinse sequences of 15 and 18 percent total tank volume performed as well as a 20 percent volume applied in five equal rinses. Each of these experiments successfully reduced final rinsate concentration below the calibrated meter detection limit of one part per million. In an effort to reduce time and rinse water volume required to complete the rinsing operation, further evaluation was restricted to a maximum triple rinse sequence using 5 and 10 percent rinse volume. Ultimate acceptance and implementation of a tank rinsing system is dependant on it's practicality. If a system is time consuming (a function of rinse sequence and rinse volume required to adequately clean a reservoir), it will not gain acceptance. A graphical representation of results from triple rinse sequences at varying nozzle operating pressures and rinse volumes is shown in Figure 15. Represented values are a three replication (minimum) average of the final (third) rinsate concentration.

**Collection/Detection Method**

A standardized method of collecting/detecting rinsate samples was established during preliminary testing. Preliminary studies were conducted to establish a collection procedure that would yield accurate and repeatable results. Initial rinsate samples were taken at two locations: 1) from the bottom mounted petcock; and 2) through the tank fill opening. Both samples were

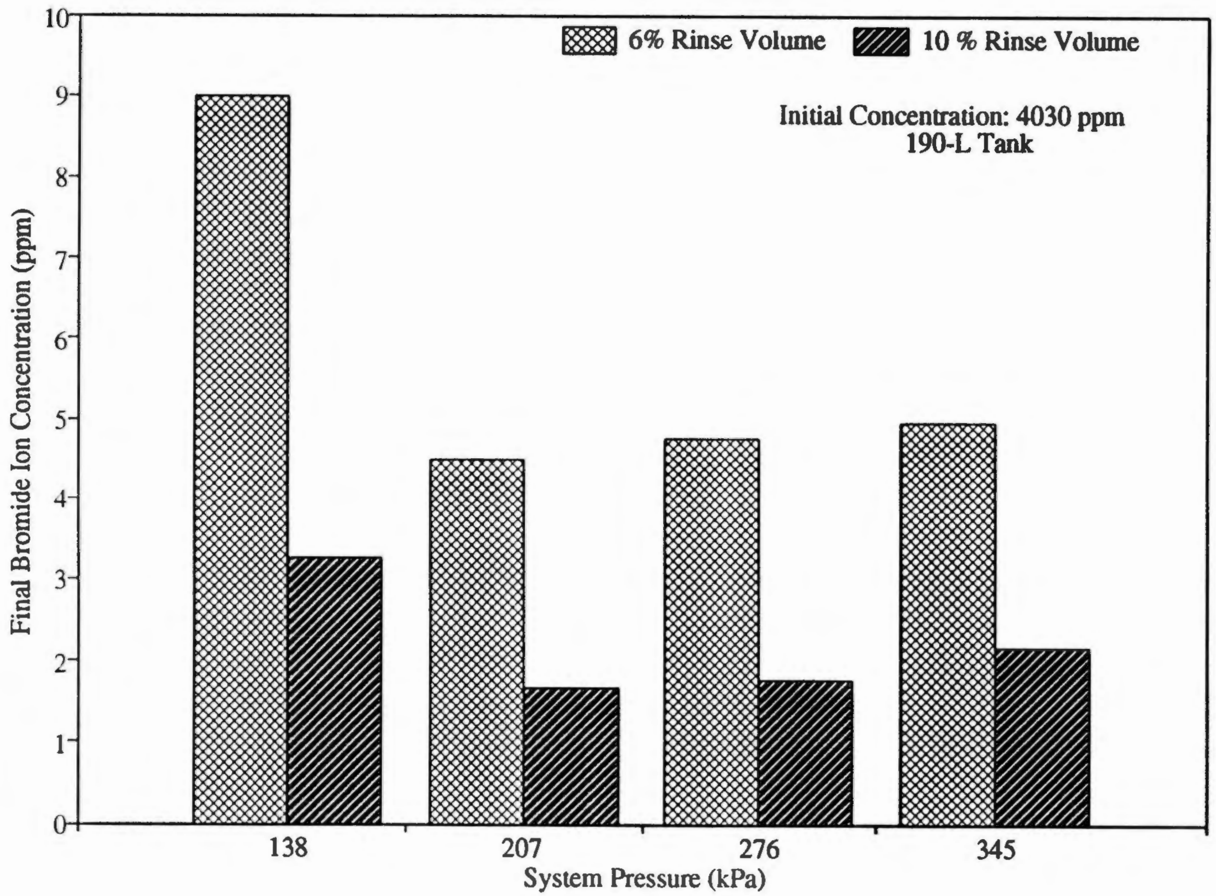



**Figure 15.** Preliminary results of final rinsate concentration from a 190-L [50-gal.] tank using a triple rinse sequence.

analyzed to determine if concentrations were affected by sampling location. Samples drawn from the petcock consistently produced concentration readings 5 to 10 percent higher than those taken from the tank fill opening. This situation was the result of carryover from previous rinsate. The carryover problem was eliminated by purging the petcock prior to collecting a sample for analysis. Extracting and discarding the first 450 ml [0.12 gal.] of rinsate adequately purged the petcock allowing the operator to obtain a representative rinsate sample from the tank.

Rinsate samples were treated with Ionic Strength Adjustor and manually stirred with sensing probes while analyzing. However, this approach proved unacceptable due to inconsistency of concentration readings. Manual stirring did not provide adequate mixing of the solution. A magnetic stir plate was subsequently used to provide sufficient mechanical agitation of the mixture.

**Transfer System**

During the project, three evolutions of the transfer system transpired. Ultimately, the original roller pump seized prompting an upgrade to a higher volume Hypro model N7700 roller pump. Although both sheaves were retained, the H-5/8 bushing was substituted with a H-15/16 bushing to accommodate the larger diameter pump shaft. New mounting plate holes were bored to install the new pump. System modifications resulted in a transfer flow rate of 89 L/min [23.5 gal./min] at 0.0 kPa [0.0 psi]. This setup performed well except for wear problems encountered with internal pump rollers. Rollers were replaced once during their service as part of the test apparatus. When it became necessary to replace them a second time, the entire transfer system was removed from the test stand and replaced with a centrifugal pump. A Teel centrifugal pump (model 1P837), with integral 1.1 kW [1.5 HP] electric motor, became the final transfer system (Figure 16). Aside from increasing the flow rate, this unit functioned significantly quieter than

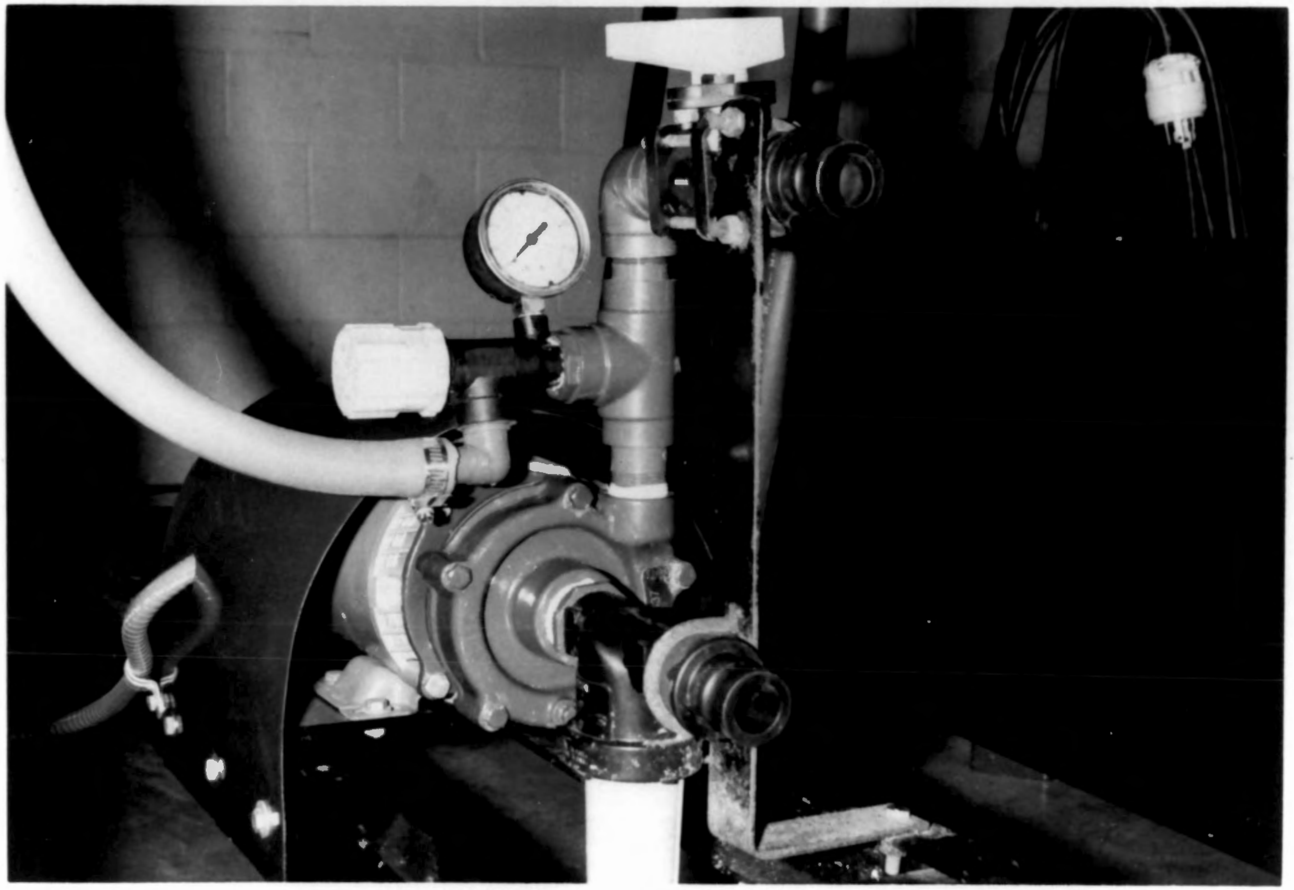


Figure 16. Teel centrifugal pump with integral motor used to transfer fluid between storage reservoir and test tanks.

either roller pump system due to having fewer mechanical components. Although the centrifugal pump was rated at 375 L/min [99 gal./min] at 0.0 kPa [0.0 psi], actual delivery was approximately 133 L/min [35 gal./min]. The 32 mm [1.25 in.] inlet port was plumbed with 25.4 mm [1.0 in.] components. Flow was further restricted by using 25.4 mm [1.0 in.] inside diameter hoses for connections between the pump and tanks.

**Rinse System**

One major rinse system modification took place during preliminary testing. The Hypro N7700 roller pump was unable to supply sufficient fluid flow to operate the tank rinsing nozzle (Spraying Systems model 27500-E ¾-18 TEF) at the manufacture's maximum rating of 345 kPa [50 psi]. A larger volume Hypro roller pump (model 1502N) superseded the N7700 pump. The smaller N7700 pump was subsequently used as part of the fluid transfer system.

To obtain the correct pump discharge flow rate, it was necessary to alter the driver-to-driven gear ratio. A pump speed not exceeding 540 rpm was required such that pump output would correspond to nozzle discharge rate over desired pressure ranges. A variation of equation 1 (page 28) was used to calculate driven gear size (equation 3) by substituting number of gear teeth (T) for sheave diameter (D).

$$N_1T_1 = N_2T_2 \tag{3}$$

The required driven gear size was established by placing appropriate values into the equation. A 60 tooth Browning gearbelt pulley (#60HQ100), providing a driven rotational speed of 517.5 rpm, replaced the 40 tooth pulley (Figure 17). The new setup delivered 100 L/min [26.3 gal./min] at 345 kPa [50 psi]. An adjustable pump mounting bracket (Figure 18),

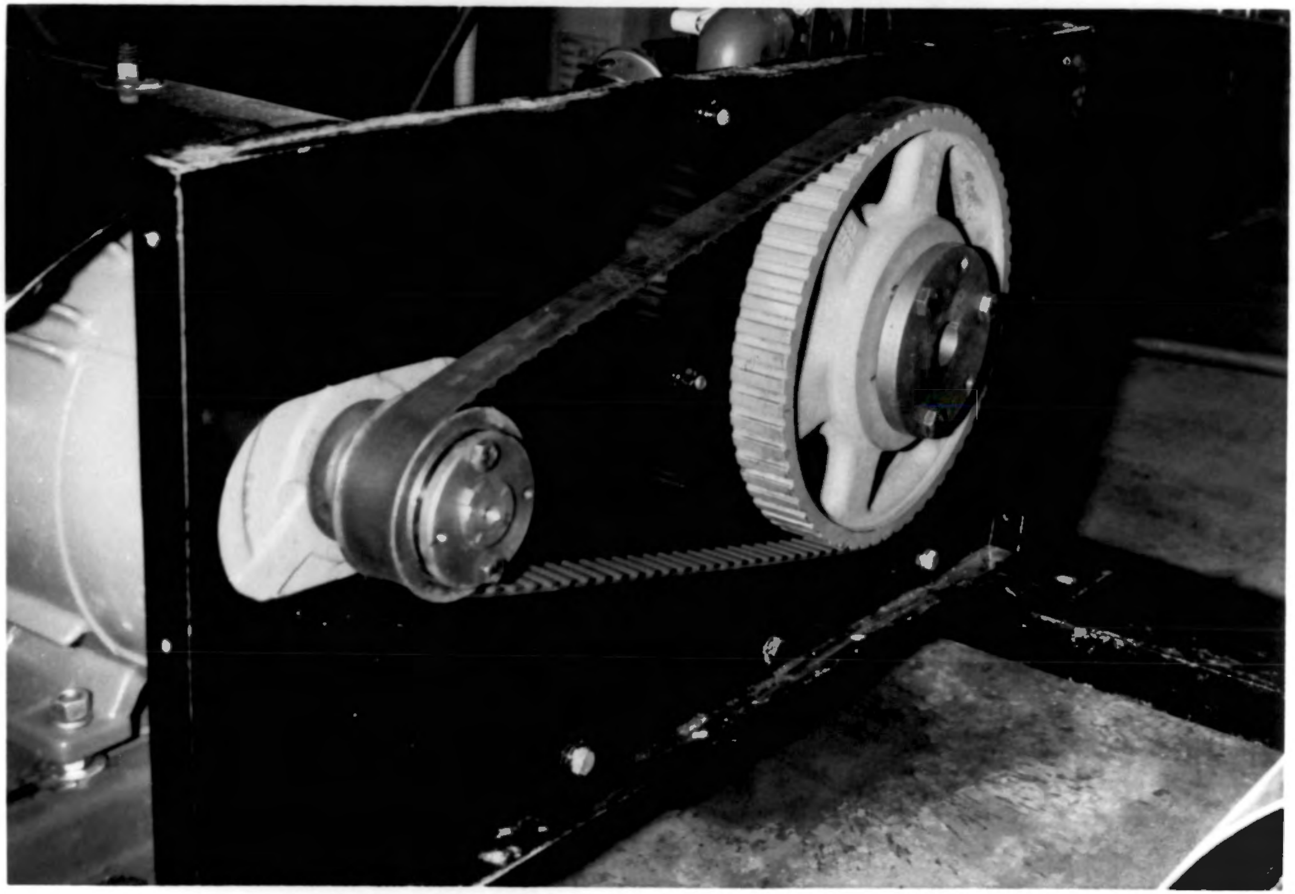


Figure 17. Rinse system gearbelt drive assembly illustrating eighteen tooth driver gearbelt pulley and sixty tooth driven gearbelt pulley.

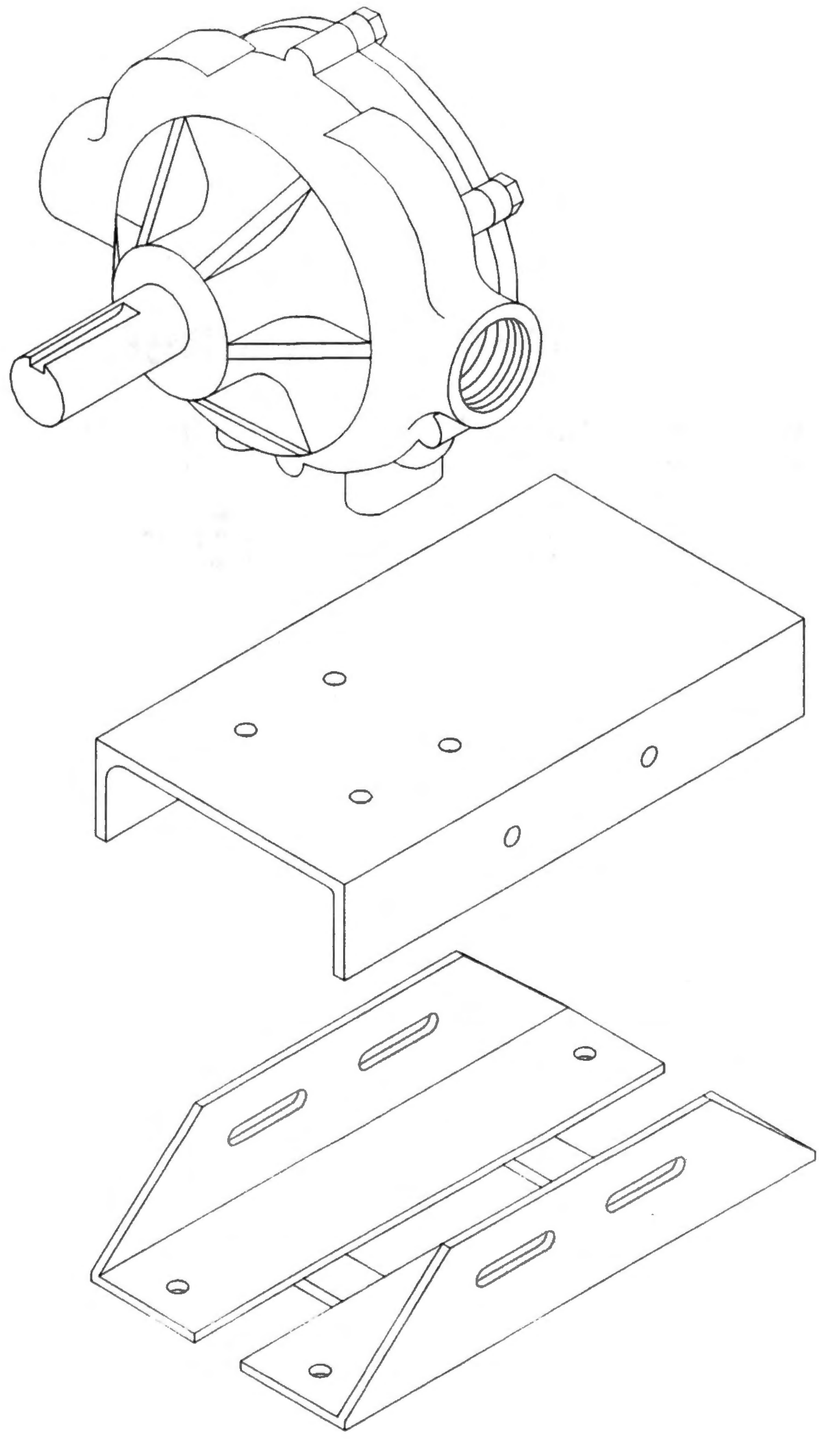
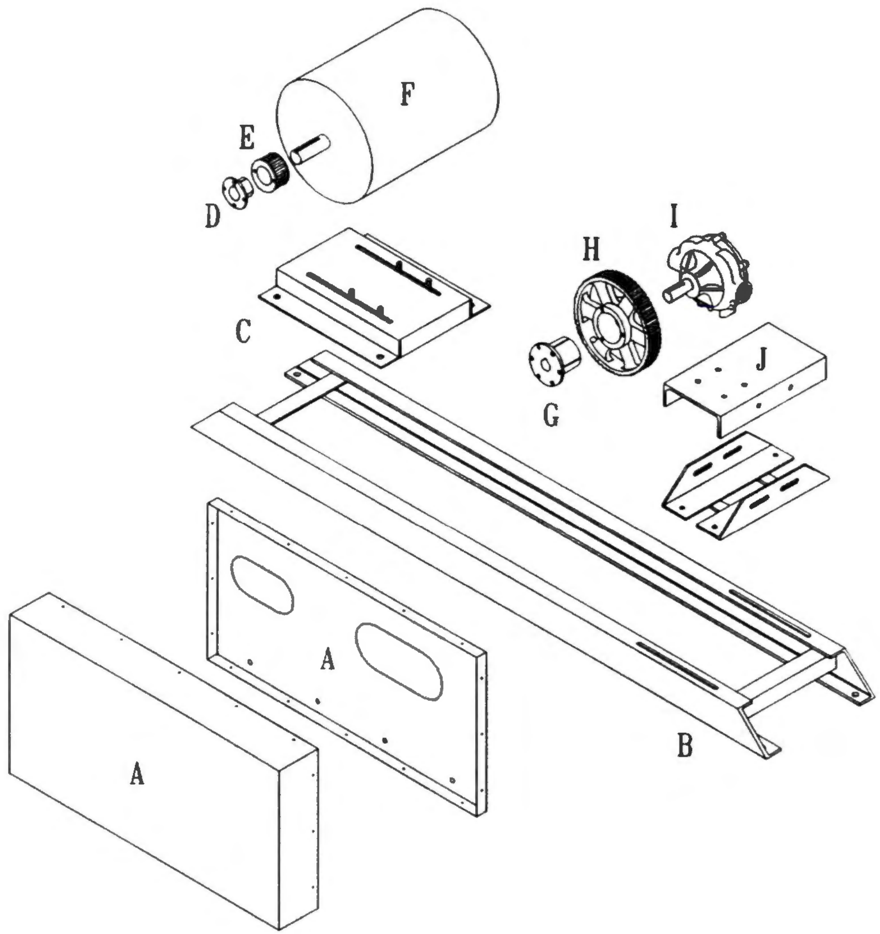


**Figure 18.** Adjustable roller pump mounting bracket.

constructed from 152 mm [6 in.] channel and 64 mm x 6 mm angle [2.5 in. x 0.25 in.], simplified pulley alignment. As a precaution against belt failure causing down time, slots were milled into the cross support. These slots allowed motor-to-shaft center distance adjustment, thus permitting substitute belt lengths to be used if the original size was not readily available. Belt tension was adjusted from the motor base plate. A protective shield, completely enclosing the drive system, was fabricated from 16 and 20 gauge sheet metal. Rinse system hardware is illustrated in Figure 19.

Clean rinse water from the 114-L [30-gal.] cone tank was supplied to the pump through 38 mm [1.5 in.] permanently plumbed components (Figures 20 and 21). Incorporating a unidirectional (check) valve eliminated back-flushing of fluid from the test tank. Pressure components are illustrated in Figures 22 and 23.

Switching to the larger rinse system pump prompted two, albeit minor, modifications. Because of higher bypass volume, the 13 mm [0.5 in.] hose linked to the pressure relief valve was exchanged for a 19 mm [0.75 in.] hose. A second modification incorporated drop tubes for bypass and fill inlets into the conical tank (Figure 24). Without drop tubes, bypass water caused disruption of fluid surface within the tank at lower nozzle operating pressures. By discharging water below the surface, drop tubes diminished fluid interruption and improved accuracy of gauging liquid level. Water level determination was important to assure the correct volume was dispensed into the test tank. Use of a clamp-on light assembly behind the polyethylene water tank further improved gauging of the fluid level.




LEGEND

A– Shield
B– Cross Support
C– Adjustable Motor Mounting Plate
D– Bushing
E– 18 Tooth Driver Gearbelt Pulley
F– 5 HP Electric Motor
G– Driven Bushing
H– 60 Tooth Driven Gearbelt Pulley
I– Roller Pump
J– Adjustable Pump Mounting Bracket

**Figure 19.** Exploded view of rinse system hardware.

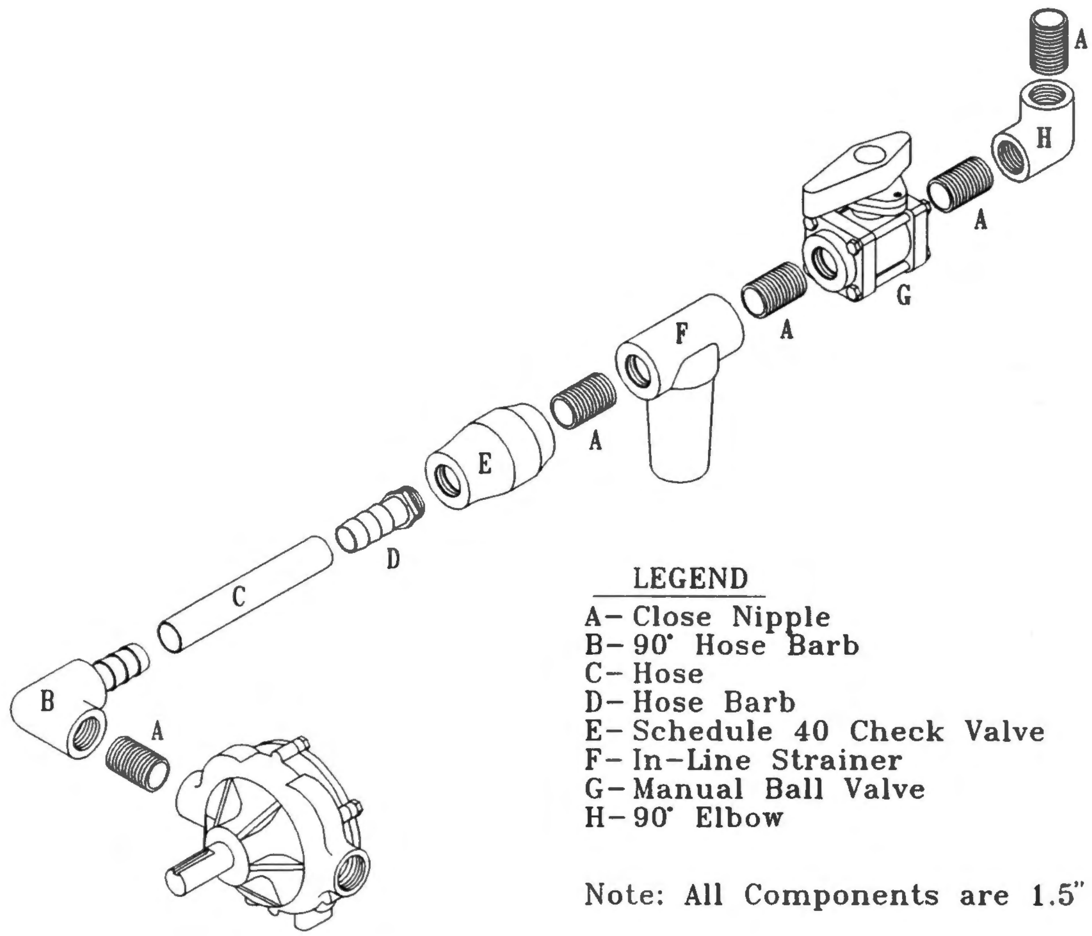



**Figure 20.** Exploded view of rinse system inlet components.

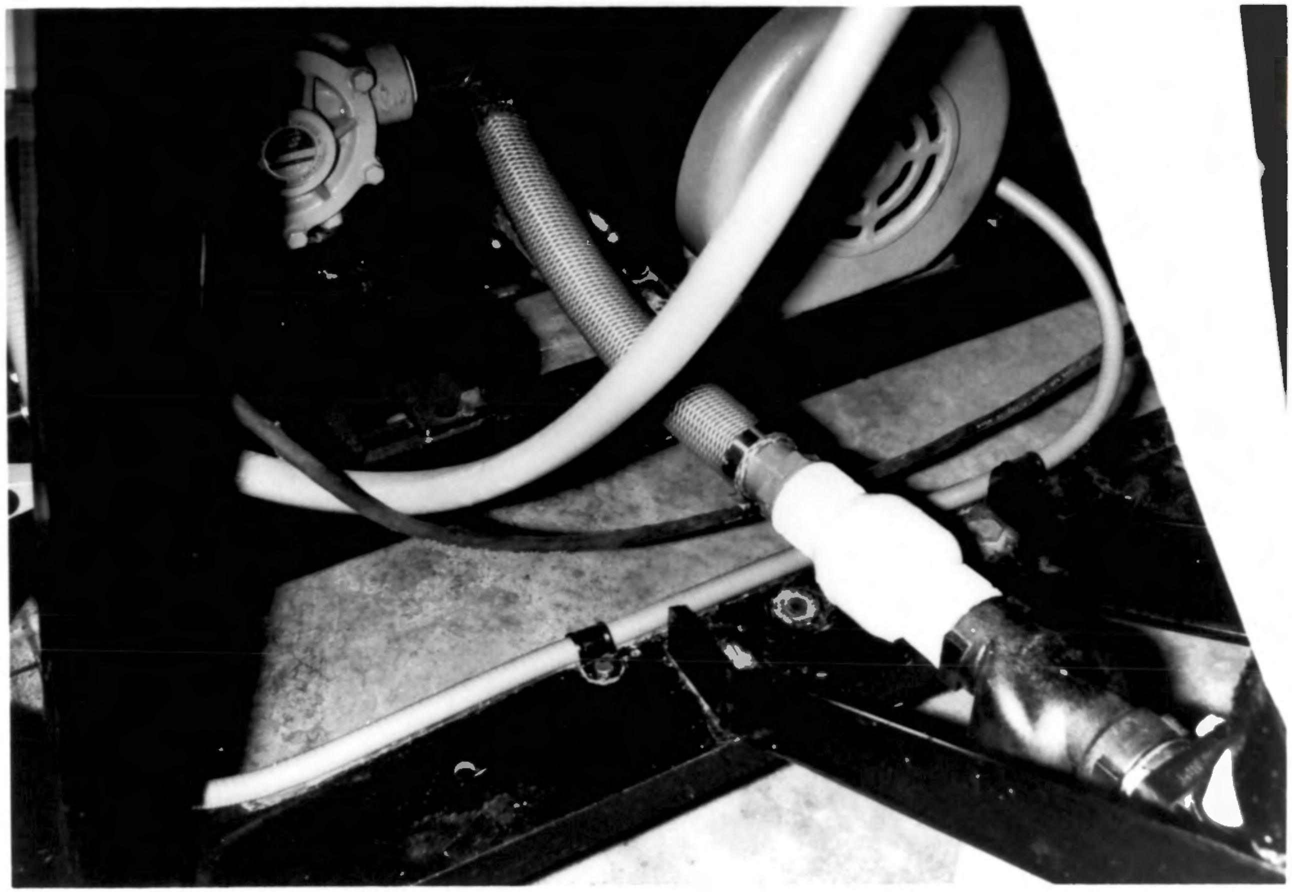


**Figure 21.** Rinse system inlet components as installed.

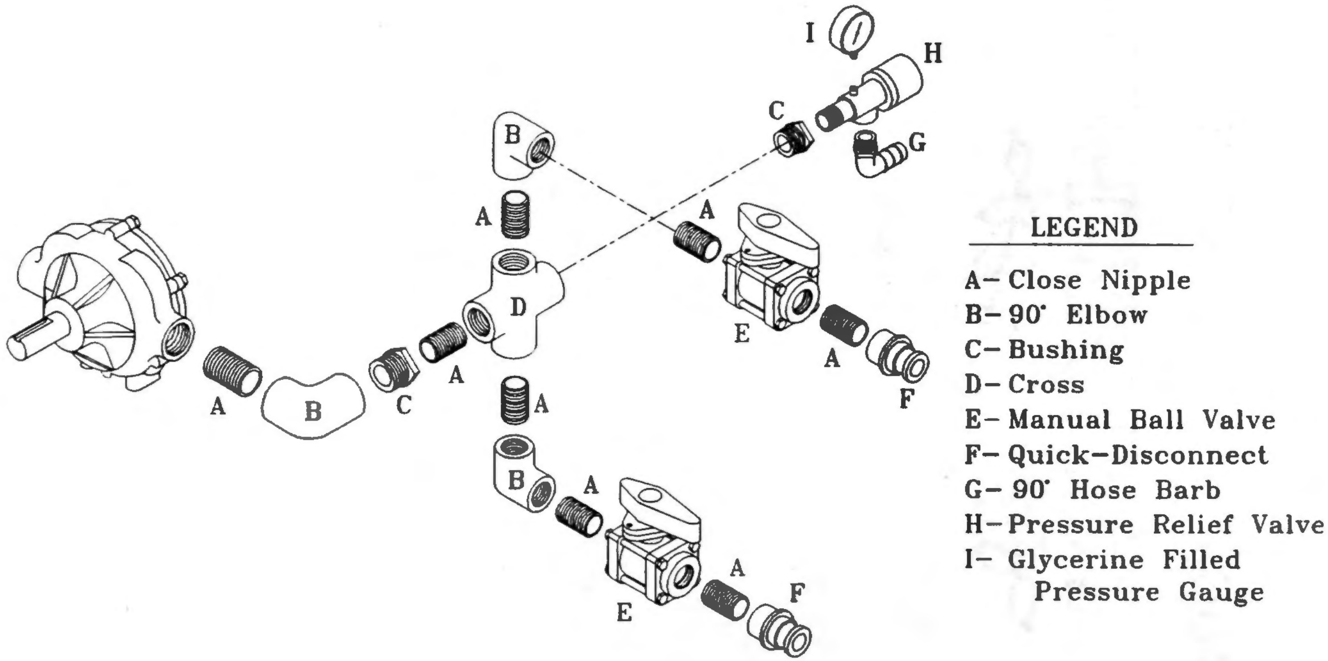



**Figure 22.** Exploded view of rinse system pressure components.

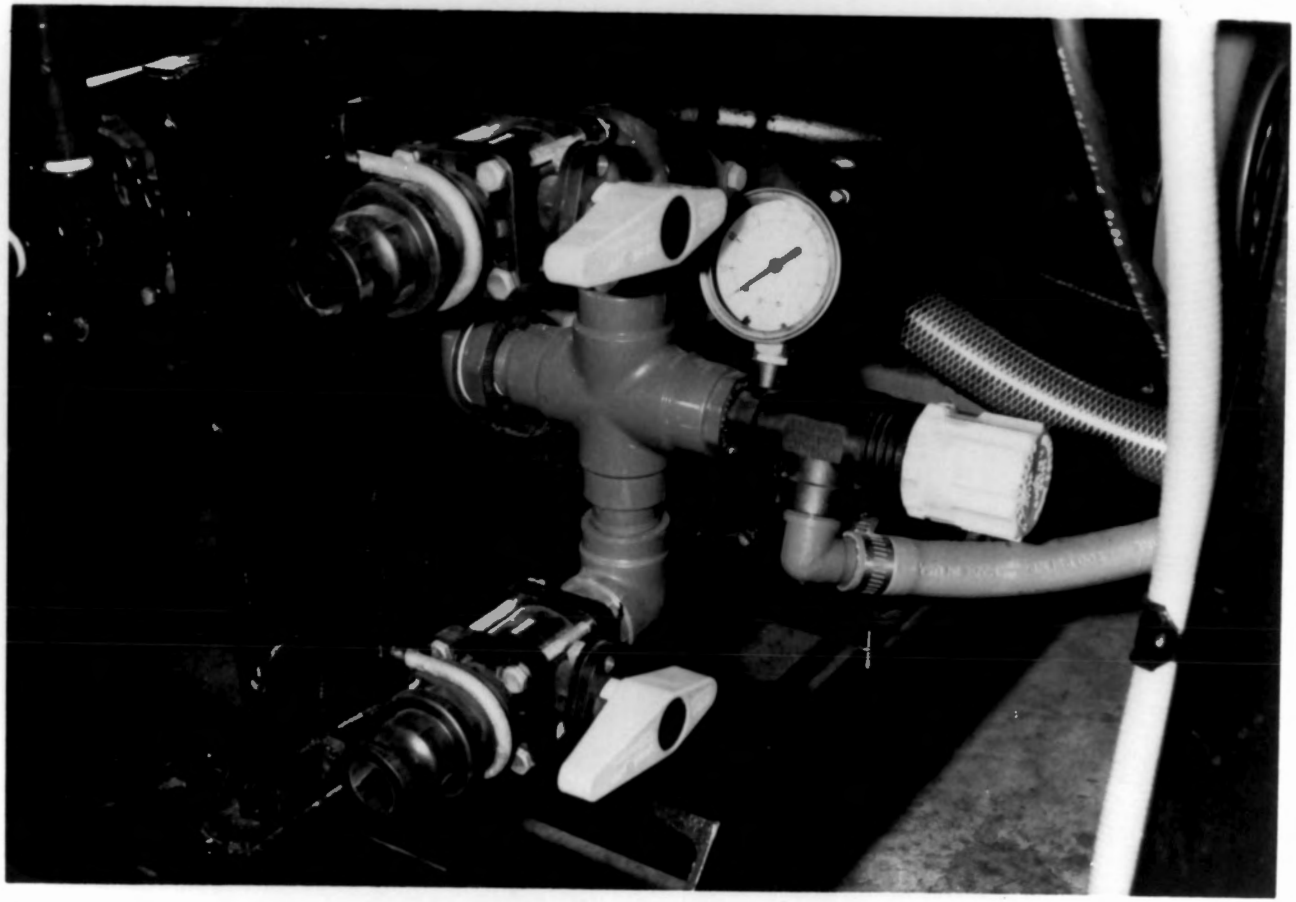


**Figure 23.** Rinse system pressure components as installed.

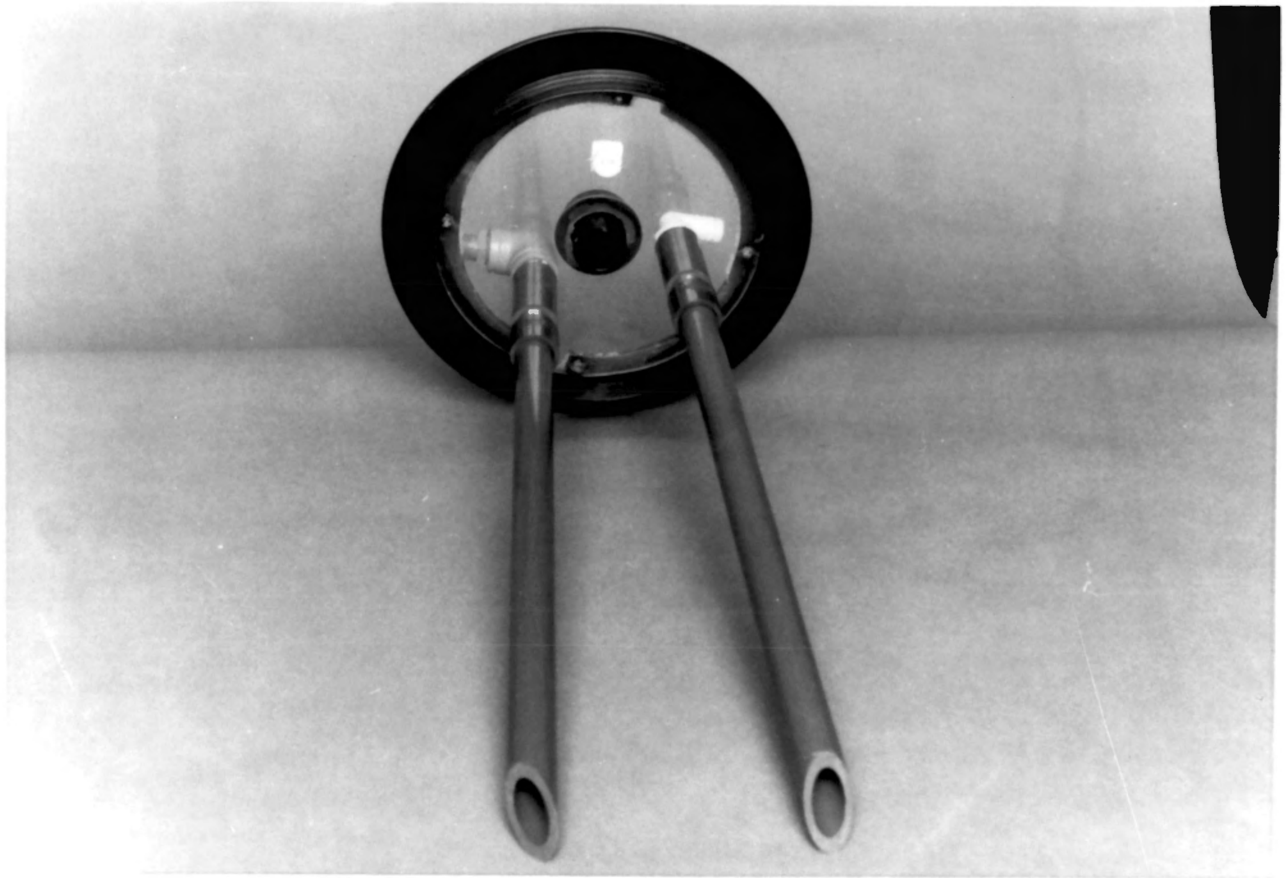


Figure 24. Conical rinse water reservoir lid fitted with bypass and fill inlet drop tubes to reduce disruption of fluid level.

**Data Collection**

Tests were conducted on five tank sizes following preliminary work to establish suitable operating parameter ranges. Four tanks were of a common cylindrical geometry while the fifth tank had a unique elliptical geometry. Preliminary studies indicated a triple rinse sequence was sufficient for removing residues from a 6 g/L (4030 ppm) tank mix of potassium bromide, thus a higher concentration solution was sought for actual testing. Detection equipment was capable of directly measuring concentrations over the range of 0.0000 to 19900 ppm. Concentrations above 19900 ppm required dilution prior to analysis. An ionic bromide solution containing 14.89 g/L (10000 ppm $Br^-$) was formulated to evaluate nozzle performance. A 10000 ppm solution was chosen for experiments because it was desired to remain within the detection equipments' direct concentration reading range, thereby eliminating the need to perform sample dilutions prior to analyzing. The probe manufacturer recommended calibration standards be made to bracket expected sample range and formulated to differ in concentration by a factor of ten. A five point calibration starting at 1 ppm (factor of ten increments) resulted in the final standard being 10000 ppm.

Tank rinsing nozzles from two manufacturers (Spraying Systems Co. and Lechler, Inc.) were tested. The Spraying Systems nozzle was tested in all five tanks while the Lechler nozzle was evaluated only in the 380-L [100-gal.] tank. Data were statistically analyzed to determine which operating parameter factors were important for reducing rinsate concentration levels.

*Spraying Systems Nozzle Evaluation*

The Spraying Systems tank rinsing nozzle was evaluated in all five sprayer tanks. Each combination of operating pressure, rinse sequence, and rinse volume (Table 3) were replicated a minimum of three times in all tank sizes. All intermediate rinsate data were collected

(Appendix B). However, only the final rinsate concentration value for a given rinsing procedure was statistically analyzed. Concentrations which fell below the meter detection lower limit (1 ppm) were recorded as 1 ppm.

Table 3. Rinse Nozzle Operating Parameters

| Operating Pressure | Rinse Sequence | Rinse Volume |
|---|---|---|
| kPa (psi) | | Percent |
| 138 (20) | Single | 5 |
| 207 (30) | Double | 10 |
| 276 (40) | Triple | |
| 345 (50) | | |

Using the fixed effects of nozzle operating pressure, rinse volume, tank size, and rinse sequence as independent variables, the full model indicated all main effects and interactions were statistically significant at $\alpha$=0.05. However, to account for variation among fixed effects and achieve a realistic estimate of each variables' impact on rinsate concentration, it was necessary to define an alternate interaction error term to test statistical significance. When the four-way interaction between the fixed effects was used as an error term, rinse sequence was clearly the most dominant factor for reducing rinsate concentrations. Rinse volume and tank size were also shown to have a statistical effect. The F-Values (Appendix C) show rinse pressure contributed the least in reducing rinsate concentration, which was suspected even before the analysis. However, if a time factor were added pressure would likely play an important role in removing partially dried rinsate residues. The model produced a computed $R^2$=0.990. Tank size by rinse volume and rinse sequence interactions (Figures 25 and 26) were the only two of statistical

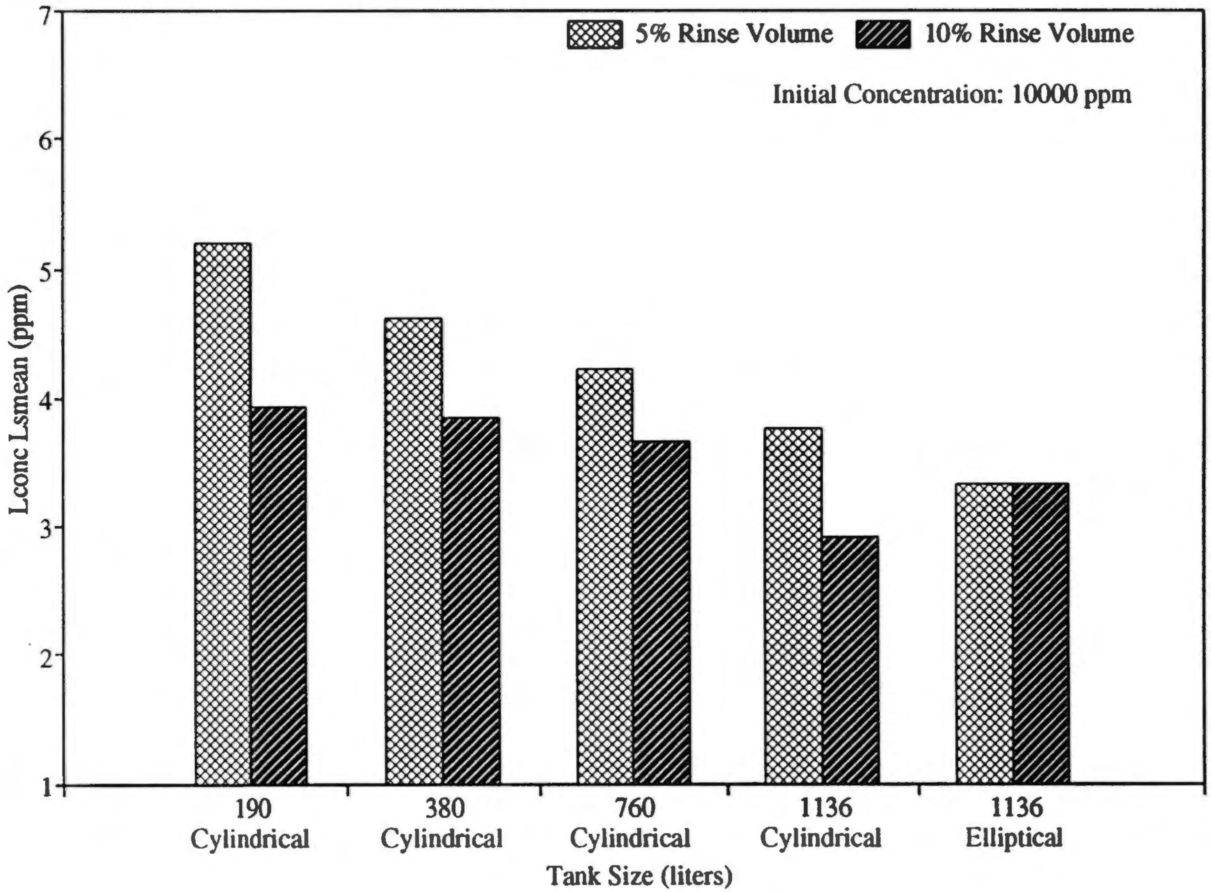



**Figure 25.** Rinse volume effect (statistically significant at $\alpha$=0.05) on final rinsate concentration using Spraying Systems nozzle with four-way main effects interaction error term.

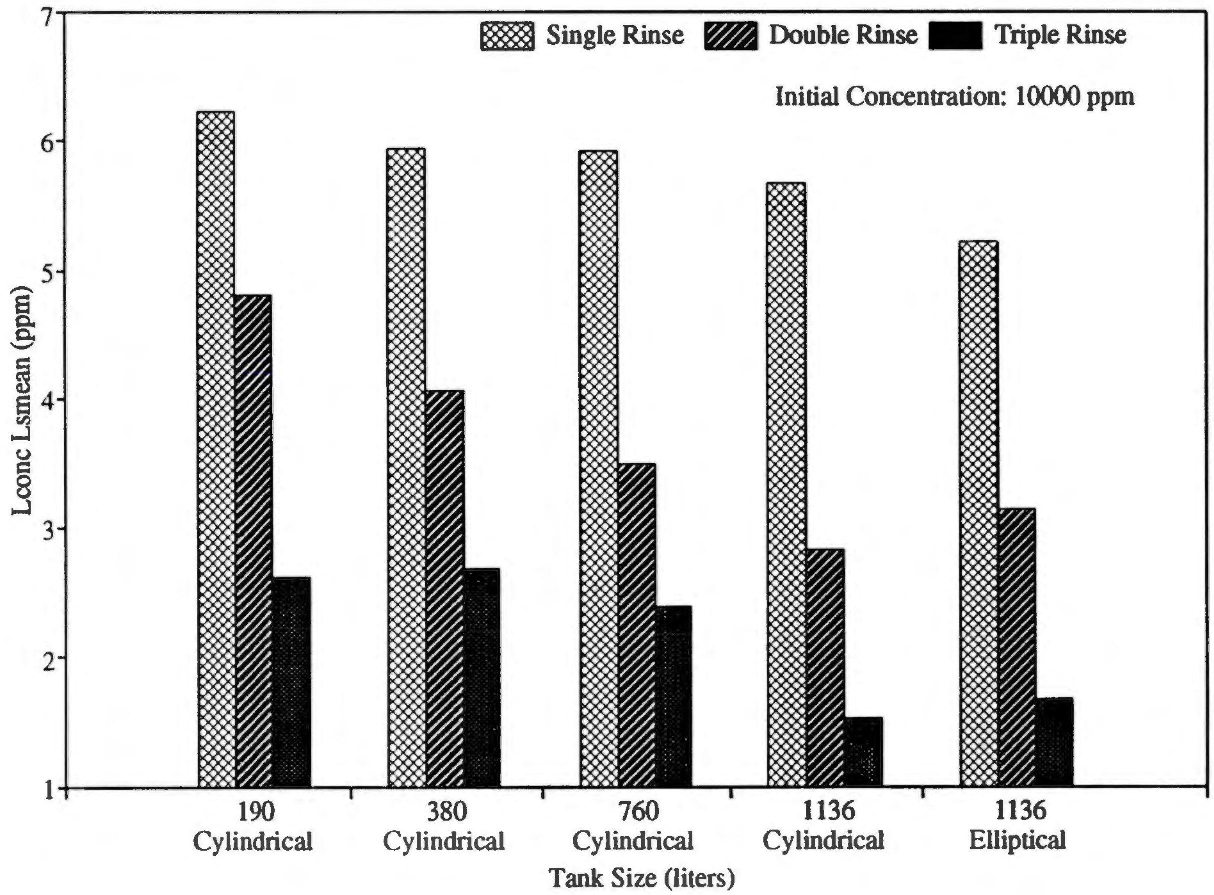



**Figure 26.** Rinse sequence effect (statistically significant at $\alpha$=0.05) on final rinsate concentration using Spraying Systems nozzle with four-way main effects interaction error term.

significance. The tank size by operating pressure interaction (Figure 27) was not significant. Mean values illustrating 5 and 10 percent rinse volume effects on each tank size are shown graphically in Figures 28 and 29.

A statistical comparison between the 1136-L cylindrical and elliptical tanks was made to determine whether tank geometry had an impact on nozzle performance. At a 95 percent confidence level, no difference was evident between the tank geometries.

*Comparison of Lechler vs. Spraying Systems Nozzles*

An experiment was performed to compare the performance of tank rinsing nozzles between manufacturers. A Lechler nozzle was evaluated and compared to the data collected from the Spraying Systems nozzle. The Lechler nozzle tested was recommended for tank diameters of 102 cm [40 in.] or less. Thus, the 380 L [100 gal.] tank was the largest that could be evaluated. Additionally, the lowest recommended operating pressure was 207 kPa [30 psi]. To enable an impartial comparison, the 138 kPa [20 psi] data from the Spraying Systems nozzle was not used in the analysis.

A model similar to the previous analysis was constructed to determine if nozzles performed comparably. Fixed effects of nozzle type, operating pressure, rinse volume, and rinse sequence were defined as independent variables. An error term using the interaction of the fixed effects indicated rinse sequence was again the dominant factor, followed by rinse volume ($\alpha$=0.05). Operating pressure and nozzle type were not significant at alpha=0.05. F-Values (Appendix C) reveal none of the interactions were significant from this model which had a computed $R^2$=0.994. Figures 30, 31, and 32 illustrate the interactions of nozzle type with operating pressure, rinse volume, and rinse sequence respectively. Mean values of actual data collected are shown graphically in Figures 33 and 34.

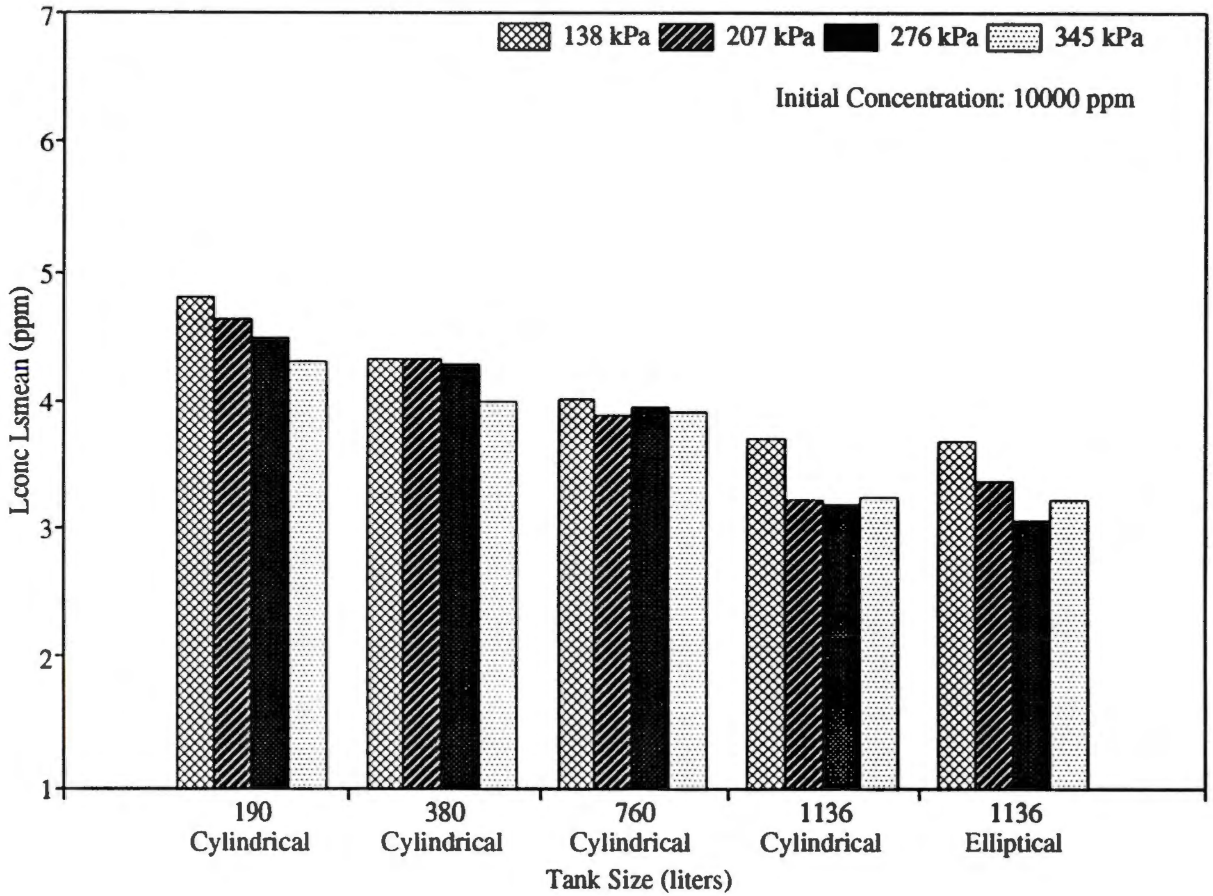



**Figure 27.** Nozzle operating pressure effect (statistically significant at $\alpha=0.05$) on final rinsate concentration using Spraying Systems nozzle with four-way main effects interaction error term.

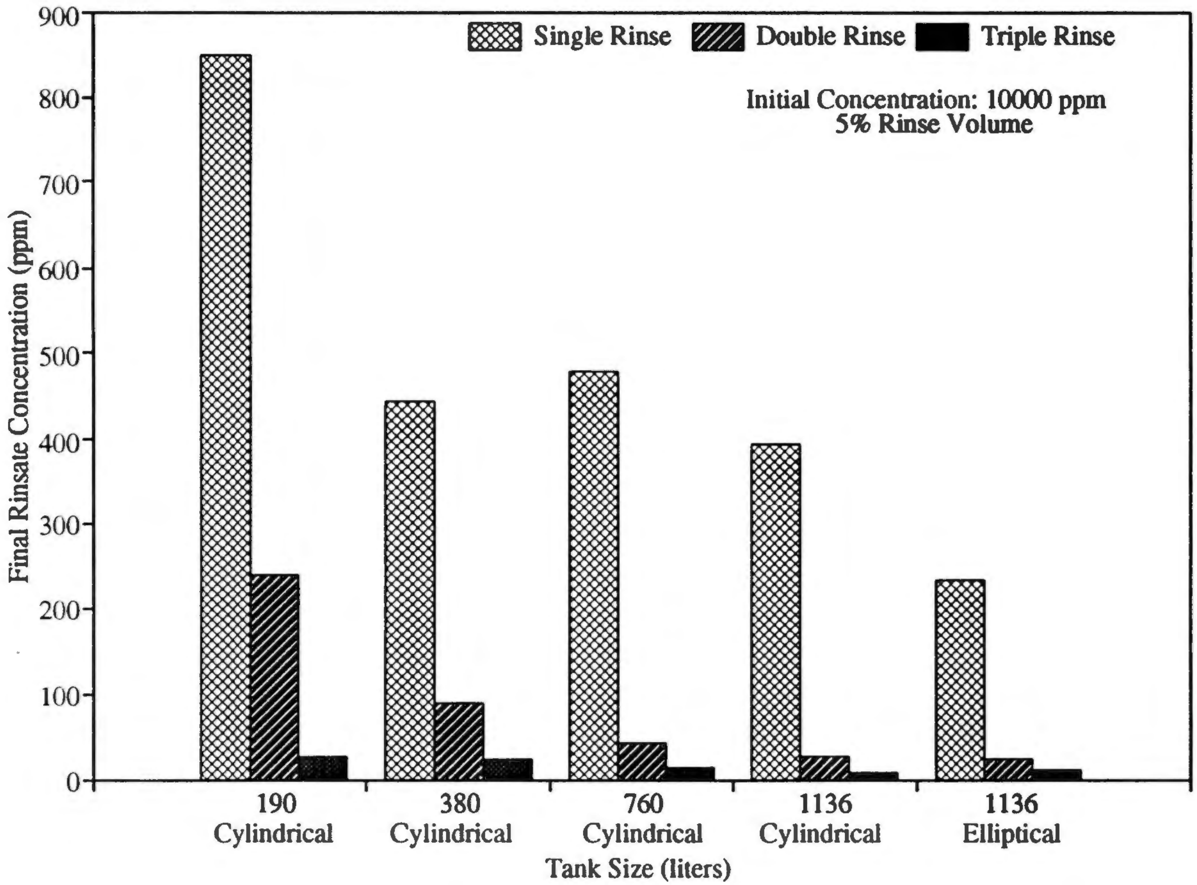



**Figure 28.** Mean final rinse concentration level using the Spraying Systems nozzle. A 5% total tank volume applied in single, double, and triple rinse sequences. Values are averaged over all pressures.

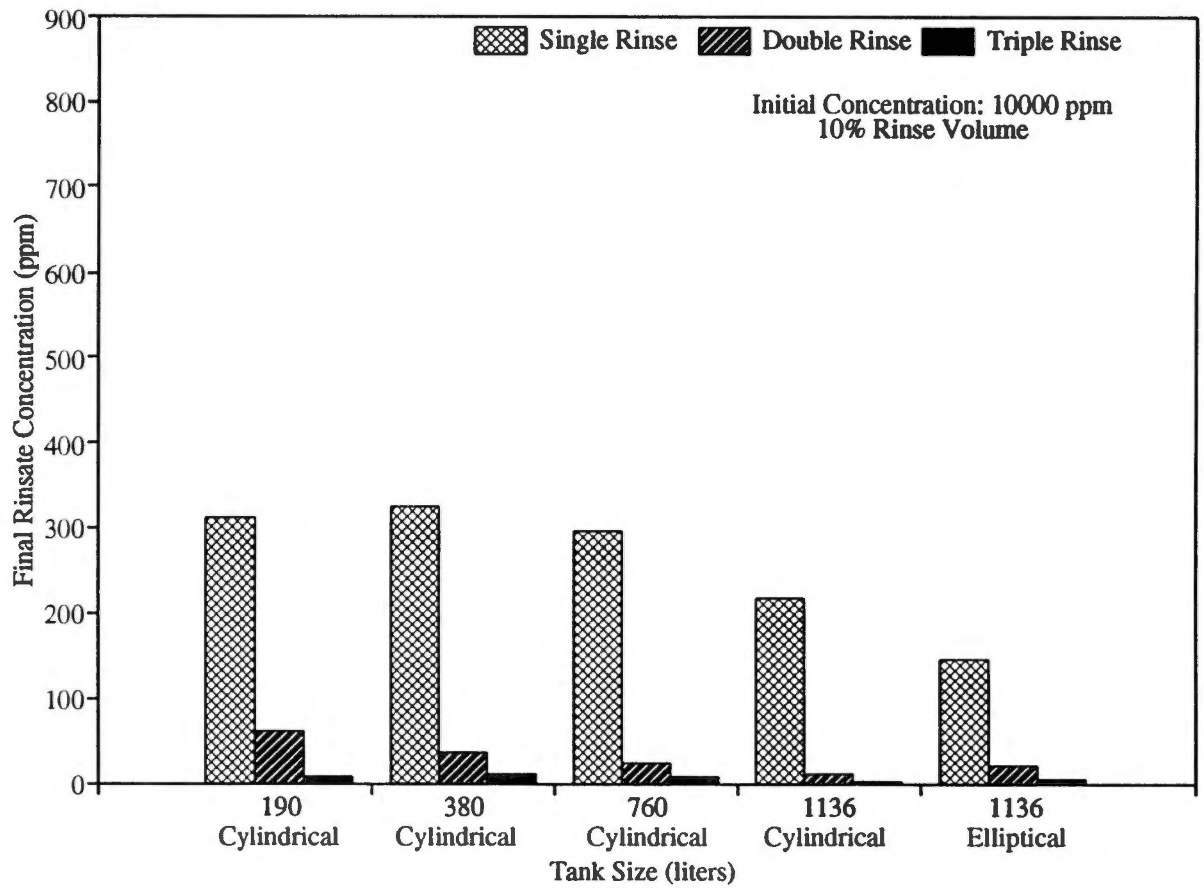



**Figure 29.** Mean final rinse concentration level using the Spraying Systems nozzle. A 10% total tank volume applied in single, double, and triple rinse sequences. Values are averaged over all pressures.

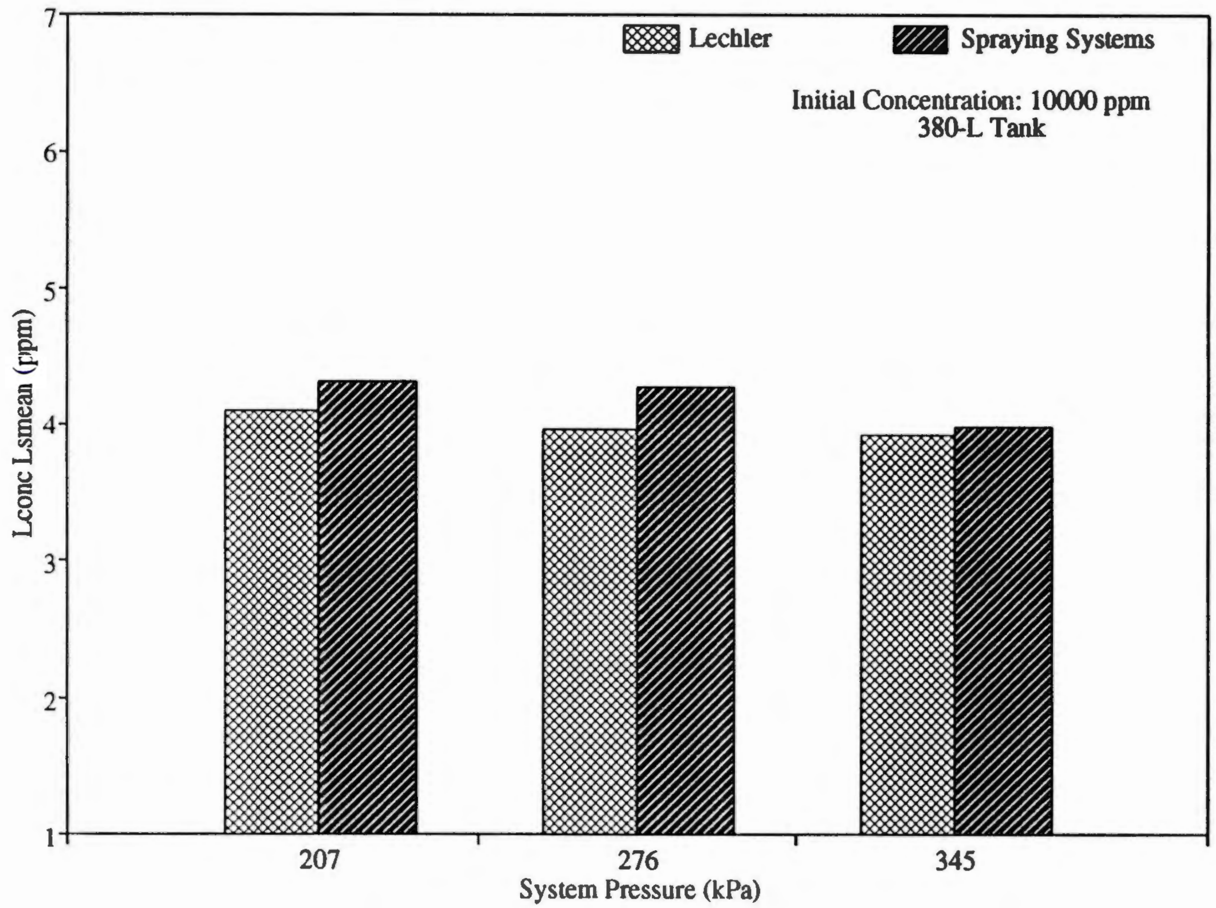



**Figure 30.** Comparison of Lechler and Spraying Systems pressure effect on rinsate concentration in the 380-L [100-gal.] tank. Interaction differences involving nozzle operating pressure were not significant at $\alpha$=0.05.

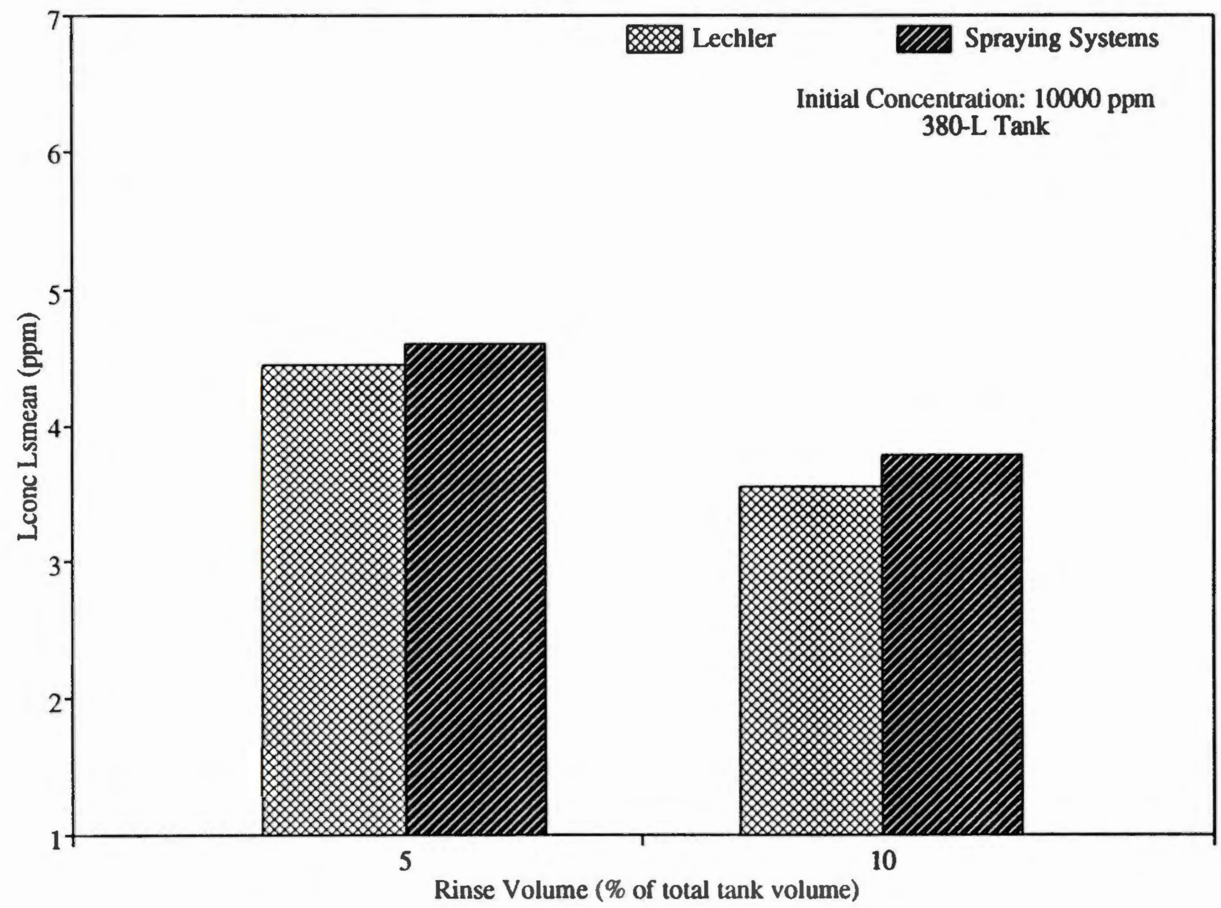



**Figure 31.** Comparison of Lechler and Spraying Systems rinse volume effect on rinsate concentration in the 380-L [100-gal.] tank. Interaction differences involving rinse volume were not significant at $\alpha=0.05$.

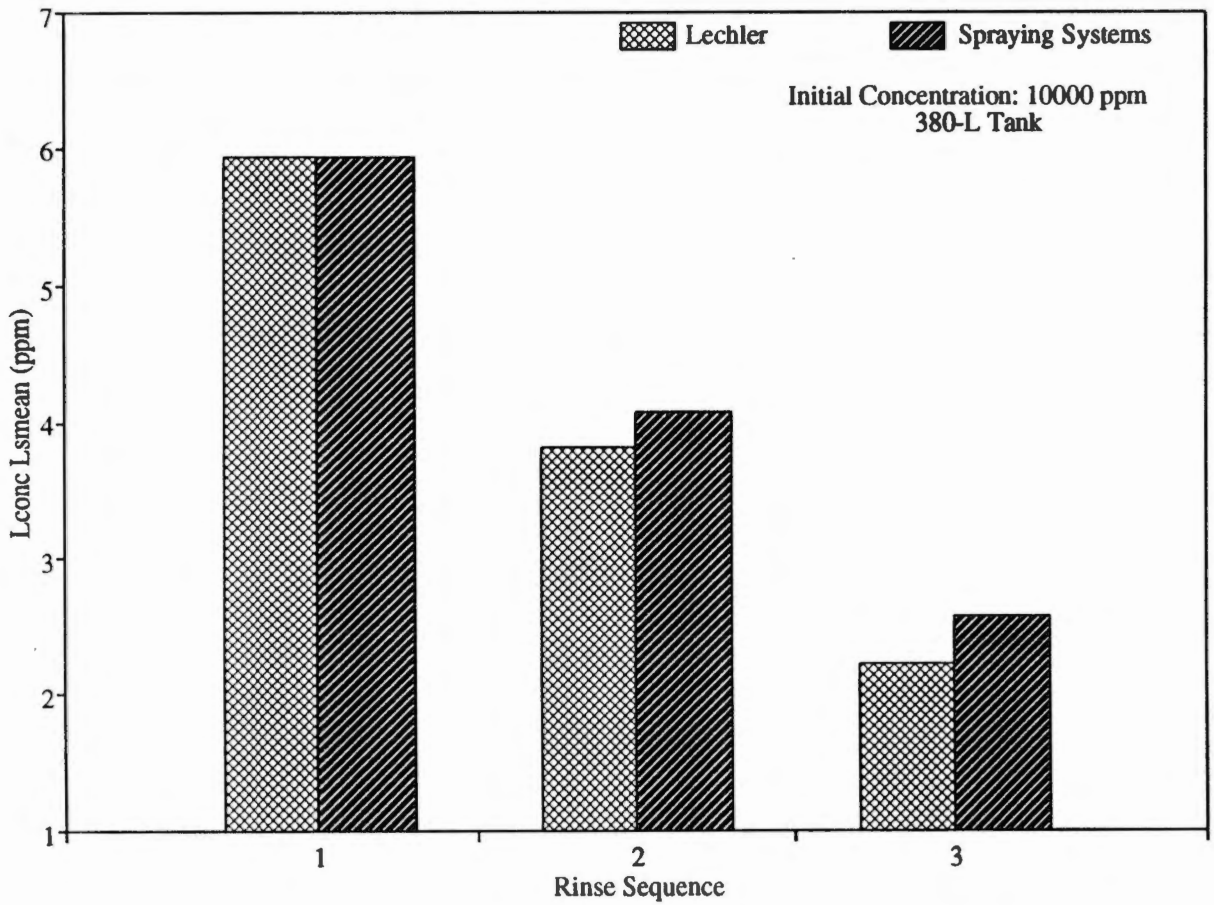



**Figure 32.** Comparison of Lechler and Spraying Systems rinse sequence effect on rinsate concentration in the 380-L [100-gal.] tank. Interaction differences involving rinse sequence were not significant at $\alpha$=0.05.

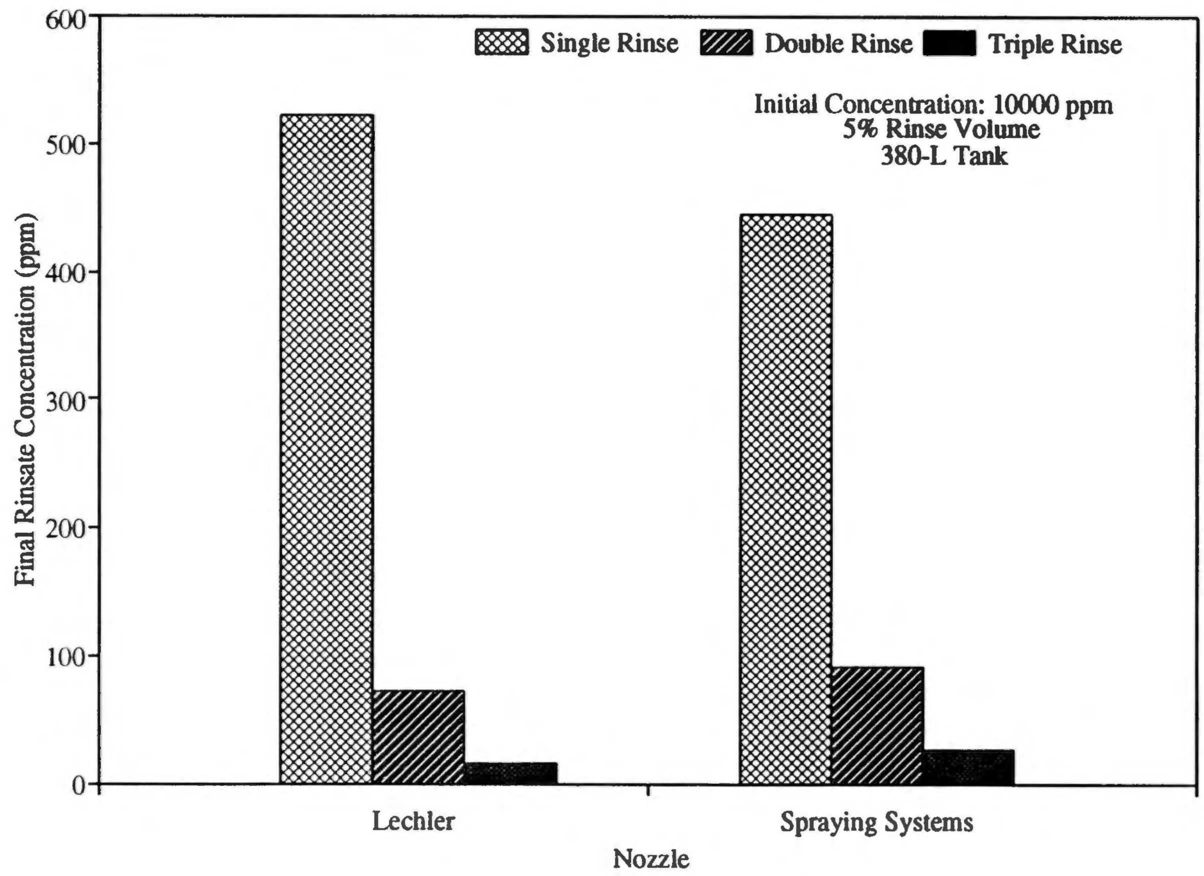



**Figure 33.** Mean bromide ion concentration level from final rinse using both nozzle types applying 5% of tank volume in single, double, and triple rinse sequences to the 380-L [100-gal.] tank.

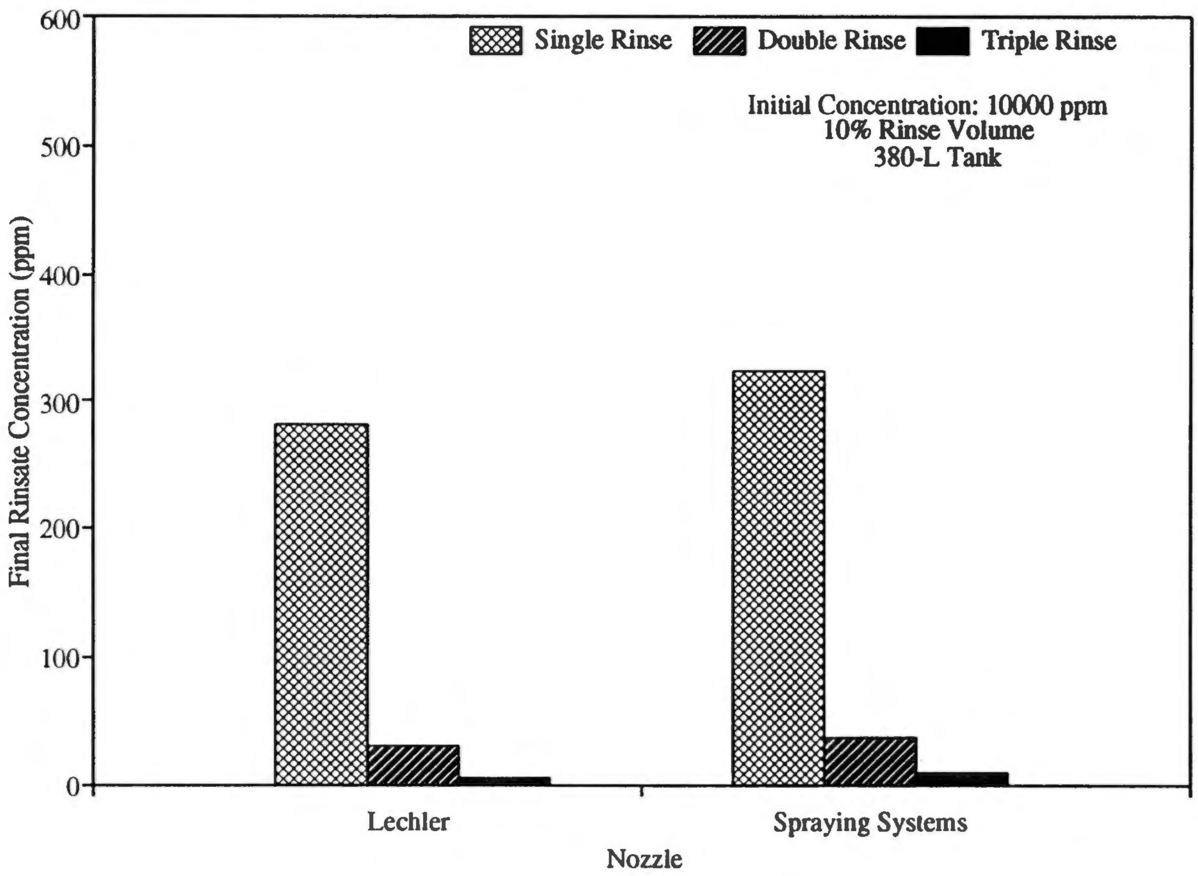



**Figure 34.** Mean bromide ion concentration level from final rinse using both nozzle types applying 10% of tank volume in single, double, and triple rinse sequences to the 380-L [100-gal.] tank.

# CHAPTER V

# SUMMARY AND CONCLUSIONS

## Summary

A laboratory scale test stand was constructed to evaluate the ability of tank rinsing nozzles to remove tracer chemical residues from sprayer reservoirs. Research efforts were directed toward determining optimal operating parameters (rinse sequence, pressure, and rinse volume) of tank rinsing nozzles to reduce agricultural sprayer rinsates requiring disposal.

Two independent fluid delivery systems were incorporated into a test apparatus. One fluid delivery system was devoted to transferring a concentrated test solution between a separate storage reservoir and a test tank. The transfer system was used to move the concentrated chemical into a test tank, thereby contaminating the interior sidewalls. After filling the tank, the solution was transferred back to the storage reservoir. A second fluid delivery system supplied clean rinse water from an auxiliary 114-L [30-gal.] reservoir to a tank rinsing nozzle centrally located inside a test tank. Contamination of the clean water supply was eliminated by using two separate fluid systems.

Two commercially available tank rinsing nozzles (Spraying Systems ¾-18 TEF and Lechler 5E), tested in five polyethylene sprayer tanks (190, 380, 760, and cylindrical/elliptical 1136-L [50, 100, 200, and 300-gal.]), were evaluated under various operating parameters. Manufacturers' recommended pressures of 138, 207, 276 and 345 kPa [20, 30, 40, and 50 psi] and 207, 276 and 345 kPa [30, 40, and 50 psi] for the Spraying Systems and Lechler, respectively. Rinse volumes equivalent to 5 and 10 percent of total tank volume were applied in three rinse sequences (single, double, triple).

A concentrated solution (10000 ppm $Br^-$) of potassium bromide was used as a tracer chemical for nozzle performance studies. An accurate and repeatable procedure to detect tracer chemical concentrations within one minute was developed.

Experimental results obtained were consistent with the Environmental Protection Agency's requirement of triple rinsing pesticide containers before disposal in a landfill. It was determined a double rinse is preferred over a single and a triple rinse is superior to both single and double rinses. These findings are comparable to those of Jeffery (1991) who noted two smaller rinses (double) reduced rinsate concentration more than one (single) large rinse.

Implementation of a tank rinsing system (based on research data) would be a viable means of reducing sprayer tank rinsates requiring disposal. Field rinsing a spray applicator and applying the diluted rinsate back over the previously treated area is a legal disposal method. The particular system constructed eliminates operator contact with concentrated chemicals during equipment rinsing, which makes it safer than hand rinsing.

**Conclusions**

Extensive studies conducted to evaluate the effectiveness of a sprayer tank rinsing system resulted in the following conclusions:

- Tank surface area to rinse volume ratio had an effect on rinsate concentration in small tank sizes for a single rinse procedure. Surface area to rinse volume ratio became less influential as tank capacity increased, due to the larger volume of water used.
- Rinse sequence was the dominant parameter in reducing tracer residues.
- A triple rinse sequence using 10 percent of total tank volume produced the lowest bromide ion concentration levels.

- Rinse volume percentage had an effect on rinsing results. Rinse sequences using a 10 percent volume performed better than a 5 percent volume (holding other parameters equal).
- Nozzle operating pressure had little impact on rinse system performance. Manufacturer's recommended operating pressures provide adequate tank rinsing.
- Tank geometry did not significantly affect the performance of tank rinsing nozzles.
- Nozzle type had little affect on rinsing effectiveness.

# CHAPTER VI

# RECOMMENDATIONS FOR FUTURE RESEARCH

Laboratory experiments utilizing a tracer chemical have successfully proven tank rinsing as a viable method of reducing residues from inner sprayer tank surfaces. Prior to conducting this research, little quantified data were available pertaining to the effectiveness of rinsing agricultural spray tanks.

Future studies should be conducted with an actual crop protection chemical. Although use of a tracer solution validated the concept of tank rinsing, experiments using typical field-strength tank mixes would be of greater value than further research with tracers. One can not infer from tracer data that the system will yield similar results with an actual chemical. This laboratory study was highly controlled (clean fluids, known chemical concentrations, single tank construction material, and accurate fluid delivery systems), unlike a field application. Several variables which must be considered in a field situation are: 1) solubility of chemical being applied; 2) additives such as crop oils; 3) multi-chemical tank mixes; 4) type of chemical formulation (liquid, wettable powder, etc.); 5) tank mix carrier (fertilizer or water); and 6) amount of time tank remains empty before being reloaded or cleaned.

A time factor should be added to future experiments to determine the effectiveness of tank rinsing nozzles on dry/partially-dry chemical residues. Clean water alone may not be sufficient for cleaning these residues, a commercial additive may be necessary (especially if fertilizers/adjuvants/crop oils are used in original tank mixes) to adequately clean reservoirs.

Ultimately, a practical system must be developed before it will be implemented and used. Research and design criteria which must be considered to gain acceptance of the concept are: 1) ease of use; 2) time required to complete the rinsing operation (function of rinse sequence and total rinse volume); and 3) cost of retrofitting a rinse system to existing chemical application equipment.

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# APPENDICES

# APPENDIX A

# APPENDIX A. Preliminary Data

| Nozzle | Tank Size (gal) | Operating Pressure (psi) | Run Volume (gal) | Temp (Celcius) | Rinsate Conc. (ppm) | Repitition (1-6) | Rinse Sequence (1-5) | Rinse Percent |
|---|---|---|---|---|---|---|---|---|
| SS | 50 | 40 | 0.0 | 30.0 | 3760 | 1 | 3 | 18 |
| SS | 50 | 40 | 3.0 | 30.9 | 137 | 1 | 3 | 18 |
| SS | 50 | 40 | 6.0 | 31.1 | 6.91 | 1 | 3 | 18 |
| SS | 50 | 40 | 9.0 | 31.1 | 1.00 | 1 | 3 | 18 |
| SS | 50 | 40 | 0.0 | 30.1 | 3780 | 2 | 3 | 18 |
| SS | 50 | 40 | 3.0 | 29.6 | 82.8 | 2 | 3 | 18 |
| SS | 50 | 40 | 6.0 | 29.6 | 6.36 | 2 | 3 | 18 |
| SS | 50 | 40 | 9.0 | 29.7 | 1.00 | 2 | 3 | 18 |
| SS | 50 | 40 | 0.0 | 32.2 | 3720 | 3 | 3 | 18 |
| SS | 50 | 40 | 3.0 | 28.9 | 120 | 3 | 3 | 18 |
| SS | 50 | 40 | 6.0 | 28.7 | 8.74 | 3 | 3 | 18 |
| SS | 50 | 40 | 9.0 | 28.7 | 1.00 | 3 | 3 | 18 |
| SS | 50 | 40 | 0.0 | 29.7 | 3710 | 1 | 5 | 20 |
| SS | 50 | 40 | 2.0 | 30.4 | 737 | 1 | 5 | 20 |
| SS | 50 | 40 | 4.0 | 31.3 | 76.5 | 1 | 5 | 20 |
| SS | 50 | 40 | 6.0 | 32.3 | 5.83 | 1 | 5 | 20 |
| SS | 50 | 40 | 8.0 | 31.9 | 3.86 | 1 | 5 | 20 |
| SS | 50 | 40 | 10.0 | 32.5 | 1.04 | 1 | 5 | 20 |
| SS | 50 | 40 | 0.0 | 29.5 | 3740 | 2 | 5 | 20 |
| SS | 50 | 40 | 2.0 | 29.1 | 732 | 2 | 5 | 20 |
| SS | 50 | 40 | 4.0 | 29.6 | 78 | 2 | 5 | 20 |
| SS | 50 | 40 | 6.0 | 29.8 | 9.35 | 2 | 5 | 20 |
| SS | 50 | 40 | 8.0 | 30.0 | 7.52 | 2 | 5 | 20 |
| SS | 50 | 40 | 10.0 | 30.3 | 4.49 | 2 | 5 | 20 |
| SS | 50 | 40 | 0.0 | 27.3 | 4020 | 1 | 3 | 15 |
| SS | 50 | 40 | 2.5 | 27.6 | 218 | 1 | 3 | 15 |
| SS | 50 | 40 | 5.0 | 27.6 | 5.84 | 1 | 3 | 15 |
| SS | 50 | 40 | 7.5 | 27.6 | 1.00 | 1 | 3 | 15 |
| SS | 50 | 40 | 0.0 | 28.0 | 4000 | 2 | 3 | 15 |
| SS | 50 | 40 | 2.5 | 29.1 | 169 | 2 | 3 | 15 |
| SS | 50 | 40 | 5.0 | 29.8 | 3.66 | 2 | 3 | 15 |
| SS | 50 | 40 | 7.5 | 30.0 | 1.00 | 2 | 3 | 15 |
| SS | 50 | 40 | 0.0 | 28.2 | 3910 | 3 | 3 | 15 |
| SS | 50 | 40 | 2.5 | 30.1 | 241 | 3 | 3 | 15 |
| SS | 50 | 40 | 5.0 | 30.8 | 8.28 | 3 | 3 | 15 |
| SS | 50 | 40 | 7.5 | 31.0 | 1.00 | 3 | 3 | 15 |
| SS | 50 | 40 | 0.0 | 29.2 | 3750 | 1 | 2 | 20 |
| SS | 50 | 40 | 5.0 | 29.5 | 100 | 1 | 2 | 20 |
| SS | 50 | 40 | 10.0 | 29.7 | 3.63 | 1 | 2 | 20 |
| SS | 50 | 40 | 0.0 | 29.4 | 3720 | 2 | 2 | 20 |
| SS | 50 | 40 | 5.0 | 31.0 | 205 | 2 | 2 | 20 |
| SS | 50 | 40 | 10.0 | 31.5 | 4.13 | 2 | 2 | 20 |
| SS | 50 | 40 | 0.0 | 28.3 | 3900 | 1 | 3 | 10 |
| SS | 50 | 40 | 2.0 | 30.4 | 199 | 1 | 3 | 10 |
| SS | 50 | 40 | 4.0 | 31.3 | 8.75 | 1 | 3 | 10 |
| SS | 50 | 40 | 5.0 | 31.5 | 1.00 | 1 | 3 | 10 |
| SS | 50 | 40 | 0.0 | 28.4 | 3960 | 2 | 3 | 10 |
| SS | 50 | 40 | 2.0 | 29.9 | 249 | 2 | 3 | 10 |
| SS | 50 | 40 | 4.0 | 30.2 | 13.4 | 2 | 3 | 10 |
| SS | 50 | 40 | 5.0 | 30.2 | 1.00 | 2 | 3 | 10 |

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| SS | 50 | 40 | 0.0 | 28.6 | 3830 | 1 | 3 | 10 |
| SS | 50 | 40 | 2.0 | 30.8 | 196 | 1 | 3 | 10 |
| SS | 50 | 40 | 4.0 | 31.0 | 10.2 | 1 | 3 | 10 |
| SS | 50 | 40 | 5.0 | 31.1 | 1.00 | 1 | 3 | 10 |
| SS | 50 | 40 | 0.0 | 29.4 | 3800 | 2 | 3 | 10 |
| SS | 50 | 40 | 2.0 | 29.6 | 301.0 | 2 | 3 | 10 |
| SS | 50 | 40 | 4.0 | 29.8 | 18.8 | 2 | 3 | 10 |
| SS | 50 | 40 | 5.0 | 30.0 | 1.71 | 2 | 3 | 10 |
| SS | 50 | 40 | 0.0 | 29.8 | 3800 | 3 | 3 | 10 |
| SS | 50 | 40 | 2.0 | 30.8 | 202 | 3 | 3 | 10 |
| SS | 50 | 40 | 4.0 | 31.2 | 15.3 | 3 | 3 | 10 |
| SS | 50 | 40 | 5.0 | 31.4 | 1.23 | 3 | 3 | 10 |
| SS | 50 | 40 | 0.0 | 30.0 | 3850 | 4 | 3 | 10 |
| SS | 50 | 40 | 2.0 | 32.6 | 270 | 4 | 3 | 10 |
| SS | 50 | 40 | 4.0 | 33.4 | 13.9 | 4 | 3 | 10 |
| SS | 50 | 40 | 5.0 | 33.4 | 1.00 | 4 | 3 | 10 |
| SS | 50 | 40 | 0.0 | 30.8 | 3780 | 5 | 3 | 10 |
| SS | 50 | 40 | 2.0 | 30.3 | 279 | 5 | 3 | 10 |
| SS | 50 | 40 | 4.0 | 30.3 | 17.6 | 5 | 3 | 10 |
| SS | 50 | 40 | 5.0 | 30.3 | 1.82 | 5 | 3 | 10 |
| SS | 50 | 40 | 0.0 | 31.8 | 3710 | 6 | 3 | 10 |
| SS | 50 | 40 | 2.0 | 30.7 | 268 | 6 | 3 | 10 |
| SS | 50 | 40 | 4.0 | 30.5 | 24.0 | 6 | 3 | 10 |
| SS | 50 | 40 | 5.0 | 30.4 | 3.27 | 6 | 3 | 10 |
| SS | 50 | 40 | 0.0 | 31.8 | 3860 | 7 | 3 | 10 |
| SS | 50 | 40 | 2.0 | 31.0 | 369 | 7 | 3 | 10 |
| SS | 50 | 40 | 4.0 | 31.0 | 31.1 | 7 | 3 | 10 |
| SS | 50 | 40 | 5.0 | 31.0 | 3.59 | 7 | 3 | 10 |
| SS | 50 | 20 | 0.0 | 28.2 | 4250 | 1 | 3 | 10 |
| SS | 50 | 20 | 2.0 | 28.5 | 209 | 1 | 3 | 10 |
| SS | 50 | 20 | 4.0 | 28.6 | 15.3 | 1 | 3 | 10 |
| SS | 50 | 20 | 5.0 | 28.6 | 1.72 | 1 | 3 | 10 |
| SS | 50 | 20 | 0.0 | 28.4 | 4160 | 2 | 3 | 10 |
| SS | 50 | 20 | 2.0 | 30.4 | 286 | 2 | 3 | 10 |
| SS | 50 | 20 | 4.0 | 31.6 | 16.2 | 2 | 3 | 10 |
| SS | 50 | 20 | 5.0 | 32.0 | 1.14 | 2 | 3 | 10 |
| SS | 50 | 20 | 0.0 | 28.7 | 4110 | 3 | 3 | 10 |
| SS | 50 | 20 | 2.0 | 29.6 | 320 | 3 | 3 | 10 |
| SS | 50 | 20 | 4.0 | 30.0 | 16.9 | 3 | 3 | 10 |
| SS | 50 | 20 | 5.0 | 30.1 | 1.40 | 3 | 3 | 10 |
| SS | 50 | 30 | 0.0 | 28.7 | 3930 | 1 | 3 | 10 |
| SS | 50 | 30 | 2.0 | 29.1 | 158 | 1 | 3 | 10 |
| SS | 50 | 30 | 4.0 | 29.0 | 11.1 | 1 | 3 | 10 |
| SS | 50 | 30 | 5.0 | 29.1 | 1.00 | 1 | 3 | 10 |
| SS | 50 | 30 | 0.0 | 28.7 | 3920 | 2 | 3 | 10 |
| SS | 50 | 30 | 2.0 | 28.5 | 245 | 2 | 3 | 10 |
| SS | 50 | 30 | 4.0 | 28.4 | 15.6 | 2 | 3 | 10 |
| SS | 50 | 30 | 5.0 | 28.4 | 1.36 | 2 | 3 | 10 |
| SS | 50 | 30 | 0.0 | 28.7 | 3920 | 3 | 3 | 10 |
| SS | 50 | 30 | 2.0 | 28.2 | 244 | 3 | 3 | 10 |
| SS | 50 | 30 | 4.0 | 27.9 | 14.5 | 3 | 3 | 10 |
| SS | 50 | 30 | 5.0 | 27.9 | 1.00 | 3 | 3 | 10 |
| SS | 50 | 50 | 0.0 | 28.7 | 3830 | 1 | 3 | 10 |
| SS | 50 | 50 | 2.0 | 30.3 | 222 | 1 | 3 | 10 |
| SS | 50 | 50 | 4.0 | 31.0 | 15.2 | 1 | 3 | 10 |
| SS | 50 | 50 | 5.0 | 31.1 | 1.00 | 1 | 3 | 10 |

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| SS | 50 | 50 | 0.0 | 29.3 | 3800 | 2 | 3 | 10 |
| SS | 50 | 50 | 2.0 | 31.3 | 206 | 2 | 3 | 10 |
| SS | 50 | 50 | 4.0 | 31.6 | 12.7 | 2 | 3 | 10 |
| SS | 50 | 50 | 5.0 | 31.8 | 1.07 | 2 | 3 | 10 |
| SS | 50 | 50 | 0.0 | 29.7 | 3000 | 3 | 3 | 10 |
| SS | 50 | 50 | 2.0 | 32.0 | 228 | 3 | 3 | 10 |
| SS | 50 | 50 | 4.0 | 32.8 | 14.6 | 3 | 3 | 10 |
| SS | 50 | 50 | 5.0 | 32.7 | 1.15 | 3 | 3 | 10 |
| SS | 50 | 20 | 0.0 | 27.9 | 4130 | 1 | 3 | 6 |
| SS | 50 | 20 | 1.0 | 28.1 | 583 | 1 | 3 | 6 |
| SS | 50 | 20 | 2.0 | 28.4 | 63.4 | 1 | 3 | 6 |
| SS | 50 | 20 | 3.0 | 28.5 | 10.2 | 1 | 3 | 6 |
| SS | 50 | 20 | 0.0 | 28.5 | 4070 | 2 | 3 | 6 |
| SS | 50 | 20 | 1.0 | 28.9 | 526 | 2 | 3 | 6 |
| SS | 50 | 20 | 2.0 | 29.2 | 88.1 | 2 | 3 | 6 |
| SS | 50 | 20 | 3.0 | 29.5 | 10.2 | 2 | 3 | 6 |
| SS | 50 | 20 | 0.0 | 28.6 | 4060 | 3 | 3 | 6 |
| SS | 50 | 20 | 1.0 | 29.4 | 634 | 3 | 3 | 6 |
| SS | 50 | 20 | 2.0 | 29.8 | 108 | 3 | 3 | 6 |
| SS | 50 | 20 | 3.0 | 30.3 | 6.63 | 3 | 3 | 6 |
| SS | 50 | 30 | 0.0 | 28.4 | 4010 | 1 | 3 | 6 |
| SS | 50 | 30 | 1.0 | 29.3 | 396 | 1 | 3 | 6 |
| SS | 50 | 30 | 2.0 | 29.7 | 36.3 | 1 | 3 | 6 |
| SS | 50 | 30 | 3.0 | 30.0 | 4.09 | 1 | 3 | 6 |
| SS | 50 | 30 | 0.0 | 29.2 | 3950 | 2 | 3 | 6 |
| SS | 50 | 30 | 1.0 | 29.5 | 551 | 2 | 3 | 6 |
| SS | 50 | 30 | 2.0 | 30.0 | 50.6 | 2 | 3 | 6 |
| SS | 50 | 30 | 3.0 | 30.2 | 5.73 | 2 | 3 | 6 |
| SS | 50 | 30 | 0.0 | 29.3 | 3900 | 3 | 3 | 6 |
| SS | 50 | 30 | 1.0 | 29.9 | 453 | 3 | 3 | 6 |
| SS | 50 | 30 | 2.0 | 29.9 | 44.7 | 3 | 3 | 6 |
| SS | 50 | 30 | 3.0 | 30.0 | 3.62 | 3 | 3 | 6 |
| SS | 50 | 40 | 0.0 | 29.6 | 3740 | 1 | 3 | 6 |
| SS | 50 | 40 | 1.0 | 29.9 | 532 | 1 | 3 | 6 |
| SS | 50 | 40 | 2.0 | 29.6 | 41.3 | 1 | 3 | 6 |
| SS | 50 | 40 | 3.0 | 29.5 | 5.92 | 1 | 3 | 6 |
| SS | 50 | 40 | 0.0 | 29.7 | 3730 | 2 | 3 | 6 |
| SS | 50 | 40 | 1.0 | 29.6 | 443 | 2 | 3 | 6 |
| SS | 50 | 40 | 2.0 | 29.5 | 51.9 | 2 | 3 | 6 |
| SS | 50 | 40 | 3.0 | 29.3 | 4.29 | 2 | 3 | 6 |
| SS | 50 | 40 | 0.0 | 29.8 | 3740 | 3 | 3 | 6 |
| SS | 50 | 40 | 1.0 | 29.6 | 412 | 3 | 3 | 6 |
| SS | 50 | 40 | 2.0 | 29.3 | 42.2 | 3 | 3 | 6 |
| SS | 50 | 40 | 3.0 | 29.2 | 4.00 | 3 | 3 | 6 |
| SS | 50 | 50 | 0.0 | 29.8 | 3720 | 1 | 3 | 6 |
| SS | 50 | 50 | 1.0 | 29.5 | 807 | 1 | 3 | 6 |
| SS | 50 | 50 | 2.0 | 29.1 | 64.4 | 1 | 3 | 6 |
| SS | 50 | 50 | 3.0 | 29.0 | 6.30 | 1 | 3 | 6 |
| SS | 50 | 50 | 0.0 | 29.9 | 3700 | 2 | 3 | 6 |
| SS | 50 | 50 | 1.0 | 29.5 | 376 | 2 | 3 | 6 |
| SS | 50 | 50 | 2.0 | 29.4 | 28.9 | 2 | 3 | 6 |
| SS | 50 | 50 | 3.0 | 29.3 | 4.34 | 2 | 3 | 6 |
| SS | 50 | 50 | 0.0 | 29.9 | 3690 | 3 | 3 | 6 |
| SS | 50 | 50 | 1.0 | 29.8 | 371 | 3 | 3 | 6 |
| SS | 50 | 50 | 2.0 | 29.8 | 43.2 | 3 | 3 | 6 |
| SS | 50 | 50 | 3.0 | 29.9 | 4.22 | 3 | 3 | 6 |

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|---|---|---|---|---|---|---|---|---|
| SS | 50 | 20 | 0.0 | 29.9 | 4290 | 1 | 3 | 10 |
| SS | 50 | 20 | 2.0 | 29.8 | 476 | 1 | 3 | 10 |
| SS | 50 | 20 | 4.0 | 30.4 | 26.5 | 1 | 3 | 10 |
| SS | 50 | 20 | 5.0 | 30.5 | 3.70 | 1 | 3 | 10 |
| SS | 50 | 20 | 0.0 | 30.4 | 4250 | 2 | 3 | 10 |
| SS | 50 | 20 | 2.0 | 30.8 | 434 | 2 | 3 | 10 |
| SS | 50 | 20 | 4.0 | 31.1 | 28.7 | 2 | 3 | 10 |
| SS | 50 | 20 | 5.0 | 31.2 | 3.32 | 2 | 3 | 10 |
| SS | 50 | 20 | 0.0 | 30.7 | 4200 | 3 | 3 | 10 |
| SS | 50 | 20 | 2.0 | 31.6 | 322 | 3 | 3 | 10 |
| SS | 50 | 20 | 4.0 | 32.0 | 30.3 | 3 | 3 | 10 |
| SS | 50 | 20 | 5.0 | 32.0 | 3.48 | 3 | 3 | 10 |
| SS | 50 | 30 | 0.0 | 30.8 | 4020 | 1 | 3 | 10 |
| SS | 50 | 30 | 2.0 | 32.4 | 327 | 1 | 3 | 10 |
| SS | 50 | 30 | 4.0 | 33.2 | 23.0 | 1 | 3 | 10 |
| SS | 50 | 30 | 5.0 | 33.5 | 2.32 | 1 | 3 | 10 |
| SS | 50 | 30 | 0.0 | 31.1 | 4040 | 2 | 3 | 10 |
| SS | 50 | 30 | 2.0 | 32.9 | 303 | 2 | 3 | 10 |
| SS | 50 | 30 | 4.0 | 33.7 | 14.8 | 2 | 3 | 10 |
| SS | 50 | 30 | 5.0 | 33.8 | 1.79 | 2 | 3 | 10 |
| SS | 50 | 30 | 0.0 | 31.2 | 4020 | 3 | 3 | 10 |
| SS | 50 | 30 | 2.0 | 32.7 | 282 | 3 | 3 | 10 |
| SS | 50 | 30 | 4.0 | 32.9 | 18.7 | 3 | 3 | 10 |
| SS | 50 | 30 | 5.0 | 33.0 | 2.24 | 3 | 3 | 10 |
| SS | 50 | 20 | 0.0 | 30.5 | 3600 | 1 | 3 | 5 |
| SS | 50 | 20 | 2.0 | 28.4 | 218 | 1 | 3 | 5 |
| SS | 50 | 20 | 4.0 | 28.2 | 16.5 | 1 | 3 | 5 |
| SS | 50 | 20 | 5.0 | 27.9 | 4.79 | 1 | 3 | 5 |
| SS | 50 | 20 | 0.0 | 29.0 | 3600 | 2 | 3 | 5 |
| SS | 50 | 20 | 2.0 | 27.5 | 312 | 2 | 3 | 5 |
| SS | 50 | 20 | 4.0 | 27.2 | 18.4 | 2 | 3 | 5 |
| SS | 50 | 20 | 5.0 | 26.8 | 1.00 | 2 | 3 | 5 |
| SS | 50 | 20 | 0.0 | 27.0 | 3600 | 3 | 3 | 5 |
| SS | 50 | 20 | 2.0 | 26.4 | 313 | 3 | 3 | 5 |
| SS | 50 | 20 | 4.0 | 26.4 | 30.0 | 3 | 3 | 5 |
| SS | 50 | 20 | 5.0 | 26.5 | 3.25 | 3 | 3 | 5 |
| SS | 50 | 30 | 0.0 | 27.5 | 3690 | 1 | 3 | 5 |
| SS | 50 | 30 | 2.0 | 26.1 | 210 | 1 | 3 | 5 |
| SS | 50 | 30 | 4.0 | 26.2 | 20.3 | 1 | 3 | 5 |
| SS | 50 | 30 | 5.0 | 26.4 | 1.67 | 1 | 3 | 5 |
| SS | 50 | 30 | 0.0 | 27.4 | 3680 | 2 | 3 | 5 |
| SS | 50 | 30 | 2.0 | 26.9 | 235 | 2 | 3 | 5 |
| SS | 50 | 30 | 4.0 | 27.0 | 16.9 | 2 | 3 | 5 |
| SS | 50 | 30 | 5.0 | 27.1 | 1.42 | 2 | 3 | 5 |
| SS | 50 | 30 | 0.0 | 27.4 | 3690 | 3 | 3 | 5 |
| SS | 50 | 30 | 2.0 | 27.6 | 306 | 3 | 3 | 5 |
| SS | 50 | 30 | 4.0 | 27.9 | 21.2 | 3 | 3 | 5 |
| SS | 50 | 30 | 5.0 | 27.9 | 2.25 | 3 | 3 | 5 |
| SS | 50 | 40 | 0.0 | 28.9 | 3580 | 1 | 3 | 5 |
| SS | 50 | 40 | 2.0 | 27.7 | 340 | 1 | 3 | 5 |
| SS | 50 | 40 | 4.0 | 27.5 | 19.7 | 1 | 3 | 5 |
| SS | 50 | 40 | 5.0 | 27.7 | 1.98 | 1 | 3 | 5 |
| SS | 50 | 40 | 0.0 | 27.5 | 3620 | 2 | 3 | 5 |
| SS | 50 | 40 | 2.0 | 26.7 | 274 | 2 | 3 | 5 |
| SS | 50 | 40 | 4.0 | 26.7 | 18.7 | 2 | 3 | 5 |
| SS | 50 | 40 | 5.0 | 26.8 | 1.56 | 2 | 3 | 5 |

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|---|---|---|---|---|---|---|---|---|
| SS | 50 | 40 | 0.0 | 26.1 | 3600 | 3 | 3 | 5 |
| SS | 50 | 40 | 2.0 | 25.7 | 381 | 3 | 3 | 5 |
| SS | 50 | 40 | 4.0 | 26.0 | 16.6 | 3 | 3 | 5 |
| SS | 50 | 40 | 5.0 | 26.5 | 2.01 | 3 | 3 | 5 |
| SS | 50 | 40 | 0.0 | 27.6 | 3600 | 4 | 3 | 5 |
| SS | 50 | 40 | 2.0 | 28.5 | 197 | 4 | 3 | 5 |
| SS | 50 | 40 | 4.0 | 28.5 | 12.4 | 4 | 3 | 5 |
| SS | 50 | 40 | 5.0 | 28.0 | 2.99 | 4 | 3 | 5 |
| SS | 50 | 40 | 0.0 | 26.4 | 3650 | 5 | 3 | 5 |
| SS | 50 | 40 | 2.0 | 27.3 | 289 | 5 | 3 | 5 |
| SS | 50 | 40 | 4.0 | 27.8 | 20.8 | 5 | 3 | 5 |
| SS | 50 | 40 | 5.0 | 28.1 | 3.06 | 5 | 3 | 5 |
| SS | 50 | 40 | 0.0 | 26.4 | 3610 | 6 | 3 | 5 |
| SS | 50 | 40 | 2.0 | 25.4 | 370 | 6 | 3 | 5 |
| SS | 50 | 40 | 4.0 | 26.3 | 28.3 | 6 | 3 | 5 |
| SS | 50 | 40 | 5.0 | 26.6 | 3.60 | 6 | 3 | 5 |

# APPENDIX B

## APPENDIX B. TEST DATA

| Nozzle | Tank Size (gal) | Operating Pressure (psi) | Run Volume (gal) | Temp (Celcius) | Rinsate Conc. (ppm) | Repitition (1-6) | Rinse Sequence (1, 2, 3) | Rinse Percent (5 or 10) |
|---|---|---|---|---|---|---|---|---|
| SS | 50 | 20 | 0.0 | 23.4 | 10000 | 1 | 3 | 10 |
| SS | 50 | 20 | 2.0 | 23.9 | 1190 | 1 | 3 | 10 |
| SS | 50 | 20 | 4.0 | 24.2 | 53.2 | 1 | 3 | 10 |
| SS | 50 | 20 | 5.0 | 24.3 | 12.8 | 1 | 3 | 10 |
| SS | 50 | 20 | 0.0 | 24.0 | 10000 | 2 | 3 | 10 |
| SS | 50 | 20 | 2.0 | 24.6 | 1185 | 2 | 3 | 10 |
| SS | 50 | 20 | 4.0 | 25.5 | 93.2 | 2 | 3 | 10 |
| SS | 50 | 20 | 5.0 | 25.8 | 18.4 | 2 | 3 | 10 |
| SS | 50 | 20 | 0.0 | 24.0 | 10000 | 3 | 3 | 10 |
| SS | 50 | 20 | 2.0 | 25.6 | 1160 | 3 | 3 | 10 |
| SS | 50 | 20 | 4.0 | 26.9 | 95.8 | 3 | 3 | 10 |
| SS | 50 | 20 | 5.0 | 27.1 | 15.5 | 3 | 3 | 10 |
| SS | 50 | 30 | 0.0 | 24.1 | 10000 | 1 | 3 | 10 |
| SS | 50 | 30 | 2.0 | 26.3 | 1090 | 1 | 3 | 10 |
| SS | 50 | 30 | 4.0 | 28.1 | 63.2 | 1 | 3 | 10 |
| SS | 50 | 30 | 5.0 | 28.6 | 11.9 | 1 | 3 | 10 |
| SS | 50 | 30 | 0.0 | 24.8 | 10000 | 2 | 3 | 10 |
| SS | 50 | 30 | 2.0 | 27.4 | 1030 | 2 | 3 | 10 |
| SS | 50 | 30 | 4.0 | 28.7 | 75.3 | 2 | 3 | 10 |
| SS | 50 | 30 | 5.0 | 28.9 | 14.3 | 2 | 3 | 10 |
| SS | 50 | 30 | 0.0 | 24.3 | 10000 | 3 | 3 | 10 |
| SS | 50 | 30 | 2.0 | 25.8 | 1080 | 3 | 3 | 10 |
| SS | 50 | 30 | 4.0 | 26.8 | 74 | 3 | 3 | 10 |
| SS | 50 | 30 | 5.0 | 27.0 | 13.3 | 3 | 3 | 10 |
| SS | 50 | 40 | 0.0 | 26.2 | 9860 | 1 | 3 | 10 |
| SS | 50 | 40 | 2.0 | 26.7 | 683 | 1 | 3 | 10 |
| SS | 50 | 40 | 4.0 | 27.0 | 57.7 | 1 | 3 | 10 |
| SS | 50 | 40 | 5.0 | 27.2 | 4.05 | 1 | 3 | 10 |
| SS | 50 | 40 | 0.0 | 26.4 | 9860.0 | 2 | 3 | 10 |
| SS | 50 | 40 | 2.0 | 27.5 | 743 | 2 | 3 | 10 |
| SS | 50 | 40 | 4.0 | 28.2 | 60.1 | 2 | 3 | 10 |
| SS | 50 | 40 | 5.0 | 28.6 | 3.93 | 2 | 3 | 10 |
| SS | 50 | 40 | 0.0 | 25.9 | 9860 | 3 | 3 | 10 |
| SS | 50 | 40 | 2.0 | 27.4 | 660 | 3 | 3 | 10 |
| SS | 50 | 40 | 4.0 | 28.1 | 51.4 | 3 | 3 | 10 |
| SS | 50 | 40 | 5.0 | 28.2 | 4.15 | 3 | 3 | 10 |
| SS | 50 | 50 | 0.0 | 26.6 | 9860 | 1 | 3 | 10 |
| SS | 50 | 50 | 2.0 | 28.0 | 703 | 1 | 3 | 10 |
| SS | 50 | 50 | 4.0 | 29.2 | 45 | 1 | 3 | 10 |
| SS | 50 | 50 | 5.0 | 29.6 | 1.00 | 1 | 3 | 10 |

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| SS | 50 | 50 | 0.0 | 26.6 | 9890 | 2 | 3 | 10 |
| SS | 50 | 50 | 2.0 | 28.8 | 660 | 2 | 3 | 10 |
| SS | 50 | 50 | 4.0 | 29.6 | 50.8 | 2 | 3 | 10 |
| SS | 50 | 50 | 5.0 | 29.9 | 1.00 | 2 | 3 | 10 |
| SS | 50 | 50 | 0.0 | 26.8 | 9860 | 3 | 3 | 10 |
| SS | 50 | 50 | 2.0 | 29.1 | 758 | 3 | 3 | 10 |
| SS | 50 | 50 | 4.0 | 30.2 | 48.5 | 3 | 3 | 10 |
| SS | 50 | 50 | 5.0 | 30.3 | 1.00 | 3 | 3 | 10 |
| SS | 50 | 20 | 0.0 | 24.6 | 10000.0 | 1 | 3 | 5 |
| SS | 50 | 20 | 1.0 | 24.8 | 2891.0 | 1 | 3 | 5 |
| SS | 50 | 20 | 2.0 | 25.0 | 313 | 1 | 3 | 5 |
| SS | 50 | 20 | 3.0 | 25.0 | 50.5 | 1 | 3 | 5 |
| SS | 50 | 20 | 0.0 | 24.5 | 10000 | 2 | 3 | 5 |
| SS | 50 | 20 | 1.0 | 24.9 | 2540 | 2 | 3 | 5 |
| SS | 50 | 20 | 2.0 | 25.0 | 383.0 | 2 | 3 | 5 |
| SS | 50 | 20 | 3.0 | 25.0 | 50.3 | 2 | 3 | 5 |
| SS | 50 | 20 | 0.0 | 24.5 | 10000 | 3 | 3 | 5 |
| SS | 50 | 20 | 1.0 | 24.4 | 2430 | 3 | 3 | 5 |
| SS | 50 | 20 | 2.0 | 24.4 | 469 | 3 | 3 | 5 |
| SS | 50 | 20 | 3.0 | 24.5 | 28.8 | 3 | 3 | 5 |
| SS | 50 | 30 | 0.0 | 24.5 | 10000 | 1 | 3 | 5 |
| SS | 50 | 30 | 1.0 | 24.0 | 2376 | 1 | 3 | 5 |
| SS | 50 | 30 | 2.0 | 23.9 | 217 | 1 | 3 | 5 |
| SS | 50 | 30 | 3.0 | 23.9 | 24.5 | 1 | 3 | 5 |
| SS | 50 | 30 | 0.0 | 24.8 | 10000 | 2 | 3 | 5 |
| SS | 50 | 30 | 1.0 | 24.5 | 2195 | 2 | 3 | 5 |
| SS | 50 | 30 | 2.0 | 24.6 | 293 | 2 | 3 | 5 |
| SS | 50 | 30 | 3.0 | 24.7 | 33.2 | 2 | 3 | 5 |
| SS | 50 | 30 | 0.0 | 24.8 | 10000 | 3 | 3 | 5 |
| SS | 50 | 30 | 1.0 | 24.1 | 2423 | 3 | 3 | 5 |
| SS | 50 | 30 | 2.0 | 24.0 | 239 | 3 | 3 | 5 |
| SS | 50 | 30 | 3.0 | 24.0 | 19.3 | 3 | 3 | 5 |
| SS | 50 | 40 | 0.0 | 24.9 | 10000 | 1 | 3 | 5 |
| SS | 50 | 40 | 1.0 | 24.5 | 2425 | 1 | 3 | 5 |
| SS | 50 | 40 | 2.0 | 24.4 | 188 | 1 | 3 | 5 |
| SS | 50 | 40 | 3.0 | 24.5 | 26.9 | 1 | 3 | 5 |
| SS | 50 | 40 | 0.0 | 24.8 | 10000 | 2 | 3 | 5 |
| SS | 50 | 40 | 1.0 | 25.6 | 2020 | 2 | 3 | 5 |
| SS | 50 | 40 | 2.0 | 26.1 | 236 | 2 | 3 | 5 |
| SS | 50 | 40 | 3.0 | 26.4 | 19.5 | 2 | 3 | 5 |
| SS | 50 | 40 | 0.0 | 24.9 | 10000 | 3 | 3 | 5 |
| SS | 50 | 40 | 1.0 | 25.1 | 2134 | 3 | 3 | 5 |
| SS | 50 | 40 | 2.0 | 25.2 | 192 | 3 | 3 | 5 |
| SS | 50 | 40 | 3.0 | 25.3 | 18.2 | 3 | 3 | 5 |

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| SS | 50 | 50 | 0.0 | 24.9 | 10000 | 1 | 3 | 5 |
| SS | 50 | 50 | 1.0 | 26.3 | 1833 | 1 | 3 | 5 |
| SS | 50 | 50 | 2.0 | 26.1 | 202 | 1 | 3 | 5 |
| SS | 50 | 50 | 3.0 | 26.0 | 29.6 | 1 | 3 | 5 |
| SS | 50 | 50 | 0.0 | 24.9 | 10000 | 2 | 3 | 5 |
| SS | 50 | 50 | 1.0 | 26.2 | 1767 | 2 | 3 | 5 |
| SS | 50 | 50 | 2.0 | 26.2 | 135 | 2 | 3 | 5 |
| SS | 50 | 50 | 3.0 | 26.0 | 20.4 | 2 | 3 | 5 |
| SS | 50 | 50 | 0.0 | 24.8 | 10000 | 3 | 3 | 5 |
| SS | 50 | 50 | 1.0 | 25.5 | 1743 | 3 | 3 | 5 |
| SS | 50 | 50 | 2.0 | 25.2 | 203 | 3 | 3 | 5 |
| SS | 50 | 50 | 3.0 | 25.4 | 19.8 | 3 | 3 | 5 |
| SS | 50 | 20 | 0.0 | 27.0 | 9830 | 1 | 2 | 10 |
| SS | 50 | 20 | 2.5 | 28.1 | 842 | 1 | 2 | 10 |
| SS | 50 | 20 | 5.0 | 28.6 | 45.8 | 1 | 2 | 10 |
| SS | 50 | 20 | 0.0 | 26.7 | 9830 | 2 | 2 | 10 |
| SS | 50 | 20 | 2.5 | 27.7 | 954 | 2 | 2 | 10 |
| SS | 50 | 20 | 5.0 | 28.2 | 42.3 | 2 | 2 | 10 |
| SS | 50 | 20 | 0.0 | 26.5 | 9800 | 3 | 2 | 10 |
| SS | 50 | 20 | 2.5 | 28.0 | 785 | 3 | 2 | 10 |
| SS | 50 | 20 | 5.0 | 28.6 | 48.7 | 3 | 2 | 10 |
| SS | 50 | 30 | 0.0 | 28.3 | 9440 | 1 | 2 | 10 |
| SS | 50 | 30 | 2.5 | 30.7 | 742 | 1 | 2 | 10 |
| SS | 50 | 30 | 5.0 | 31.4 | 55.8 | 1 | 2 | 10 |
| SS | 50 | 30 | 0.0 | 27.9 | 9440 | 2 | 2 | 10 |
| SS | 50 | 30 | 2.5 | 29.8 | 730 | 2 | 2 | 10 |
| SS | 50 | 30 | 5.0 | 30.1 | 57.1 | 2 | 2 | 10 |
| SS | 50 | 30 | 0.0 | 27.4 | 9440 | 3 | 2 | 10 |
| SS | 50 | 30 | 2.5 | 29.0 | 759 | 3 | 2 | 10 |
| SS | 50 | 30 | 5.0 | 29.6 | 64.1 | 3 | 2 | 10 |
| SS | 50 | 40 | 0.0 | 26.4 | 9750 | 1 | 2 | 10 |
| SS | 50 | 40 | 2.5 | 26.8 | 887 | 1 | 2 | 10 |
| SS | 50 | 40 | 5.0 | 27.1 | 61.8 | 1 | 2 | 10 |
| SS | 50 | 40 | 0.0 | 26.6 | 9750 | 2 | 2 | 10 |
| SS | 50 | 40 | 2.5 | 27.3 | 887 | 2 | 2 | 10 |
| SS | 50 | 40 | 5.0 | 27.6 | 72.5 | 2 | 2 | 10 |
| SS | 50 | 40 | 0.0 | 26.5 | 9750 | 3 | 2 | 10 |
| SS | 50 | 40 | 2.5 | 26.7 | 855 | 3 | 2 | 10 |
| SS | 50 | 40 | 5.0 | 26.7 | 72.3 | 3 | 2 | 10 |
| SS | 50 | 50 | 0.0 | 26.5 | 9750 | 1 | 2 | 10 |
| SS | 50 | 50 | 2.5 | 25.8 | 906 | 1 | 2 | 10 |
| SS | 50 | 50 | 5.0 | 25.7 | 75.4 | 1 | 2 | 10 |

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| SS | 50 | 50 | 0.0 | 26.6 | 9750 | 2 | 2 | 10 |
| SS | 50 | 50 | 2.5 | 26.3 | 894 | 2 | 2 | 10 |
| SS | 50 | 50 | 5.0 | 26.5 | 76.2 | 2 | 2 | 10 |
| SS | 50 | 50 | 0.0 | 26.6 | 9750 | 3 | 2 | 10 |
| SS | 50 | 50 | 2.5 | 26.4 | 898 | 3 | 2 | 10 |
| SS | 50 | 50 | 5.0 | 26.6 | 73.8 | 3 | 2 | 10 |
| SS | 50 | 20 | 0.0 | 26.4 | 10000 | 1 | 2 | 5 |
| SS | 50 | 20 | 1.0 | 26.2 | 2863 | 1 | 2 | 5 |
| SS | 50 | 20 | 2.5 | 26.1 | 242 | 1 | 2 | 5 |
| SS | 50 | 20 | 0.0 | 26.4 | 10000 | 2 | 2 | 5 |
| SS | 50 | 20 | 1.0 | 25.8 | 2804 | 2 | 2 | 5 |
| SS | 50 | 20 | 2.5 | 25.7 | 280 | 2 | 2 | 5 |
| SS | 50 | 20 | 0.0 | 26.5 | 10000 | 3 | 2 | 5 |
| SS | 50 | 20 | 1.0 | 26.0 | 2780 | 3 | 2 | 5 |
| SS | 50 | 20 | 2.5 | 26.0 | 271 | 3 | 2 | 5 |
| SS | 50 | 30 | 0.0 | 26.5 | 10000 | 1 | 2 | 5 |
| SS | 50 | 30 | 1.0 | 25.9 | 2705 | 1 | 2 | 5 |
| SS | 50 | 30 | 2.5 | 25.9 | 234 | 1 | 2 | 5 |
| SS | 50 | 30 | 0.0 | 26.5 | 10000 | 2 | 2 | 5 |
| SS | 50 | 30 | 1.0 | 25.2 | 2668 | 2 | 2 | 5 |
| SS | 50 | 30 | 2.5 | 25.3 | 230 | 2 | 2 | 5 |
| SS | 50 | 30 | 0.0 | 26.6 | 10000 | 3 | 2 | 5 |
| SS | 50 | 30 | 1.0 | 26.1 | 2679 | 3 | 2 | 5 |
| SS | 50 | 30 | 2.5 | 26.3 | 242 | 3 | 2 | 5 |
| SS | 50 | 40 | 0.0 | 26.6 | 10000 | 1 | 2 | 5 |
| SS | 50 | 40 | 1.0 | 27.2 | 2440 | 1 | 2 | 5 |
| SS | 50 | 40 | 2.5 | 27.0 | 213 | 1 | 2 | 5 |
| SS | 50 | 40 | 0.0 | 26.7 | 10000 | 2 | 2 | 5 |
| SS | 50 | 40 | 1.0 | 27.3 | 2359 | 2 | 2 | 5 |
| SS | 50 | 40 | 2.5 | 27.3 | 290 | 2 | 2 | 5 |
| SS | 50 | 40 | 0.0 | 26.7 | 10000 | 3 | 2 | 5 |
| SS | 50 | 40 | 1.0 | 26.9 | 2411 | 3 | 2 | 5 |
| SS | 50 | 40 | 2.5 | 26.8 | 257 | 3 | 2 | 5 |
| SS | 50 | 50 | 0.0 | 26.7 | 10000 | 1 | 2 | 5 |
| SS | 50 | 50 | 1.0 | 27.1 | 2198 | 1 | 2 | 5 |
| SS | 50 | 50 | 2.5 | 27.3 | 216 | 1 | 2 | 5 |
| SS | 50 | 50 | 0.0 | 26.8 | 10000 | 2 | 2 | 5 |
| SS | 50 | 50 | 1.0 | 26.8 | 2130 | 2 | 2 | 5 |
| SS | 50 | 50 | 2.5 | 26.5 | 198 | 2 | 2 | 5 |
| SS | 50 | 50 | 0.0 | 26.8 | 10000 | 3 | 2 | 5 |
| SS | 50 | 50 | 1.0 | 27.1 | 2176 | 3 | 2 | 5 |
| SS | 50 | 50 | 2.5 | 27.0 | 223 | 3 | 2 | 5 |

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| SS | 50 | 20 | 0.0 | 26.9 | 10000 | 1 | 1 | 10 |
| SS | 50 | 20 | 5.0 | 27.0 | 446 | 1 | 1 | 10 |
| SS | 50 | 20 | 0.0 | 26.9 | 10000 | 2 | 1 | 10 |
| SS | 50 | 20 | 5.0 | 26.8 | 431 | 2 | 1 | 10 |
| SS | 50 | 20 | 0.0 | 26.9 | 10000 | 3 | 1 | 10 |
| SS | 50 | 20 | 5.0 | 27.2 | 412 | 3 | 1 | 10 |
| SS | 50 | 30 | 0.0 | 26.9 | 10000 | 1 | 1 | 10 |
| SS | 50 | 30 | 5.0 | 25.6 | 320 | 1 | 1 | 10 |
| SS | 50 | 30 | 0.0 | 27.0 | 10000 | 2 | 1 | 10 |
| SS | 50 | 30 | 5.0 | 25.9 | 332 | 2 | 1 | 10 |
| SS | 50 | 30 | 0.0 | 27.0 | 10000 | 3 | 1 | 10 |
| SS | 50 | 30 | 5.0 | 26.4 | 309 | 3 | 1 | 10 |
| SS | 50 | 40 | 0.0 | 27.0 | 10000 | 1 | 1 | 10 |
| SS | 50 | 40 | 5.0 | 26.7 | 265 | 1 | 1 | 10 |
| SS | 50 | 40 | 0.0 | 27.1 | 10000 | 2 | 1 | 10 |
| SS | 50 | 40 | 5.0 | 26.6 | 280 | 2 | 1 | 10 |
| SS | 50 | 40 | 0.0 | 27.1 | 10000 | 3 | 1 | 10 |
| SS | 50 | 40 | 5.0 | 25.7 | 263 | 3 | 1 | 10 |
| SS | 50 | 50 | 0.0 | 27.1 | 10000 | 1 | 1 | 10 |
| SS | 50 | 50 | 5.0 | 27.0 | 244 | 1 | 1 | 10 |
| SS | 50 | 50 | 0.0 | 27.1 | 10000 | 2 | 1 | 10 |
| SS | 50 | 50 | 5.0 | 26.8 | 225 | 2 | 1 | 10 |
| SS | 50 | 50 | 0.0 | 27.0 | 10000 | 3 | 1 | 10 |
| SS | 50 | 50 | 5.0 | 25.8 | 227 | 3 | 1 | 10 |
| SS | 50 | 20 | 0.0 | 27.0 | 9830 | 1 | 1 | 5 |
| SS | 50 | 20 | 2.5 | 28.1 | 842 | 1 | 1 | 5 |
| SS | 50 | 20 | 0.0 | 26.7 | 9830 | 2 | 1 | 5 |
| SS | 50 | 20 | 2.5 | 27.7 | 954 | 2 | 1 | 5 |
| SS | 50 | 20 | 0.0 | 26.5 | 9800 | 3 | 1 | 5 |
| SS | 50 | 20 | 2.5 | 28.0 | 785 | 3 | 1 | 5 |
| SS | 50 | 30 | 0.0 | 28.3 | 9440 | 1 | 1 | 5 |
| SS | 50 | 30 | 2.5 | 30.7 | 742 | 1 | 1 | 5 |
| SS | 50 | 30 | 0.0 | 27.9 | 9440 | 2 | 1 | 5 |
| SS | 50 | 30 | 2.5 | 29.8 | 730 | 2 | 1 | 5 |
| SS | 50 | 30 | 0.0 | 27.4 | 9440 | 3 | 1 | 5 |
| SS | 50 | 30 | 2.5 | 29.0 | 759 | 3 | 1 | 5 |
| SS | 50 | 40 | 0.0 | 26.4 | 9750 | 1 | 1 | 5 |
| SS | 50 | 40 | 2.5 | 26.8 | 887 | 1 | 1 | 5 |

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| SS | 50 | 40 | 0.0 | 26.6 | 9750 | 2 | 1 | 5 |
| SS | 50 | 40 | 2.5 | 27.3 | 887 | 2 | 1 | 5 |
| SS | 50 | 40 | 0.0 | 26.5 | 9750 | 3 | 1 | 5 |
| SS | 50 | 40 | 2.5 | 26.7 | 885 | 3 | 1 | 5 |
| SS | 50 | 50 | 0.0 | 26.5 | 9750 | 1 | 1 | 5 |
| SS | 50 | 50 | 2.5 | 25.8 | 906 | 1 | 1 | 5 |
| SS | 50 | 50 | 0.0 | 26.6 | 9750 | 2 | 1 | 5 |
| SS | 50 | 50 | 2.5 | 26.3 | 894 | 2 | 1 | 5 |
| SS | 50 | 50 | 0.0 | 26.6 | 9750 | 3 | 1 | 5 |
| SS | 50 | 50 | 2.5 | 26.4 | 898 | 3 | 1 | 5 |
| L5E | 100 | 30 | 0.0 | 28.0 | 10000 | 1 | 3 | 10 |
| L5E | 100 | 30 | 4.0 | 28.5 | 774 | 1 | 3 | 10 |
| L5E | 100 | 30 | 7.0 | 29.0 | 47.2 | 1 | 3 | 10 |
| L5E | 100 | 30 | 10.0 | 29.1 | 5.3 | 1 | 3 | 10 |
| L5E | 100 | 30 | 0.0 | 28.4 | 10000 | 2 | 3 | 10 |
| L5E | 100 | 30 | 4.0 | 29.0 | 590 | 2 | 3 | 10 |
| L5E | 100 | 30 | 7.0 | 29.2 | 32.1 | 2 | 3 | 10 |
| L5E | 100 | 30 | 10.0 | 29.5 | 4.77 | 2 | 3 | 10 |
| L5E | 100 | 30 | 0.0 | 28.4 | 10000 | 3 | 3 | 10 |
| L5E | 100 | 30 | 4.0 | 29.0 | 649 | 3 | 3 | 10 |
| L5E | 100 | 30 | 7.0 | 29.3 | 35.2 | 3 | 3 | 10 |
| L5E | 100 | 30 | 10.0 | 29.5 | 4.55 | 3 | 3 | 10 |
| L5E | 100 | 40 | 0.0 | 28.6 | 10000 | 1 | 3 | 10 |
| L5E | 100 | 40 | 4.0 | 29.5 | 737 | 1 | 3 | 10 |
| L5E | 100 | 40 | 7.0 | 29.9 | 33.4 | 1 | 3 | 10 |
| L5E | 100 | 40 | 10.0 | 30.0 | 4.36 | 1 | 3 | 10 |
| L5E | 100 | 40 | 0.0 | 28.8 | 10000 | 2 | 3 | 10 |
| L5E | 100 | 40 | 4.0 | 29.7 | 644 | 2 | 3 | 10 |
| L5E | 100 | 40 | 7.0 | 30.2 | 33.5 | 2 | 3 | 10 |
| L5E | 100 | 40 | 10.0 | 30.3 | 3.75 | 2 | 3 | 10 |
| L5E | 100 | 40 | 0.0 | 28.9 | 10000 | 3 | 3 | 10 |
| L5E | 100 | 40 | 4.0 | 29.7 | 623 | 3 | 3 | 10 |
| L5E | 100 | 40 | 7.0 | 29.9 | 39.1 | 3 | 3 | 10 |
| L5E | 100 | 40 | 10.0 | 30.0 | 4.14 | 3 | 3 | 10 |
| L5E | 100 | 50 | 0.0 | 28.6 | 10000 | 1 | 3 | 10 |
| L5E | 100 | 50 | 4.0 | 28.9 | 628 | 1 | 3 | 10 |
| L5E | 100 | 50 | 7.0 | 29.0 | 33.8 | 1 | 3 | 10 |
| L5E | 100 | 50 | 10.0 | 29.1 | 4.13 | 1 | 3 | 10 |
| L5E | 100 | 50 | 0.0 | 28.9 | 10000 | 2 | 3 | 10 |
| L5E | 100 | 50 | 4.0 | 29.4 | 672 | 2 | 3 | 10 |
| L5E | 100 | 50 | 7.0 | 29.6 | 37.6 | 2 | 3 | 10 |
| L5E | 100 | 50 | 10.0 | 29.7 | 3.57 | 2 | 3 | 10 |

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|---|---|---|---|---|---|---|---|---|
| L5E | 100 | 50 | 0.0 | 29.1 | 10000 | 3 | 3 | 10 |
| L5E | 100 | 50 | 4.0 | 29.4 | 499 | 3 | 3 | 10 |
| L5E | 100 | 50 | 7.0 | 29.4 | 37.7 | 3 | 3 | 10 |
| L5E | 100 | 50 | 10.0 | 29.6 | 3.42 | 3 | 3 | 10 |
| | | | | | | | | |
| L5E | 100 | 30 | 0.0 | 28.1 | 10000 | 1 | 3 | 5 |
| L5E | 100 | 30 | 2.0 | 27.9 | 1440 | 1 | 3 | 5 |
| L5E | 100 | 30 | 4.0 | 28.2 | 112 | 1 | 3 | 5 |
| L5E | 100 | 30 | 5.0 | 28.3 | 18.5 | 1 | 3 | 5 |
| | | | | | | | | |
| L5E | 100 | 30 | 0.0 | 28.2 | 10000 | 2 | 3 | 5 |
| L5E | 100 | 30 | 2.0 | 28.4 | 1130 | 2 | 3 | 5 |
| L5E | 100 | 30 | 4.0 | 28.7 | 100 | 2 | 3 | 5 |
| L5E | 100 | 30 | 5.0 | 28.8 | 13.2 | 2 | 3 | 5 |
| | | | | | | | | |
| L5E | 100 | 30 | 0.0 | 28.3 | 10000 | 3 | 3 | 5 |
| L5E | 100 | 30 | 2.0 | 28.7 | 1080 | 3 | 3 | 5 |
| L5E | 100 | 30 | 4.0 | 29.0 | 88 | 3 | 3 | 5 |
| L5E | 100 | 30 | 5.0 | 29.1 | 17.2 | 3 | 3 | 5 |
| | | | | | | | | |
| L5E | 100 | 40 | 0.0 | 28.4 | 10000 | 1 | 3 | 5 |
| L5E | 100 | 40 | 2.0 | 28.9 | 1030 | 1 | 3 | 5 |
| L5E | 100 | 40 | 4.0 | 29.3 | 88.6 | 1 | 3 | 5 |
| L5E | 100 | 40 | 5.0 | 29.4 | 17.4 | 1 | 3 | 5 |
| | | | | | | | | |
| L5E | 100 | 40 | 0.0 | 28.5 | 10000 | 2 | 3 | 5 |
| L5E | 100 | 40 | 2.0 | 29.1 | 1060 | 2 | 3 | 5 |
| L5E | 100 | 40 | 4.0 | 29.4 | 87.7 | 2 | 3 | 5 |
| L5E | 100 | 40 | 5.0 | 29.5 | 16.5 | 2 | 3 | 5 |
| | | | | | | | | |
| L5E | 100 | 40 | 0.0 | 28.6 | 10000 | 3 | 3 | 5 |
| L5E | 100 | 40 | 2.0 | 29.2 | 1100 | 3 | 3 | 5 |
| L5E | 100 | 40 | 4.0 | 29.6 | 87.4 | 3 | 3 | 5 |
| L5E | 100 | 40 | 5.0 | 29.7 | 16.3 | 3 | 3 | 5 |
| | | | | | | | | |
| L5E | 100 | 50 | 0.0 | 28.7 | 10000 | 1 | 3 | 5 |
| L5E | 100 | 50 | 2.0 | 29.4 | 970 | 1 | 3 | 5 |
| L5E | 100 | 50 | 4.0 | 29.8 | 67.8 | 1 | 3 | 5 |
| L5E | 100 | 50 | 5.0 | 29.9 | 12.1 | 1 | 3 | 5 |
| | | | | | | | | |
| L5E | 100 | 50 | 0.0 | 28.8 | 10000 | 2 | 3 | 5 |
| L5E | 100 | 50 | 2.0 | 29.6 | 1020 | 2 | 3 | 5 |
| L5E | 100 | 50 | 4.0 | 29.9 | 82.6 | 2 | 3 | 5 |
| L5E | 100 | 50 | 5.0 | 30.0 | 16.4 | 2 | 3 | 5 |
| | | | | | | | | |
| L5E | 100 | 50 | 0.0 | 28.8 | 10000 | 3 | 3 | 5 |
| L5E | 100 | 50 | 2.0 | 29.7 | 1100 | 3 | 3 | 5 |
| L5E | 100 | 50 | 4.0 | 29.9 | 74.1 | 3 | 3 | 5 |
| L5E | 100 | 50 | 5.0 | 30.0 | 14.2 | 3 | 3 | 5 |
| | | | | | | | | |
| L5E | 100 | 30 | 0.0 | 28.5 | 10000 | 1 | 2 | 10 |
| L5E | 100 | 30 | 5.0 | 28.3 | 612 | 1 | 2 | 10 |
| L5E | 100 | 30 | 10.0 | 28.4 | 37.2 | 1 | 2 | 10 |
| | | | | | | | | |
| L5E | 100 | 30 | 0.0 | 28.2 | 10000 | 2 | 2 | 10 |
| L5E | 100 | 30 | 5.0 | 28.0 | 653 | 2 | 2 | 10 |
| L5E | 100 | 30 | 10.0 | 28.0 | 34.6 | 2 | 2 | 10 |

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|---|---|---|---|---|---|---|---|---|
| L5E | 100 | 30 | 0.0 | 27.9 | 10000 | 3 | 2 | 10 |
| L5E | 100 | 30 | 5.0 | 27.6 | 580 | 3 | 2 | 10 |
| L5E | 100 | 30 | 10.0 | 27.6 | 39.3 | 3 | 2 | 10 |
| L5E | 100 | 40 | 0.0 | 28.2 | 10000 | 1 | 2 | 10 |
| L5E | 100 | 40 | 5.0 | 27.6 | 621 | 1 | 2 | 10 |
| L5E | 100 | 40 | 10.0 | 27.6 | 31.6 | 1 | 2 | 10 |
| L5E | 100 | 40 | 0.0 | 28.3 | 10000 | 2 | 2 | 10 |
| L5E | 100 | 40 | 5.0 | 27.4 | 485 | 2 | 2 | 10 |
| L5E | 100 | 40 | 10.0 | 27.3 | 27.8 | 2 | 2 | 10 |
| L5E | 100 | 40 | 0.0 | 28.2 | 10000 | 3 | 2 | 10 |
| L5E | 100 | 40 | 5.0 | 27.3 | 536 | 3 | 2 | 10 |
| L5E | 100 | 40 | 10.0 | 27.1 | 25.3 | 3 | 2 | 10 |
| L5E | 100 | 50 | 0.0 | 28.2 | 10000 | 1 | 2 | 10 |
| L5E | 100 | 50 | 5.0 | 27.8 | 493 | 1 | 2 | 10 |
| L5E | 100 | 50 | 10.0 | 27.9 | 18.9 | 1 | 2 | 10 |
| L5E | 100 | 50 | 0.0 | 28.3 | 10000 | 2 | 2 | 10 |
| L5E | 100 | 50 | 5.0 | 28.0 | 508 | 2 | 2 | 10 |
| L5E | 100 | 50 | 10.0 | 28.1 | 23.9 | 2 | 2 | 10 |
| L5E | 100 | 50 | 0.0 | 28.5 | 10000 | 3 | 2 | 10 |
| L5E | 100 | 50 | 5.0 | 28.6 | 454 | 3 | 2 | 10 |
| L5E | 100 | 50 | 10.0 | 28.8 | 24.2 | 3 | 2 | 10 |
| L5E | 100 | 30 | 0.0 | 29.0 | 10000 | 1 | 2 | 5 |
| L5E | 100 | 30 | 2.5 | 28.5 | 847 | 1 | 2 | 5 |
| L5E | 100 | 30 | 5.0 | 28.4 | 70.7 | 1 | 2 | 5 |
| L5E | 100 | 30 | 0.0 | 29.0 | 10000 | 2 | 2 | 5 |
| L5E | 100 | 30 | 2.5 | 28.6 | 712 | 2 | 2 | 5 |
| L5E | 100 | 30 | 5.0 | 28.6 | 66.3 | 2 | 2 | 5 |
| L5E | 100 | 30 | 0.0 | 29.0 | 10000 | 3 | 2 | 5 |
| L5E | 100 | 30 | 2.5 | 28.4 | 788 | 3 | 2 | 5 |
| L5E | 100 | 30 | 5.0 | 28.4 | 64.4 | 3 | 2 | 5 |
| L5E | 100 | 40 | 0.0 | 28.9 | 10000 | 1 | 2 | 5 |
| L5E | 100 | 40 | 2.5 | 28.3 | 841 | 1 | 2 | 5 |
| L5E | 100 | 40 | 5.0 | 28.2 | 60.8 | 1 | 2 | 5 |
| L5E | 100 | 40 | 0.0 | 28.9 | 10000 | 2 | 2 | 5 |
| L5E | 100 | 40 | 2.5 | 28.3 | 818 | 2 | 2 | 5 |
| L5E | 100 | 40 | 5.0 | 28.3 | 60.8 | 2 | 2 | 5 |
| L5E | 100 | 40 | 0.0 | 29.0 | 10000 | 3 | 2 | 5 |
| L5E | 100 | 40 | 2.5 | 28.3 | 710 | 3 | 2 | 5 |
| L5E | 100 | 40 | 5.0 | 28.4 | 72.1 | 3 | 2 | 5 |
| L5E | 100 | 50 | 0.0 | 28.5 | 10000 | 1 | 2 | 5 |
| L5E | 100 | 50 | 2.5 | 28.2 | 1050 | 1 | 2 | 5 |
| L5E | 100 | 50 | 5.0 | 28.6 | 83.8 | 1 | 2 | 5 |

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|---|---|---|---|---|---|---|---|---|
| L5E | 100 | 50 | 0.0 | 28.3 | 10000 | 2 | 2 | 5 |
| L5E | 100 | 50 | 2.5 | 28.3 | 962 | 2 | 2 | 5 |
| L5E | 100 | 50 | 5.0 | 28.3 | 78.9 | 2 | 2 | 5 |
| L5E | 100 | 50 | 0.0 | 28.6 | 10000 | 3 | 2 | 5 |
| L5E | 100 | 50 | 2.5 | 28.2 | 958 | 3 | 2 | 5 |
| L5E | 100 | 50 | 5.0 | 28.3 | 84.7 | 3 | 2 | 5 |
| L5E | 100 | 30 | 0.0 | 29.5 | 10000 | 1 | 1 | 10 |
| L5E | 100 | 30 | 10.0 | 28.8 | 409 | 1 | 1 | 10 |
| L5E | 100 | 30 | 0.0 | 29.4 | 10000 | 2 | 1 | 10 |
| L5E | 100 | 30 | 10.0 | 28.5 | 367 | 2 | 1 | 10 |
| L5E | 100 | 30 | 0.0 | 29.4 | 10000 | 3 | 1 | 10 |
| L5E | 100 | 30 | 10.0 | 28.6 | 348 | 3 | 1 | 10 |
| L5E | 100 | 40 | 0.0 | 29.6 | 10000 | 1 | 1 | 10 |
| L5E | 100 | 40 | 10.0 | 28.8 | 293 | 1 | 1 | 10 |
| L5E | 100 | 40 | 0.0 | 29.6 | 10000 | 2 | 1 | 10 |
| L5E | 100 | 40 | 10.0 | 29.3 | 220 | 2 | 1 | 10 |
| L5E | 100 | 40 | 0.0 | 29.6 | 10000 | 3 | 1 | 10 |
| L5E | 100 | 40 | 10.0 | 29.0 | 246 | 3 | 1 | 10 |
| L5E | 100 | 50 | 0.0 | 29.6 | 10000 | 1 | 1 | 10 |
| L5E | 100 | 50 | 10.0 | 30.4 | 178 | 1 | 1 | 10 |
| L5E | 100 | 50 | 0.0 | 29.6 | 10000 | 2 | 1 | 10 |
| L5E | 100 | 50 | 10.0 | 29.7 | 206 | 2 | 1 | 10 |
| L5E | 100 | 50 | 0.0 | 29.6 | 10000 | 3 | 1 | 10 |
| L5E | 100 | 50 | 10.0 | 29.4 | 265 | 3 | 1 | 10 |
| L5E | 100 | 30 | 0.0 | 29.4 | 10000 | 1 | 1 | 5 |
| L5E | 100 | 30 | 5.0 | 27.2 | 515 | 1 | 1 | 5 |
| L5E | 100 | 30 | 0.0 | 29.4 | 10000 | 2 | 1 | 5 |
| L5E | 100 | 30 | 5.0 | 27.2 | 507 | 2 | 1 | 5 |
| L5E | 100 | 30 | 0.0 | 29.3 | 10000 | 3 | 1 | 5 |
| L5E | 100 | 30 | 5.0 | 27.0 | 522 | 3 | 1 | 5 |
| L5E | 100 | 40 | 0.0 | 29.3 | 10000 | 1 | 1 | 5 |
| L5E | 100 | 40 | 5.0 | 26.9 | 481 | 1 | 1 | 5 |
| L5E | 100 | 40 | 0.0 | 29.3 | 10000 | 2 | 1 | 5 |
| L5E | 100 | 40 | 5.0 | 26.9 | 478 | 2 | 1 | 5 |
| L5E | 100 | 40 | 0.0 | 29.2 | 10000 | 3 | 1 | 5 |
| L5E | 100 | 40 | 5.0 | 26.9 | 462 | 3 | 1 | 5 |
| L5E | 100 | 50 | 0.0 | 28.5 | 10000 | 1 | 1 | 5 |
| L5E | 100 | 50 | 5.0 | 27.1 | 620 | 1 | 1 | 5 |

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|---|---|---|---|---|---|---|---|---|
| L5E | 100 | 50 | 0.0 | 28.8 | 10000 | 2 | 1 | 5 |
| L5E | 100 | 50 | 5.0 | 26.9 | 578 | 2 | 1 | 5 |
| L5E | 100 | 50 | 0.0 | 28.9 | 10000 | 3 | 1 | 5 |
| L5E | 100 | 50 | 5.0 | 26.9 | 544 | 3 | 1 | 5 |
| SS | 100 | 20 | 0.0 | 22.4 | 10000 | 1 | 3 | 10 |
| SS | 100 | 20 | 4.0 | 23.0 | 668 | 1 | 3 | 10 |
| SS | 100 | 20 | 7.0 | 23.4 | 64.8 | 1 | 3 | 10 |
| SS | 100 | 20 | 10.0 | 23.7 | 12.3 | 1 | 3 | 10 |
| SS | 100 | 20 | 0.0 | 22.4 | 9960 | 2 | 3 | 10 |
| SS | 100 | 20 | 4.0 | 23.3 | 551 | 2 | 3 | 10 |
| SS | 100 | 20 | 7.0 | 23.6 | 49.2 | 2 | 3 | 10 |
| SS | 100 | 20 | 10.0 | 23.8 | 16.9 | 2 | 3 | 10 |
| SS | 100 | 20 | 0.0 | 22.8 | 10000 | 3 | 3 | 10 |
| SS | 100 | 20 | 4.0 | 25.1 | 585 | 3 | 3 | 10 |
| SS | 100 | 20 | 7.0 | 26.0 | 45.5 | 3 | 3 | 10 |
| SS | 100 | 20 | 10.0 | 26.1 | 10.1 | 3 | 3 | 10 |
| SS | 100 | 30 | 0.0 | 23.4 | 10000 | 1 | 3 | 10 |
| SS | 100 | 30 | 4.0 | 26.3 | 661 | 1 | 3 | 10 |
| SS | 100 | 30 | 7.0 | 27.1 | 72.1 | 1 | 3 | 10 |
| SS | 100 | 30 | 10.0 | 27.4 | 11.1 | 1 | 3 | 10 |
| SS | 100 | 30 | 0.0 | 23.4 | 10000 | 2 | 3 | 10 |
| SS | 100 | 30 | 4.0 | 26.1 | 496 | 2 | 3 | 10 |
| SS | 100 | 30 | 7.0 | 26.3 | 51.4 | 2 | 3 | 10 |
| SS | 100 | 30 | 10.0 | 26.7 | 16.5 | 2 | 3 | 10 |
| SS | 100 | 30 | 0.0 | 23.6 | 9960 | 3 | 3 | 10 |
| SS | 100 | 30 | 4.0 | 26.3 | 488 | 3 | 3 | 10 |
| SS | 100 | 30 | 7.0 | 27.1 | 50.1 | 3 | 3 | 10 |
| SS | 100 | 30 | 10.0 | 27.3 | 16.1 | 3 | 3 | 10 |
| SS | 100 | 40 | 0.0 | 24.0 | 10000 | 1 | 3 | 10 |
| SS | 100 | 40 | 4.0 | 25.9 | 646 | 1 | 3 | 10 |
| SS | 100 | 40 | 7.0 | 27.5 | 49.7 | 1 | 3 | 10 |
| SS | 100 | 40 | 10.0 | 27.9 | 11 | 1 | 3 | 10 |
| SS | 100 | 40 | 0.0 | 24.1 | 10000 | 2 | 3 | 10 |
| SS | 100 | 40 | 4.0 | 26.9 | 411 | 2 | 3 | 10 |
| SS | 100 | 40 | 7.0 | 27.5 | 35.3 | 2 | 3 | 10 |
| SS | 100 | 40 | 10.0 | 27.9 | 6.39 | 2 | 3 | 10 |
| SS | 100 | 40 | 0.0 | 23.6 | 10000 | 3 | 3 | 10 |
| SS | 100 | 40 | 4.0 | 25.1 | 464 | 3 | 3 | 10 |
| SS | 100 | 40 | 7.0 | 25.5 | 42.4 | 3 | 3 | 10 |
| SS | 100 | 40 | 10.0 | 25.7 | 8.42 | 3 | 3 | 10 |
| SS | 100 | 50 | 0.0 | 24.3 | 10000 | 1 | 3 | 10 |
| SS | 100 | 50 | 4.0 | 25.3 | 411 | 1 | 3 | 10 |
| SS | 100 | 50 | 7.0 | 25.7 | 33.2 | 1 | 3 | 10 |
| SS | 100 | 50 | 10.0 | 25.9 | 1.00 | 1 | 3 | 10 |

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|---|---|---|---|---|---|---|---|---|
| SS | 100 | 50 | 0.0 | 24.1 | 10000 | 2 | 3 | 10 |
| SS | 100 | 50 | 4.0 | 25.8 | 408 | 2 | 3 | 10 |
| SS | 100 | 50 | 7.0 | 26.5 | 27.5 | 2 | 3 | 10 |
| SS | 100 | 50 | 10.0 | 27.3 | 2.65 | 2 | 3 | 10 |
| SS | 100 | 50 | 0.0 | 24.1 | 10000 | 3 | 3 | 10 |
| SS | 100 | 50 | 4.0 | 26.2 | 423 | 3 | 3 | 10 |
| SS | 100 | 50 | 7.0 | 26.8 | 27.6 | 3 | 3 | 10 |
| SS | 100 | 50 | 10.0 | 27.4 | 1.00 | 3 | 3 | 10 |
| SS | 100 | 20 | 0.0 | 25.2 | 9960 | 1 | 3 | 5 |
| SS | 100 | 20 | 2.0 | 25.7 | 1120 | 1 | 3 | 5 |
| SS | 100 | 20 | 4.0 | 25.9 | 93.1 | 1 | 3 | 5 |
| SS | 100 | 20 | 5.0 | 26.1 | 22 | 1 | 3 | 5 |
| SS | 100 | 20 | 0.0 | 25.2 | 9960 | 2 | 3 | 5 |
| SS | 100 | 20 | 2.0 | 25.5 | 1360 | 2 | 3 | 5 |
| SS | 100 | 20 | 4.0 | 25.7 | 118 | 2 | 3 | 5 |
| SS | 100 | 20 | 5.0 | 25.9 | 38.2 | 2 | 3 | 5 |
| SS | 100 | 20 | 0.0 | 25.2 | 9930 | 3 | 3 | 5 |
| SS | 100 | 20 | 2.0 | 25.4 | 1190 | 3 | 3 | 5 |
| SS | 100 | 20 | 4.0 | 25.6 | 127 | 3 | 3 | 5 |
| SS | 100 | 20 | 5.0 | 25.8 | 31.4 | 3 | 3 | 5 |
| SS | 100 | 30 | 0.0 | 25.1 | 10000 | 1 | 3 | 5 |
| SS | 100 | 30 | 2.0 | 25.7 | 937 | 1 | 3 | 5 |
| SS | 100 | 30 | 4.0 | 26.1 | 55.8 | 1 | 3 | 5 |
| SS | 100 | 30 | 5.0 | 26.2 | 21.6 | 1 | 3 | 5 |
| SS | 100 | 30 | 0.0 | 25.1 | 10000 | 2 | 3 | 5 |
| SS | 100 | 30 | 2.0 | 25.6 | 1180 | 2 | 3 | 5 |
| SS | 100 | 30 | 4.0 | 26.2 | 77.6 | 2 | 3 | 5 |
| SS | 100 | 30 | 5.0 | 26.4 | 21.6 | 2 | 3 | 5 |
| SS | 100 | 30 | 0.0 | 25.1 | 9960 | 3 | 3 | 5 |
| SS | 100 | 30 | 2.0 | 25.7 | 882 | 3 | 3 | 5 |
| SS | 100 | 30 | 4.0 | 26.1 | 79.5 | 3 | 3 | 5 |
| SS | 100 | 30 | 5.0 | 26.3 | 20.7 | 3 | 3 | 5 |
| SS | 100 | 40 | 0.0 | 24.9 | 9960 | 1 | 3 | 5 |
| SS | 100 | 40 | 2.0 | 25.8 | 1040 | 1 | 3 | 5 |
| SS | 100 | 40 | 4.0 | 26.4 | 79.8 | 1 | 3 | 5 |
| SS | 100 | 40 | 5.0 | 26.9 | 23.2 | 1 | 3 | 5 |
| SS | 100 | 40 | 0.0 | 25.0 | 9960 | 2 | 3 | 5 |
| SS | 100 | 40 | 2.0 | 26.0 | 1080 | 2 | 3 | 5 |
| SS | 100 | 40 | 4.0 | 26.2 | 85.4 | 2 | 3 | 5 |
| SS | 100 | 40 | 5.0 | 26.6 | 37.8 | 2 | 3 | 5 |
| SS | 100 | 40 | 0.0 | 25.0 | 10000 | 3 | 3 | 5 |
| SS | 100 | 40 | 2.0 | 25.7 | 911 | 3 | 3 | 5 |
| SS | 100 | 40 | 4.0 | 26.0 | 60.6 | 3 | 3 | 5 |
| SS | 100 | 40 | 5.0 | 26.1 | 24.8 | 3 | 3 | 5 |

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|---|---|---|---|---|---|---|---|---|
| SS | 100 | 50 | 0.0 | 24.7 | 10000 | 1 | 3 | 5 |
| SS | 100 | 50 | 2.0 | 25.1 | 811 | 1 | 3 | 5 |
| SS | 100 | 50 | 4.0 | 25.3 | 75.4 | 1 | 3 | 5 |
| SS | 100 | 50 | 5.0 | 25.5 | 22.5 | 1 | 3 | 5 |
| SS | 100 | 50 | 0.0 | 24.7 | 10000 | 2 | 3 | 5 |
| SS | 100 | 50 | 2.0 | 25.3 | 965 | 2 | 3 | 5 |
| SS | 100 | 50 | 4.0 | 25.8 | 71.7 | 2 | 3 | 5 |
| SS | 100 | 50 | 5.0 | 26.2 | 19.8 | 2 | 3 | 5 |
| SS | 100 | 50 | 0.0 | 24.8 | 10000 | 3 | 3 | 5 |
| SS | 100 | 50 | 2.0 | 25.6 | 1020 | 3 | 3 | 5 |
| SS | 100 | 50 | 4.0 | 25.9 | 77.6 | 3 | 3 | 5 |
| SS | 100 | 50 | 5.0 | 26.1 | 22.3 | 3 | 3 | 5 |
| SS | 100 | 20 | 0.0 | 23.4 | 9890 | 1 | 2 | 10 |
| SS | 100 | 20 | 5.0 | 25.7 | 451 | 1 | 2 | 10 |
| SS | 100 | 20 | 10.0 | 26.6 | 36.6 | 1 | 2 | 10 |
| SS | 100 | 20 | 0.0 | 24.3 | 9910 | 2 | 2 | 10 |
| SS | 100 | 20 | 5.0 | 26.7 | 445 | 2 | 2 | 10 |
| SS | 100 | 20 | 10.0 | 27.5 | 36.7 | 2 | 2 | 10 |
| SS | 100 | 20 | 0.0 | 24.2 | 9930 | 3 | 2 | 10 |
| SS | 100 | 20 | 5.0 | 26.1 | 438 | 3 | 2 | 10 |
| SS | 100 | 20 | 10.0 | 26.5 | 32.7 | 3 | 2 | 10 |
| SS | 100 | 30 | 0.0 | 24.3 | 10000 | 1 | 2 | 10 |
| SS | 100 | 30 | 5.0 | 24.7 | 430 | 1 | 2 | 10 |
| SS | 100 | 30 | 10.0 | 24.9 | 35 | 1 | 2 | 10 |
| SS | 100 | 30 | 0.0 | 23.9 | 10000 | 2 | 2 | 10 |
| SS | 100 | 30 | 5.0 | 24.9 | 483 | 2 | 2 | 10 |
| SS | 100 | 30 | 10.0 | 25.5 | 32.1 | 2 | 2 | 10 |
| SS | 100 | 30 | 0.0 | 23.1 | 10000 | 3 | 2 | 10 |
| SS | 100 | 30 | 5.0 | 23.1 | 448 | 3 | 2 | 10 |
| SS | 100 | 30 | 10.0 | 23.4 | 38.7 | 3 | 2 | 10 |
| SS | 100 | 40 | 0.0 | 23.0 | 10000 | 1 | 2 | 10 |
| SS | 100 | 40 | 5.0 | 23.8 | 604 | 1 | 2 | 10 |
| SS | 100 | 40 | 10.0 | 24.1 | 31.9 | 1 | 2 | 10 |
| SS | 100 | 40 | 0.0 | 24.2 | 10000 | 2 | 2 | 10 |
| SS | 100 | 40 | 5.0 | 25.5 | 468 | 2 | 2 | 10 |
| SS | 100 | 40 | 10.0 | 26.2 | 41.5 | 2 | 2 | 10 |
| SS | 100 | 40 | 0.0 | 24.3 | 10000 | 3 | 2 | 10 |
| SS | 100 | 40 | 5.0 | 25.3 | 307 | 3 | 2 | 10 |
| SS | 100 | 40 | 10.0 | 25.7 | 34 | 3 | 2 | 10 |
| SS | 100 | 50 | 0.0 | 24.2 | 10000 | 1 | 2 | 10 |
| SS | 100 | 50 | 5.0 | 24.5 | 463 | 1 | 2 | 10 |
| SS | 100 | 50 | 10.0 | 24.6 | 49.9 | 1 | 2 | 10 |

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|---|---|---|---|---|---|---|---|---|
| SS | 100 | 50 | 0.0 | 24.5 | 10000 | 2 | 2 | 10 |
| SS | 100 | 50 | 5.0 | 25.6 | 415 | 2 | 2 | 10 |
| SS | 100 | 50 | 10.0 | 26.2 | 36.6 | 2 | 2 | 10 |
| SS | 100 | 50 | 0.0 | 24.8 | 10000 | 3 | 2 | 10 |
| SS | 100 | 50 | 5.0 | 25.6 | 390 | 3 | 2 | 10 |
| SS | 100 | 50 | 10.0 | 25.7 | 39.3 | 3 | 2 | 10 |
| SS | 100 | 20 | 0.0 | 25.1 | 9960 | 1 | 2 | 5 |
| SS | 100 | 20 | 2.5 | 25.3 | 752 | 1 | 2 | 5 |
| SS | 100 | 20 | 5.0 | 25.2 | 76.2 | 1 | 2 | 5 |
| SS | 100 | 20 | 0.0 | 25.3 | 10000 | 2 | 2 | 5 |
| SS | 100 | 20 | 2.5 | 25.6 | 1100 | 2 | 2 | 5 |
| SS | 100 | 20 | 5.0 | 26.1 | 89.2 | 2 | 2 | 5 |
| SS | 100 | 20 | 0.0 | 25.4 | 9960 | 3 | 2 | 5 |
| SS | 100 | 20 | 2.5 | 25.8 | 898 | 3 | 2 | 5 |
| SS | 100 | 20 | 5.0 | 26.1 | 84.5 | 3 | 2 | 5 |
| SS | 100 | 30 | 0.0 | 25.3 | 9930 | 1 | 2 | 5 |
| SS | 100 | 30 | 2.5 | 25.6 | 1000 | 1 | 2 | 5 |
| SS | 100 | 30 | 5.0 | 25.6 | 98.9 | 1 | 2 | 5 |
| SS | 100 | 30 | 0.0 | 25.5 | 9930 | 2 | 2 | 5 |
| SS | 100 | 30 | 2.5 | 25.7 | 958 | 2 | 2 | 5 |
| SS | 100 | 30 | 5.0 | 26.2 | 115 | 2 | 2 | 5 |
| SS | 100 | 30 | 0.0 | 25.5 | 9960 | 3 | 2 | 5 |
| SS | 100 | 30 | 2.5 | 25.7 | 1010 | 3 | 2 | 5 |
| SS | 100 | 30 | 5.0 | 26.0 | 81.8 | 3 | 2 | 5 |
| SS | 100 | 40 | 0.0 | 25.4 | 9930 | 1 | 2 | 5 |
| SS | 100 | 40 | 2.5 | 25.6 | 1040 | 1 | 2 | 5 |
| SS | 100 | 40 | 5.0 | 26.2 | 132 | 1 | 2 | 5 |
| SS | 100 | 40 | 0.0 | 25.7 | 9930 | 2 | 2 | 5 |
| SS | 100 | 40 | 2.5 | 26.8 | 841 | 2 | 2 | 5 |
| SS | 100 | 40 | 5.0 | 27.2 | 66 | 2 | 2 | 5 |
| SS | 100 | 40 | 0.0 | 25.6 | 9900 | 3 | 2 | 5 |
| SS | 100 | 40 | 2.5 | 26.5 | 944 | 3 | 2 | 5 |
| SS | 100 | 40 | 5.0 | 26.9 | 77.8 | 3 | 2 | 5 |
| SS | 100 | 50 | 0.0 | 25.6 | 9960 | 1 | 2 | 5 |
| SS | 100 | 50 | 2.5 | 26.3 | 1000 | 1 | 2 | 5 |
| SS | 100 | 50 | 5.0 | 26.8 | 89.2 | 1 | 2 | 5 |
| SS | 100 | 50 | 0.0 | 25.4 | 9930 | 2 | 2 | 5 |
| SS | 100 | 50 | 2.5 | 26.4 | 927 | 2 | 2 | 5 |
| SS | 100 | 50 | 5.0 | 27.0 | 90.2 | 2 | 2 | 5 |
| SS | 100 | 50 | 0.0 | 25.9 | 9900 | 3 | 2 | 5 |
| SS | 100 | 50 | 2.5 | 26.5 | 1060 | 3 | 2 | 5 |
| SS | 100 | 50 | 5.0 | 27.0 | 84.5 | 3 | 2 | 5 |

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|---|---|---|---|---|---|---|---|---|
| SS | 100 | 20 | 0.0 | 25.8 | 10000 | 1 | 1 | 10 |
| SS | 100 | 20 | 10.0 | 26.3 | 306 | 1 | 1 | 10 |
| SS | 100 | 20 | 0.0 | 25.9 | 10000 | 2 | 1 | 10 |
| SS | 100 | 20 | 10.0 | 26.5 | 315 | 2 | 1 | 10 |
| SS | 100 | 20 | 0.0 | 25.9 | 10000 | 3 | 1 | 10 |
| SS | 100 | 20 | 10.0 | 26.6 | 327 | 3 | 1 | 10 |
| SS | 100 | 30 | 0.0 | 25.7 | 10000 | 1 | 1 | 10 |
| SS | 100 | 30 | 10.0 | 26.4 | 325 | 1 | 1 | 10 |
| SS | 100 | 30 | 0.0 | 25.6 | 10000 | 2 | 1 | 10 |
| SS | 100 | 30 | 10.0 | 26.6 | 331 | 2 | 1 | 10 |
| SS | 100 | 30 | 0.0 | 25.8 | 10000 | 3 | 1 | 10 |
| SS | 100 | 30 | 10.0 | 26.8 | 319 | 3 | 1 | 10 |
| SS | 100 | 40 | 0.0 | 25.9 | 10000 | 1 | 1 | 10 |
| SS | 100 | 40 | 10.0 | 26.6 | 356 | 1 | 1 | 10 |
| SS | 100 | 40 | 0.0 | 25.8 | 10000 | 2 | 1 | 10 |
| SS | 100 | 40 | 10.0 | 26.8 | 394 | 2 | 1 | 10 |
| SS | 100 | 40 | 0.0 | 25.9 | 10000 | 3 | 1 | 10 |
| SS | 100 | 40 | 10.0 | 26.5 | 358 | 3 | 1 | 10 |
| SS | 100 | 50 | 0.0 | 25.9 | 10000 | 1 | 1 | 10 |
| SS | 100 | 50 | 10.0 | 26.2 | 285 | 1 | 1 | 10 |
| SS | 100 | 50 | 0.0 | 25.9 | 10000 | 2 | 1 | 10 |
| SS | 100 | 50 | 10.0 | 26.4 | 277 | 2 | 1 | 10 |
| SS | 100 | 50 | 0.0 | 25.9 | 10000 | 3 | 1 | 10 |
| SS | 100 | 50 | 10.0 | 26.7 | 290 | 3 | 1 | 10 |
| SS | 100 | 20 | 0.0 | 23.4 | 9890 | 1 | 1 | 5 |
| SS | 100 | 20 | 5.0 | 25.7 | 451 | 1 | 1 | 5 |
| SS | 100 | 20 | 0.0 | 24.3 | 9910 | 2 | 1 | 5 |
| SS | 100 | 20 | 5.0 | 26.7 | 445 | 2 | 1 | 5 |
| SS | 100 | 20 | 0.0 | 24.2 | 9930 | 3 | 1 | 5 |
| SS | 100 | 20 | 5.0 | 26.1 | 438 | 3 | 1 | 5 |
| SS | 100 | 30 | 0.0 | 24.3 | 10000 | 1 | 1 | 5 |
| SS | 100 | 30 | 5.0 | 24.7 | 430 | 1 | 1 | 5 |
| SS | 100 | 30 | 0.0 | 23.9 | 10000 | 2 | 1 | 5 |
| SS | 100 | 30 | 5.0 | 24.9 | 483 | 2 | 1 | 5 |
| SS | 100 | 30 | 0.0 | 23.1 | 10000 | 3 | 1 | 5 |
| SS | 100 | 30 | 5.0 | 23.1 | 448 | 3 | 1 | 5 |
| SS | 100 | 40 | 0.0 | 23.0 | 10000 | 1 | 1 | 5 |
| SS | 100 | 40 | 5.0 | 23.8 | 604 | 1 | 1 | 5 |

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|---|---|---|---|---|---|---|---|---|
| SS | 100 | 40 | 0.0 | 24.2 | 10000 | 2 | 1 | 5 |
| SS | 100 | 40 | 5.0 | 25.5 | 468 | 2 | 1 | 5 |
| SS | 100 | 40 | 0.0 | 24.3 | 10000 | 3 | 1 | 5 |
| SS | 100 | 40 | 5.0 | 25.3 | 307 | 3 | 1 | 5 |
| SS | 100 | 50 | 0.0 | 24.2 | 10000 | 1 | 1 | 5 |
| SS | 100 | 50 | 5.0 | 24.5 | 463 | 1 | 1 | 5 |
| SS | 100 | 50 | 0.0 | 24.5 | 10000 | 2 | 1 | 5 |
| SS | 100 | 50 | 5.0 | 25.6 | 415 | 2 | 1 | 5 |
| SS | 100 | 50 | 0.0 | 24.8 | 10000 | 3 | 1 | 5 |
| SS | 100 | 50 | 5.0 | 25.6 | 390 | 3 | 1 | 5 |
| SS | 200 | 20 | 0.0 | 22.4 | 10000 | 1 | 3 | 10 |
| SS | 200 | 20 | 7.0 | 22.3 | 634 | 1 | 3 | 10 |
| SS | 200 | 20 | 14.0 | 22.2 | 52.2 | 1 | 3 | 10 |
| SS | 200 | 20 | 20.0 | 22.2 | 7.15 | 1 | 3 | 10 |
| SS | 200 | 20 | 0.0 | 22.4 | 10000 | 2 | 3 | 10 |
| SS | 200 | 20 | 7.0 | 22.2 | 660 | 2 | 3 | 10 |
| SS | 200 | 20 | 14.0 | 22.2 | 35 | 2 | 3 | 10 |
| SS | 200 | 20 | 20.0 | 22.1 | 9.58 | 2 | 3 | 10 |
| SS | 200 | 20 | 0.0 | 22.8 | 10000 | 3 | 3 | 10 |
| SS | 200 | 20 | 7.0 | 23.6 | 546 | 3 | 3 | 10 |
| SS | 200 | 20 | 14.0 | 24.1 | 37.5 | 3 | 3 | 10 |
| SS | 200 | 20 | 20.0 | 24.3 | 8.02 | 3 | 3 | 10 |
| SS | 200 | 30 | 0.0 | 22.9 | 10000 | 1 | 3 | 10 |
| SS | 200 | 30 | 7.0 | 23.3 | 507 | 1 | 3 | 10 |
| SS | 200 | 30 | 14.0 | 23.4 | 33.6 | 1 | 3 | 10 |
| SS | 200 | 30 | 20.0 | 23.4 | 6.02 | 1 | 3 | 10 |
| SS | 200 | 30 | 0.0 | 23.1 | 10000 | 2 | 3 | 10 |
| SS | 200 | 30 | 7.0 | 24.2 | 445 | 2 | 3 | 10 |
| SS | 200 | 30 | 14.0 | 24.6 | 47 | 2 | 3 | 10 |
| SS | 200 | 30 | 20.0 | 24.7 | 7.74 | 2 | 3 | 10 |
| SS | 200 | 30 | 0.0 | 23.0 | 10000 | 3 | 3 | 10 |
| SS | 200 | 30 | 7.0 | 22.9 | 604 | 3 | 3 | 10 |
| SS | 200 | 30 | 14.0 | 22.6 | 39.2 | 3 | 3 | 10 |
| SS | 200 | 30 | 20.0 | 22.4 | 7 | 3 | 3 | 10 |
| SS | 200 | 40 | 0.0 | 22.9 | 10000 | 1 | 3 | 10 |
| SS | 200 | 40 | 7.0 | 22.1 | 548 | 1 | 3 | 10 |
| SS | 200 | 40 | 14.0 | 21.7 | 30.3 | 1 | 3 | 10 |
| SS | 200 | 40 | 20.0 | 21.7 | 4.27 | 1 | 3 | 10 |
| SS | 200 | 40 | 0.0 | 22.9 | 10000 | 2 | 3 | 10 |
| SS | 200 | 40 | 7.0 | 21.8 | 617 | 2 | 3 | 10 |
| SS | 200 | 40 | 14.0 | 21.4 | 40.6 | 2 | 3 | 10 |
| SS | 200 | 40 | 20.0 | 21.4 | 6.1 | 2 | 3 | 10 |

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|---|---|---|---|---|---|---|---|---|
| SS | 200 | 40 | 0.0 | 23.2 | 10000 | 3 | 3 | 10 |
| SS | 200 | 40 | 7.0 | 21.9 | 643 | 3 | 3 | 10 |
| SS | 200 | 40 | 14.0 | 21.6 | 32.7 | 3 | 3 | 10 |
| SS | 200 | 40 | 20.0 | 21.7 | 6.72 | 3 | 3 | 10 |
| SS | 200 | 50 | 0.0 | 23.3 | 10000 | 1 | 3 | 10 |
| SS | 200 | 50 | 7.0 | 21.8 | 619 | 1 | 3 | 10 |
| SS | 200 | 50 | 14.0 | 21.6 | 35.4 | 1 | 3 | 10 |
| SS | 200 | 50 | 20.0 | 21.5 | 6.23 | 1 | 3 | 10 |
| SS | 200 | 50 | 0.0 | 22.8 | 10000 | 2 | 3 | 10 |
| SS | 200 | 50 | 7.0 | 21.9 | 754 | 2 | 3 | 10 |
| SS | 200 | 50 | 14.0 | 21.5 | 35.4 | 2 | 3 | 10 |
| SS | 200 | 50 | 20.0 | 21.4 | 8.82 | 2 | 3 | 10 |
| SS | 200 | 50 | 0.0 | 23.6 | 10000 | 3 | 3 | 10 |
| SS | 200 | 50 | 7.0 | 21.7 | 695 | 3 | 3 | 10 |
| SS | 200 | 50 | 14.0 | 21.3 | 56.2 | 3 | 3 | 10 |
| SS | 200 | 50 | 20.0 | 21.3 | 8.43 | 3 | 3 | 10 |
| SS | 200 | 20 | 0.0 | 26.2 | 10000 | 1 | 3 | 5 |
| SS | 200 | 20 | 4.0 | 24.7 | 971 | 1 | 3 | 5 |
| SS | 200 | 20 | 7.0 | 24.3 | 113 | 1 | 3 | 5 |
| SS | 200 | 20 | 10.0 | 24.4 | 17.9 | 1 | 3 | 5 |
| SS | 200 | 20 | 0.0 | 26.0 | 10000 | 2 | 3 | 5 |
| SS | 200 | 20 | 4.0 | 23.8 | 863 | 2 | 3 | 5 |
| SS | 200 | 20 | 7.0 | 23.2 | 86.8 | 2 | 3 | 5 |
| SS | 200 | 20 | 10.0 | 23.1 | 14.2 | 2 | 3 | 5 |
| SS | 200 | 20 | 0.0 | 26.1 | 10000 | 3 | 3 | 5 |
| SS | 200 | 20 | 4.0 | 23.2 | 807 | 3 | 3 | 5 |
| SS | 200 | 20 | 7.0 | 22.8 | 102 | 3 | 3 | 5 |
| SS | 200 | 20 | 10.0 | 22.6 | 13.8 | 3 | 3 | 5 |
| SS | 200 | 30 | 0.0 | 26.4 | 10000 | 1 | 3 | 5 |
| SS | 200 | 30 | 4.0 | 24.6 | 863 | 1 | 3 | 5 |
| SS | 200 | 30 | 7.0 | 24.5 | 81.5 | 1 | 3 | 5 |
| SS | 200 | 30 | 10.0 | 24.4 | 10.9 | 1 | 3 | 5 |
| SS | 200 | 30 | 0.0 | 26.4 | 10000 | 2 | 3 | 5 |
| SS | 200 | 30 | 4.0 | 23.9 | 739 | 2 | 3 | 5 |
| SS | 200 | 30 | 7.0 | 23.6 | 96 | 2 | 3 | 5 |
| SS | 200 | 30 | 10.0 | 23.3 | 10.9 | 2 | 3 | 5 |
| SS | 200 | 30 | 0.0 | 27.3 | 10000 | 3 | 3 | 5 |
| SS | 200 | 30 | 4.0 | 22.8 | 908 | 3 | 3 | 5 |
| SS | 200 | 30 | 7.0 | 22.3 | 112 | 3 | 3 | 5 |
| SS | 200 | 30 | 10.0 | 22.3 | 17.0 | 3 | 3 | 5 |
| SS | 200 | 40 | 0.0 | 26.0 | 10000 | 1 | 3 | 5 |
| SS | 200 | 40 | 4.0 | 23.2 | 807 | 1 | 3 | 5 |
| SS | 200 | 40 | 7.0 | 23.0 | 92.2 | 1 | 3 | 5 |
| SS | 200 | 40 | 10.0 | 22.7 | 14.2 | 1 | 3 | 5 |

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|---|---|---|---|---|---|---|---|---|
| SS | 200 | 40 | 0.0 | 26.5 | 10000 | 2 | 3 | 5 |
| SS | 200 | 40 | 4.0 | 24.0 | 784 | 2 | 3 | 5 |
| SS | 200 | 40 | 7.0 | 23.9 | 96.7 | 2 | 3 | 5 |
| SS | 200 | 40 | 10.0 | 23.7 | 16.1 | 2 | 3 | 5 |
| SS | 200 | 40 | 0.0 | 26.6 | 10000 | 3 | 3 | 5 |
| SS | 200 | 40 | 4.0 | 24.8 | 902 | 3 | 3 | 5 |
| SS | 200 | 40 | 7.0 | 24.9 | 105 | 3 | 3 | 5 |
| SS | 200 | 40 | 10.0 | 24.8 | 12.1 | 3 | 3 | 5 |
| SS | 200 | 50 | 0.0 | 26.6 | 10000 | 1 | 3 | 5 |
| SS | 200 | 50 | 4.0 | 24.8 | 1040 | 1 | 3 | 5 |
| SS | 200 | 50 | 7.0 | 24.5 | 79.4 | 1 | 3 | 5 |
| SS | 200 | 50 | 10.0 | 24.4 | 17.0 | 1 | 3 | 5 |
| SS | 200 | 50 | 0.0 | 26.8 | 10000 | 2 | 3 | 5 |
| SS | 200 | 50 | 4.0 | 25.5 | 1090 | 2 | 3 | 5 |
| SS | 200 | 50 | 7.0 | 25.6 | 64.5 | 2 | 3 | 5 |
| SS | 200 | 50 | 10.0 | 25.7 | 13.4 | 2 | 3 | 5 |
| SS | 200 | 50 | 0.0 | 26.9 | 10000 | 3 | 3 | 5 |
| SS | 200 | 50 | 4.0 | 24.9 | 1010 | 3 | 3 | 5 |
| SS | 200 | 50 | 7.0 | 24.8 | 63.1 | 3 | 3 | 5 |
| SS | 200 | 50 | 10.0 | 24.7 | 17.0 | 3 | 3 | 5 |
| SS | 200 | 20 | 0.0 | 21.8 | 10000 | 1 | 2 | 10 |
| SS | 200 | 20 | 10.0 | 23.5 | 475 | 1 | 2 | 10 |
| SS | 200 | 20 | 20.0 | 24.3 | 30.0 | 1 | 2 | 10 |
| SS | 200 | 20 | 0.0 | 22.2 | 10000 | 2 | 2 | 10 |
| SS | 200 | 20 | 10.0 | 24.1 | 507 | 2 | 2 | 10 |
| SS | 200 | 20 | 20.0 | 24.6 | 26.5 | 2 | 2 | 10 |
| SS | 200 | 20 | 0.0 | 22.4 | 10000 | 3 | 2 | 10 |
| SS | 200 | 20 | 10.0 | 24.9 | 371 | 3 | 2 | 10 |
| SS | 200 | 20 | 20.0 | 25.4 | 19.4 | 3 | 2 | 10 |
| SS | 200 | 30 | 0.0 | 22.2 | 10000 | 1 | 2 | 10 |
| SS | 200 | 30 | 10.0 | 20.8 | 370 | 1 | 2 | 10 |
| SS | 200 | 30 | 20.0 | 20.6 | 21.4 | 1 | 2 | 10 |
| SS | 200 | 30 | 0.0 | 22.3 | 10000 | 2 | 2 | 10 |
| SS | 200 | 30 | 10.0 | 21.6 | 509 | 2 | 2 | 10 |
| SS | 200 | 30 | 20.0 | 21.7 | 26.3 | 2 | 2 | 10 |
| SS | 200 | 30 | 0.0 | 22.3 | 10000 | 3 | 2 | 10 |
| SS | 200 | 30 | 10.0 | 20.9 | 385 | 3 | 2 | 10 |
| SS | 200 | 30 | 20.0 | 20.6 | 20.8 | 3 | 2 | 10 |
| SS | 200 | 40 | 0.0 | 22.2 | 10000 | 1 | 2 | 10 |
| SS | 200 | 40 | 10.0 | 20.4 | 579 | 1 | 2 | 10 |
| SS | 200 | 40 | 20.0 | 20.0 | 29.2 | 1 | 2 | 10 |
| SS | 200 | 40 | 0.0 | 22.2 | 10000 | 2 | 2 | 10 |
| SS | 200 | 40 | 10.0 | 19.5 | 568 | 2 | 2 | 10 |
| SS | 200 | 40 | 20.0 | 18.7 | 27.5 | 2 | 2 | 10 |

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|---|---|---|---|---|---|---|---|---|
| SS | 200 | 40 | 0.0 | 22.4 | 10000 | 3 | 2 | 10 |
| SS | 200 | 40 | 10.0 | 20.2 | 549 | 3 | 2 | 10 |
| SS | 200 | 40 | 20.0 | 19.7 | 28.7 | 3 | 2 | 10 |
| SS | 200 | 40 | 0.0 | 23.3 | 10000 | 1 | 2 | 10 |
| SS | 200 | 40 | 10.0 | 24.0 | 487 | 1 | 2 | 10 |
| SS | 200 | 40 | 20.0 | 24.3 | 21.6 | 1 | 2 | 10 |
| SS | 200 | 40 | 0.0 | 23.2 | 10000 | 2 | 2 | 10 |
| SS | 200 | 40 | 10.0 | 21.9 | 410 | 2 | 2 | 10 |
| SS | 200 | 40 | 20.0 | 21.6 | 23.0 | 2 | 2 | 10 |
| SS | 200 | 40 | 0.0 | 23.1 | 10000 | 3 | 2 | 10 |
| SS | 200 | 40 | 10.0 | 21.4 | 410 | 3 | 2 | 10 |
| SS | 200 | 40 | 20.0 | 21.1 | 27.5 | 3 | 2 | 10 |
| SS | 200 | 50 | 0.0 | 22.8 | 10000 | 1 | 2 | 10 |
| SS | 200 | 50 | 10.0 | 24.2 | 487 | 1 | 2 | 10 |
| SS | 200 | 50 | 20.0 | 24.7 | 25.7 | 1 | 2 | 10 |
| SS | 200 | 50 | 0.0 | 23.2 | 10000 | 2 | 2 | 10 |
| SS | 200 | 50 | 10.0 | 24.8 | 503 | 2 | 2 | 10 |
| SS | 200 | 50 | 20.0 | 25.3 | 28.8 | 2 | 2 | 10 |
| SS | 200 | 50 | 0.0 | 22.8 | 10000 | 3 | 2 | 10 |
| SS | 200 | 50 | 10.0 | 21.6 | 445 | 3 | 2 | 10 |
| SS | 200 | 50 | 20.0 | 21.1 | 30.8 | 3 | 2 | 10 |
| SS | 200 | 50 | 0.0 | 23.2 | 10000 | 4 | 2 | 10 |
| SS | 200 | 50 | 10.0 | 24.7 | 406 | 4 | 2 | 10 |
| SS | 200 | 50 | 20.0 | 25.0 | 25.3 | 4 | 2 | 10 |
| SS | 200 | 50 | 0.0 | 22.9 | 10000 | 5 | 2 | 10 |
| SS | 200 | 50 | 10.0 | 24.5 | 461 | 5 | 2 | 10 |
| SS | 200 | 50 | 20.0 | 25.1 | 27.6 | 5 | 2 | 10 |
| SS | 200 | 50 | 0.0 | 23.2 | 10000 | 6 | 2 | 10 |
| SS | 200 | 50 | 10.0 | 23.7 | 487 | 6 | 2 | 10 |
| SS | 200 | 50 | 20.0 | 23.7 | 18.3 | 6 | 2 | 10 |
| SS | 200 | 20 | 0.0 | 25.6 | 10000 | 1 | 2 | 5 |
| SS | 200 | 20 | 5.0 | 26.5 | 902 | 1 | 2 | 5 |
| SS | 200 | 20 | 10.0 | 27.1 | 61.6 | 1 | 2 | 5 |
| SS | 200 | 20 | 0.0 | 26.3 | 10000 | 2 | 2 | 5 |
| SS | 200 | 20 | 5.0 | 25.8 | 831 | 2 | 2 | 5 |
| SS | 200 | 20 | 10.0 | 25.5 | 65.2 | 2 | 2 | 5 |
| SS | 200 | 20 | 0.0 | 26.3 | 10000 | 3 | 2 | 5 |
| SS | 200 | 20 | 5.0 | 26.0 | 591 | 3 | 2 | 5 |
| SS | 200 | 20 | 10.0 | 26.4 | 50.0 | 3 | 2 | 5 |
| SS | 200 | 30 | 0.0 | 26.5 | 10000 | 1 | 2 | 5 |
| SS | 200 | 30 | 5.0 | 25.5 | 675 | 1 | 2 | 5 |
| SS | 200 | 30 | 10.0 | 25.4 | 48.5 | 1 | 2 | 5 |

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|---|---|---|---|---|---|---|---|---|
| SS | 200 | 30 | 0.0 | 26.4 | 10000 | 2 | 2 | 5 |
| SS | 200 | 30 | 5.0 | 25.1 | 574 | 2 | 2 | 5 |
| SS | 200 | 30 | 10.0 | 24.9 | 43.1 | 2 | 2 | 5 |
| SS | 200 | 30 | 0.0 | 26.3 | 10000 | 3 | 2 | 5 |
| SS | 200 | 30 | 5.0 | 25.7 | 837 | 3 | 2 | 5 |
| SS | 200 | 30 | 10.0 | 25.8 | 38.1 | 3 | 2 | 5 |
| SS | 200 | 40 | 0.0 | 21.5 | 10000 | 1 | 2 | 5 |
| SS | 200 | 40 | 5.0 | 21.6 | 652 | 1 | 2 | 5 |
| SS | 200 | 40 | 10.0 | 21.7 | 31.5 | 1 | 2 | 5 |
| SS | 200 | 40 | 0.0 | 21.8 | 10000 | 2 | 2 | 5 |
| SS | 200 | 40 | 5.0 | 21.4 | 657 | 2 | 2 | 5 |
| SS | 200 | 40 | 10.0 | 21.4 | 34.1 | 2 | 2 | 5 |
| SS | 200 | 40 | 0.0 | 21.7 | 10000 | 3 | 2 | 5 |
| SS | 200 | 40 | 5.0 | 21.2 | 562 | 3 | 2 | 5 |
| SS | 200 | 40 | 10.0 | 21.2 | 40.9 | 3 | 2 | 5 |
| SS | 200 | 50 | 0.0 | 21.7 | 10000 | 1 | 2 | 5 |
| SS | 200 | 50 | 5.0 | 23.1 | 611 | 1 | 2 | 5 |
| SS | 200 | 50 | 10.0 | 23.7 | 35.0 | 1 | 2 | 5 |
| SS | 200 | 50 | 0.0 | 21.9 | 10000 | 2 | 2 | 5 |
| SS | 200 | 50 | 5.0 | 22.1 | 657 | 2 | 2 | 5 |
| SS | 200 | 50 | 10.0 | 22.1 | 32.6 | 2 | 2 | 5 |
| SS | 200 | 50 | 0.0 | 21.9 | 10000 | 3 | 2 | 5 |
| SS | 200 | 50 | 5.0 | 22.8 | 524 | 3 | 2 | 5 |
| SS | 200 | 50 | 10.0 | 23.4 | 32.4 | 3 | 2 | 5 |
| SS | 200 | 20 | 0.0 | 23.9 | 10000 | 1 | 1 | 10 |
| SS | 200 | 20 | 20.0 | 21.9 | 292 | 1 | 1 | 10 |
| SS | 200 | 20 | 0.0 | 23.9 | 10000 | 2 | 1 | 10 |
| SS | 200 | 20 | 20.0 | 22.0 | 267 | 2 | 1 | 10 |
| SS | 200 | 20 | 0.0 | 23.9 | 10000 | 3 | 1 | 10 |
| SS | 200 | 20 | 20.0 | 21.1 | 294 | 3 | 1 | 10 |
| SS | 200 | 30 | 0.0 | 24.0 | 10000 | 1 | 1 | 10 |
| SS | 200 | 30 | 20.0 | 22.8 | 312 | 1 | 1 | 10 |
| SS | 200 | 30 | 0.0 | 24.2 | 10000 | 2 | 1 | 10 |
| SS | 200 | 30 | 20.0 | 23.3 | 315 | 2 | 1 | 10 |
| SS | 200 | 30 | 0.0 | 24.2 | 10000 | 3 | 1 | 10 |
| SS | 200 | 30 | 20.0 | 23.0 | 275 | 3 | 1 | 10 |
| SS | 200 | 40 | 0.0 | 24.2 | 10000 | 1 | 1 | 10 |
| SS | 200 | 40 | 20.0 | 21.4 | 385 | 1 | 1 | 10 |
| SS | 200 | 40 | 0.0 | 24.2 | 10000 | 2 | 1 | 10 |
| SS | 200 | 40 | 20.0 | 20.9 | 360 | 2 | 1 | 10 |

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|---|---|---|---|---|---|---|---|---|
| SS | 200 | 40 | 0.0 | 24.2 | 10000 | 3 | 1 | 10 |
| SS | 200 | 40 | 20.0 | 20.5 | 355 | 3 | 1 | 10 |
| SS | 200 | 50 | 0.0 | 24.2 | 10000 | 1 | 1 | 10 |
| SS | 200 | 50 | 20.0 | 24.7 | 235 | 1 | 1 | 10 |
| SS | 200 | 50 | 0.0 | 24.2 | 10000 | 2 | 1 | 10 |
| SS | 200 | 50 | 20.0 | 20.6 | 260 | 2 | 1 | 10 |
| SS | 200 | 50 | 0.0 | 24.2 | 10000 | 3 | 1 | 10 |
| SS | 200 | 50 | 20.0 | 21.6 | 223 | 3 | 1 | 10 |
| SS | 200 | 20 | 0.0 | 21.8 | 10000 | 1 | 1 | 5 |
| SS | 200 | 20 | 10.0 | 23.5 | 475 | 1 | 1 | 5 |
| SS | 200 | 20 | 0.0 | 22.2 | 10000 | 2 | 1 | 5 |
| SS | 200 | 20 | 10.0 | 24.1 | 507 | 2 | 1 | 5 |
| SS | 200 | 20 | 0.0 | 22.4 | 10000 | 3 | 1 | 5 |
| SS | 200 | 20 | 10.0 | 24.9 | 371 | 3 | 1 | 5 |
| SS | 200 | 30 | 0.0 | 22.2 | 10000 | 1 | 1 | 5 |
| SS | 200 | 30 | 10.0 | 20.8 | 370 | 1 | 1 | 5 |
| SS | 200 | 30 | 0.0 | 22.3 | 10000 | 2 | 1 | 5 |
| SS | 200 | 30 | 10.0 | 20.9 | 385 | 2 | 1 | 5 |
| SS | 200 | 30 | 0.0 | 22.3 | 10000 | 3 | 1 | 5 |
| SS | 200 | 30 | 10.0 | 21.6 | 509 | 3 | 1 | 5 |
| SS | 200 | 40 | 0.0 | 22.2 | 10000 | 1 | 1 | 5 |
| SS | 200 | 40 | 10.0 | 20.4 | 579 | 1 | 1 | 5 |
| SS | 200 | 40 | 0.0 | 22.2 | 10000 | 2 | 1 | 5 |
| SS | 200 | 40 | 10.0 | 19.5 | 568 | 2 | 1 | 5 |
| SS | 200 | 40 | 0.0 | 22.4 | 10000 | 3 | 1 | 5 |
| SS | 200 | 40 | 10.0 | 20.2 | 549 | 3 | 1 | 5 |
| SS | 200 | 50 | 0.0 | 22.8 | 10000 | 1 | 1 | 5 |
| SS | 200 | 50 | 10.0 | 24.2 | 487 | 1 | 1 | 5 |
| SS | 200 | 50 | 0.0 | 23.2 | 10000 | 2 | 1 | 5 |
| SS | 200 | 50 | 10.0 | 24.8 | 503 | 2 | 1 | 5 |
| SS | 200 | 50 | 0.0 | 22.8 | 10000 | 3 | 1 | 5 |
| SS | 200 | 50 | 10.0 | 21.6 | 445 | 3 | 1 | 5 |
| SS | 300C | 20 | 0.0 | 29.1 | 10000 | 1 | 3 | 10 |
| SS | 300C | 20 | 10.0 | 29.2 | 670 | 1 | 3 | 10 |
| SS | 300C | 20 | 20.0 | 29.4 | 24.2 | 1 | 3 | 10 |
| SS | 300C | 20 | 30.0 | 29.8 | 3.26 | 1 | 3 | 10 |
| SS | 300C | 20 | 0.0 | 29.5 | 10000 | 2 | 3 | 10 |
| SS | 300C | 20 | 10.0 | 29.6 | 546 | 2 | 3 | 10 |
| SS | 300C | 20 | 20.0 | 29.5 | 33.1 | 2 | 3 | 10 |
| SS | 300C | 20 | 30.0 | 29.7 | 1.37 | 2 | 3 | 10 |

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|---|---|---|---|---|---|---|---|---|
| SS | 300C | 20 | 0.0 | 28.2 | 10000 | 3 | 3 | 10 |
| SS | 300C | 20 | 10.0 | 28.4 | 538 | 3 | 3 | 10 |
| SS | 300C | 20 | 20.0 | 28.5 | 30.3 | 3 | 3 | 10 |
| SS | 300C | 20 | 30.0 | 28.3 | 3.83 | 3 | 3 | 10 |
| SS | 300C | 30 | 0.0 | 28.5 | 10000 | 1 | 3 | 10 |
| SS | 300C | 30 | 10.0 | 29.7 | 563 | 1 | 3 | 10 |
| SS | 300C | 30 | 20.0 | 30.0 | 27.2 | 1 | 3 | 10 |
| SS | 300C | 30 | 30.0 | 30.1 | 1.51 | 1 | 3 | 10 |
| SS | 300C | 30 | 0.0 | 28.9 | 10000 | 2 | 3 | 10 |
| SS | 300C | 30 | 10.0 | 29.5 | 530 | 2 | 3 | 10 |
| SS | 300C | 30 | 20.0 | 29.9 | 42.5 | 2 | 3 | 10 |
| SS | 300C | 30 | 30.0 | 30.0 | 1.91 | 2 | 3 | 10 |
| SS | 300C | 30 | 0.0 | 28.9 | 10000 | 3 | 3 | 10 |
| SS | 300C | 30 | 10.0 | 29.5 | 349 | 3 | 3 | 10 |
| SS | 300C | 30 | 20.0 | 29.9 | 22.1 | 3 | 3 | 10 |
| SS | 300C | 30 | 30.0 | 30.0 | 1.75 | 3 | 3 | 10 |
| SS | 300C | 40 | 0.0 | 30.2 | 10000 | 1 | 3 | 10 |
| SS | 300C | 40 | 10.0 | 29.6 | 366 | 1 | 3 | 10 |
| SS | 300C | 40 | 20.0 | 29.8 | 16.8 | 1 | 3 | 10 |
| SS | 300C | 40 | 30.0 | 29.9 | 1.44 | 1 | 3 | 10 |
| SS | 300C | 40 | 0.0 | 30.2 | 10000 | 2 | 3 | 10 |
| SS | 300C | 40 | 10.0 | 28.8 | 423 | 2 | 3 | 10 |
| SS | 300C | 40 | 20.0 | 29.0 | 21.0 | 2 | 3 | 10 |
| SS | 300C | 40 | 30.0 | 29.2 | 1.89 | 2 | 3 | 10 |
| SS | 300C | 40 | 0.0 | 30.2 | 10000 | 3 | 3 | 10 |
| SS | 300C | 40 | 10.0 | 28.7 | 525 | 3 | 3 | 10 |
| SS | 300C | 40 | 20.0 | 28.6 | 17.6 | 3 | 3 | 10 |
| SS | 300C | 40 | 30.0 | 28.6 | 1.81 | 3 | 3 | 10 |
| SS | 300C | 50 | 0.0 | 30.3 | 10000 | 1 | 3 | 10 |
| SS | 300C | 50 | 10.0 | 29.3 | 376 | 1 | 3 | 10 |
| SS | 300C | 50 | 20.0 | 30.0 | 14.5 | 1 | 3 | 10 |
| SS | 300C | 50 | 30.0 | 30.1 | 1.75 | 1 | 3 | 10 |
| SS | 300C | 50 | 0.0 | 30.3 | 10000 | 2 | 3 | 10 |
| SS | 300C | 50 | 10.0 | 29.8 | 333 | 2 | 3 | 10 |
| SS | 300C | 50 | 20.0 | 30.1 | 14.2 | 2 | 3 | 10 |
| SS | 300C | 50 | 30.0 | 30.6 | 1.51 | 2 | 3 | 10 |
| SS | 300C | 50 | 0.0 | 30.4 | 10000 | 3 | 3 | 10 |
| SS | 300C | 50 | 10.0 | 29.5 | 390 | 3 | 3 | 10 |
| SS | 300C | 50 | 20.0 | 29.7 | 14.2 | 3 | 3 | 10 |
| SS | 300C | 50 | 30.0 | 29.9 | 1.44 | 3 | 3 | 10 |
| SS | 300C | 20 | 0.0 | 27.7 | 10000 | 1 | 3 | 5 |
| SS | 300C | 20 | 5.0 | 27.3 | 1250 | 1 | 3 | 5 |
| SS | 300C | 20 | 10.0 | 27.2 | 65.7 | 1 | 3 | 5 |
| SS | 300C | 20 | 15.0 | 27.5 | 20.9 | 1 | 3 | 5 |

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|---|---|---|---|---|---|---|---|---|
| SS | 300C | 20 | 0.0 | 28.0 | 10000 | 2 | 3 | 5 |
| SS | 300C | 20 | 5.0 | 27.5 | 1120 | 2 | 3 | 5 |
| SS | 300C | 20 | 10.0 | 26.8 | 93.1 | 2 | 3 | 5 |
| SS | 300C | 20 | 15.0 | 26.5 | 17.6 | 2 | 3 | 5 |
| SS | 300C | 20 | 0.0 | 27.0 | 10000 | 3 | 3 | 5 |
| SS | 300C | 20 | 5.0 | 28.3 | 947 | 3 | 3 | 5 |
| SS | 300C | 20 | 10.0 | 28.8 | 52.8 | 3 | 3 | 5 |
| SS | 300C | 20 | 15.0 | 28.9 | 17.2 | 3 | 3 | 5 |
| SS | 300C | 30 | 0.0 | 28.9 | 10000 | 1 | 3 | 5 |
| SS | 300C | 30 | 5.0 | 28.3 | 1110 | 1 | 3 | 5 |
| SS | 300C | 30 | 10.0 | 28.1 | 62.1 | 1 | 3 | 5 |
| SS | 300C | 30 | 15.0 | 28.0 | 6.58 | 1 | 3 | 5 |
| SS | 300C | 30 | 0.0 | 29.1 | 10000 | 2 | 3 | 5 |
| SS | 300C | 30 | 5.0 | 28.0 | 1120 | 2 | 3 | 5 |
| SS | 300C | 30 | 10.0 | 27.5 | 58.1 | 2 | 3 | 5 |
| SS | 300C | 30 | 15.0 | 27.4 | 6.28 | 2 | 3 | 5 |
| SS | 300C | 30 | 0.0 | 28.6 | 10000 | 3 | 3 | 5 |
| SS | 300C | 30 | 5.0 | 27.9 | 957 | 3 | 3 | 5 |
| SS | 300C | 30 | 10.0 | 27.8 | 64.7 | 3 | 3 | 5 |
| SS | 300C | 30 | 15.0 | 27.8 | 6.44 | 3 | 3 | 5 |
| SS | 300C | 40 | 0.0 | 28.3 | 10000 | 1 | 3 | 5 |
| SS | 300C | 40 | 5.0 | 28.0 | 1150 | 1 | 3 | 5 |
| SS | 300C | 40 | 10.0 | 27.8 | 70.3 | 1 | 3 | 5 |
| SS | 300C | 40 | 15.0 | 27.7 | 6.03 | 1 | 3 | 5 |
| SS | 300C | 40 | 0.0 | 28.3 | 10000 | 2 | 3 | 5 |
| SS | 300C | 40 | 5.0 | 28.3 | 871 | 2 | 3 | 5 |
| SS | 300C | 40 | 10.0 | 28.5 | 48.7 | 2 | 3 | 5 |
| SS | 300C | 40 | 15.0 | 28.7 | 4.3 | 2 | 3 | 5 |
| SS | 300C | 40 | 0.0 | 28.3 | 10000 | 3 | 3 | 5 |
| SS | 300C | 40 | 5.0 | 28.3 | 933 | 3 | 3 | 5 |
| SS | 300C | 40 | 10.0 | 28.3 | 60.3 | 3 | 3 | 5 |
| SS | 300C | 40 | 15.0 | 28.3 | 4.03 | 3 | 3 | 5 |
| SS | 300C | 50 | 0.0 | 28.4 | 10000 | 1 | 3 | 5 |
| SS | 300C | 50 | 5.0 | 28.3 | 742 | 1 | 3 | 5 |
| SS | 300C | 50 | 10.0 | 28.5 | 45.8 | 1 | 3 | 5 |
| SS | 300C | 50 | 15.0 | 28.5 | 2.58 | 1 | 3 | 5 |
| SS | 300C | 50 | 0.0 | 28.4 | 10000 | 2 | 3 | 5 |
| SS | 300C | 50 | 5.0 | 28.5 | 809 | 2 | 3 | 5 |
| SS | 300C | 50 | 10.0 | 28.6 | 43.1 | 2 | 3 | 5 |
| SS | 300C | 50 | 15.0 | 28.6 | 2.35 | 2 | 3 | 5 |
| SS | 300C | 50 | 0.0 | 28.5 | 10000 | 3 | 3 | 5 |
| SS | 300C | 50 | 5.0 | 28.3 | 702 | 3 | 3 | 5 |
| SS | 300C | 50 | 10.0 | 28.1 | 42.4 | 3 | 3 | 5 |
| SS | 300C | 50 | 15.0 | 28.1 | 2.30 | 3 | 3 | 5 |

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|---|---|---|---|---|---|---|---|---|
| SS | 300C | 20 | 0.0 | 27.2 | 10000 | 1 | 2 | 10 |
| SS | 300C | 20 | 15.0 | 29.4 | 415 | 1 | 2 | 10 |
| SS | 300C | 20 | 30.0 | 30.5 | 12.6 | 1 | 2 | 10 |
| SS | 300C | 20 | 0.0 | 28.0 | 10000 | 2 | 2 | 10 |
| SS | 300C | 20 | 15.0 | 28.9 | 384 | 2 | 2 | 10 |
| SS | 300C | 20 | 30.0 | 28.5 | 16.7 | 2 | 2 | 10 |
| SS | 300C | 20 | 0.0 | 27.8 | 10000 | 3 | 2 | 10 |
| SS | 300C | 20 | 15.0 | 27.8 | 390 | 3 | 2 | 10 |
| SS | 300C | 20 | 30.0 | 27.2 | 14.5 | 3 | 2 | 10 |
| SS | 300C | 30 | 0.0 | 27.6 | 10000 | 1 | 2 | 10 |
| SS | 300C | 30 | 15.0 | 26.9 | 306 | 1 | 2 | 10 |
| SS | 300C | 30 | 30.0 | 26.3 | 3.93 | 1 | 2 | 10 |
| SS | 300C | 30 | 0.0 | 27.7 | 10000 | 2 | 2 | 10 |
| SS | 300C | 30 | 15.0 | 26.3 | 250 | 2 | 2 | 10 |
| SS | 300C | 30 | 30.0 | 26.0 | 7.92 | 2 | 2 | 10 |
| SS | 300C | 30 | 0.0 | 27.7 | 10000 | 3 | 2 | 10 |
| SS | 300C | 30 | 15.0 | 26.1 | 230 | 3 | 2 | 10 |
| SS | 300C | 30 | 30.0 | 26.3 | 3.58 | 3 | 2 | 10 |
| SS | 300C | 40 | 0.0 | 28.3 | 10000 | 1 | 2 | 10 |
| SS | 300C | 40 | 15.0 | 26.7 | 344 | 1 | 2 | 10 |
| SS | 300C | 40 | 30.0 | 26.2 | 7.92 | 1 | 2 | 10 |
| SS | 300C | 40 | 0.0 | 28.2 | 10000 | 2 | 2 | 10 |
| SS | 300C | 40 | 15.0 | 27.3 | 326 | 2 | 2 | 10 |
| SS | 300C | 40 | 30.0 | 28.5 | 8.48 | 2 | 2 | 10 |
| SS | 300C | 40 | 0.0 | 28.6 | 10000 | 3 | 2 | 10 |
| SS | 300C | 40 | 15.0 | 28.0 | 291 | 3 | 2 | 10 |
| SS | 300C | 40 | 30.0 | 27.6 | 7.22 | 3 | 2 | 10 |
| SS | 300C | 50 | 0.0 | 28.2 | 10000 | 1 | 2 | 10 |
| SS | 300C | 50 | 15.0 | 27.2 | 371 | 1 | 2 | 10 |
| SS | 300C | 50 | 30.0 | 26.9 | 11.3 | 1 | 2 | 10 |
| SS | 300C | 50 | 0.0 | 28.3 | 10000 | 2 | 2 | 10 |
| SS | 300C | 50 | 15.0 | 27.3 | 368 | 2 | 2 | 10 |
| SS | 300C | 50 | 30.0 | 27.2 | 14.2 | 2 | 2 | 10 |
| SS | 300C | 50 | 0.0 | 28.5 | 10000 | 3 | 2 | 10 |
| SS | 300C | 50 | 15.0 | 27.2 | 340 | 3 | 2 | 10 |
| SS | 300C | 50 | 30.0 | 27.0 | 8.38 | 3 | 2 | 10 |
| SS | 300C | 20 | 0.0 | 27.7 | 10000 | 1 | 2 | 5 |
| SS | 300C | 20 | 7.5 | 26.5 | 509 | 1 | 2 | 5 |
| SS | 300C | 20 | 15.0 | 26.2 | 29.5 | 1 | 2 | 5 |
| SS | 300C | 20 | 0.0 | 27.7 | 10000 | 2 | 2 | 5 |
| SS | 300C | 20 | 7.5 | 28.0 | 384 | 2 | 2 | 5 |
| SS | 300C | 20 | 15.0 | 28.3 | 29.2 | 2 | 2 | 5 |

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|---|---|---|---|---|---|---|---|---|
| SS | 300C | 20 | 0.0 | 26.8 | 10000 | 3 | 2 | 5 |
| SS | 300C | 20 | 7.5 | 26.2 | 480 | 3 | 2 | 5 |
| SS | 300C | 20 | 15.0 | 26.2 | 36.5 | 3 | 2 | 5 |
| SS | 300C | 30 | 0.0 | 28.0 | 10000 | 1 | 2 | 5 |
| SS | 300C | 30 | 7.5 | 27.6 | 269 | 1 | 2 | 5 |
| SS | 300C | 30 | 15.0 | 27.4 | 26.8 | 1 | 2 | 5 |
| SS | 300C | 30 | 0.0 | 28.2 | 10000 | 2 | 2 | 5 |
| SS | 300C | 30 | 7.5 | 27.7 | 518 | 2 | 2 | 5 |
| SS | 300C | 30 | 15.0 | 27.6 | 25.4 | 2 | 2 | 5 |
| SS | 300C | 30 | 0.0 | 28.5 | 10000 | 3 | 2 | 5 |
| SS | 300C | 30 | 7.5 | 29.4 | 346 | 3 | 2 | 5 |
| SS | 300C | 30 | 15.0 | 29.9 | 22.8 | 3 | 2 | 5 |
| SS | 300C | 40 | 0.0 | 28.8 | 10000 | 1 | 2 | 5 |
| SS | 300C | 40 | 7.5 | 28.1 | 380 | 1 | 2 | 5 |
| SS | 300C | 40 | 15.0 | 27.8 | 23.8 | 1 | 2 | 5 |
| SS | 300C | 40 | 0.0 | 28.1 | 10000 | 2 | 2 | 5 |
| SS | 300C | 40 | 7.5 | 27.6 | 364 | 2 | 2 | 5 |
| SS | 300C | 40 | 15.0 | 27.4 | 17.8 | 2 | 2 | 5 |
| SS | 300C | 40 | 0.0 | 28.7 | 10000 | 3 | 2 | 5 |
| SS | 300C | 40 | 7.5 | 27.6 | 372 | 3 | 2 | 5 |
| SS | 300C | 40 | 15.0 | 27.4 | 26.8 | 3 | 2 | 5 |
| SS | 300C | 50 | 0.0 | 29.1 | 10000 | 1 | 2 | 5 |
| SS | 300C | 50 | 7.5 | 27.9 | 553 | 1 | 2 | 5 |
| SS | 300C | 50 | 15.0 | 27.6 | 25.2 | 1 | 2 | 5 |
| SS | 300C | 50 | 0.0 | 28.8 | 10000 | 2 | 2 | 5 |
| SS | 300C | 50 | 7.5 | 28.3 | 566 | 2 | 2 | 5 |
| SS | 300C | 50 | 15.0 | 28.3 | 33.8 | 2 | 2 | 5 |
| SS | 300C | 50 | 0.0 | 29.1 | 10000 | 3 | 2 | 5 |
| SS | 300C | 50 | 7.5 | 28.5 | 524 | 3 | 2 | 5 |
| SS | 300C | 50 | 15.0 | 28.4 | 40.8 | 3 | 2 | 5 |
| SS | 300C | 20 | 0.0 | 26.9 | 10000 | 1 | 1 | 10 |
| SS | 300C | 20 | 30.0 | 29.5 | 275 | 1 | 1 | 10 |
| SS | 300C | 20 | 0.0 | 27.3 | 10000 | 2 | 1 | 10 |
| SS | 300C | 20 | 30.0 | 27.8 | 286 | 2 | 1 | 10 |
| SS | 300C | 20 | 0.0 | 27.3 | 10000 | 3 | 1 | 10 |
| SS | 300C | 20 | 30.0 | 27.2 | 240 | 3 | 1 | 10 |
| SS | 300C | 30 | 0.0 | 27.2 | 10000 | 1 | 1 | 10 |
| SS | 300C | 30 | 30.0 | 28.6 | 196 | 1 | 1 | 10 |
| SS | 300C | 30 | 0.0 | 27.4 | 10000 | 2 | 1 | 10 |
| SS | 300C | 30 | 30.0 | 27.3 | 183 | 2 | 1 | 10 |
| SS | 300C | 30 | 0.0 | 27.6 | 10000 | 3 | 1 | 10 |
| SS | 300C | 30 | 30.0 | 26.9 | 204 | 3 | 1 | 10 |

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|---|---|---|---|---|---|---|---|---|
| SS | 300C | 40 | 0.0 | 28.4 | 10000 | 1 | 1 | 10 |
| SS | 300C | 40 | 30.0 | 27.3 | 223 | 1 | 1 | 10 |
| SS | 300C | 40 | 0.0 | 28.8 | 10000 | 2 | 1 | 10 |
| SS | 300C | 40 | 30.0 | 28.4 | 166 | 2 | 1 | 10 |
| SS | 300C | 40 | 0.0 | 28.9 | 10000 | 3 | 1 | 10 |
| SS | 300C | 40 | 30.0 | 26.7 | 229 | 3 | 1 | 10 |
| SS | 300C | 50 | 0.0 | 28.9 | 10000 | 1 | 1 | 10 |
| SS | 300C | 50 | 30.0 | 28.7 | 207 | 1 | 1 | 10 |
| SS | 300C | 50 | 0.0 | 28.9 | 10000 | 2 | 1 | 10 |
| SS | 300C | 50 | 30.0 | 28.3 | 198 | 2 | 1 | 10 |
| SS | 300C | 50 | 0.0 | 29.0 | 10000 | 3 | 1 | 10 |
| SS | 300C | 50 | 30.0 | 28.5 | 215 | 3 | 1 | 10 |
| SS | 300C | 20 | 0.0 | 28.2 | 10000 | 1 | 1 | 5 |
| SS | 300C | 20 | 15.0 | 29.4 | 465 | 1 | 1 | 5 |
| SS | 300C | 20 | 0.0 | 28.3 | 10000 | 2 | 1 | 5 |
| SS | 300C | 20 | 15.0 | 29.0 | 430 | 2 | 1 | 5 |
| SS | 300C | 20 | 0.0 | 28.4 | 10000 | 3 | 1 | 5 |
| SS | 300C | 20 | 15.0 | 28.8 | 412 | 3 | 1 | 5 |
| SS | 300C | 30 | 0.0 | 28.5 | 10000 | 1 | 1 | 5 |
| SS | 300C | 30 | 15.0 | 28.5 | 375 | 1 | 1 | 5 |
| SS | 300C | 30 | 0.0 | 28.5 | 10000 | 2 | 1 | 5 |
| SS | 300C | 30 | 15.0 | 29.8 | 396 | 2 | 1 | 5 |
| SS | 300C | 30 | 0.0 | 28.7 | 10000 | 3 | 1 | 5 |
| SS | 300C | 30 | 15.0 | 28.9 | 462 | 3 | 1 | 5 |
| SS | 300C | 40 | 0.0 | 28.0 | 10000 | 1 | 1 | 5 |
| SS | 300C | 40 | 15.0 | 28.2 | 374 | 1 | 1 | 5 |
| SS | 300C | 40 | 0.0 | 28.3 | 10000 | 2 | 1 | 5 |
| SS | 300C | 40 | 15.0 | 27.7 | 241 | 2 | 1 | 5 |
| SS | 300C | 40 | 0.0 | 28.3 | 10000 | 3 | 1 | 5 |
| SS | 300C | 40 | 15.0 | 27.9 | 353 | 3 | 1 | 5 |
| SS | 300C | 50 | 0.0 | 27.2 | 10000 | 1 | 1 | 5 |
| SS | 300C | 50 | 15.0 | 29.1 | 471 | 1 | 1 | 5 |
| SS | 300C | 50 | 0.0 | 27.4 | 10000 | 2 | 1 | 5 |
| SS | 300C | 50 | 15.0 | 27.8 | 381 | 2 | 1 | 5 |
| SS | 300C | 50 | 0.0 | 27.5 | 10000 | 3 | 1 | 5 |
| SS | 300C | 50 | 15.0 | 27.4 | 372 | 3 | 1 | 5 |

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|---|---|---|---|---|---|---|---|---|
| SS | 300E | 20 | 0.0 | 28.5 | 10000 | 1 | 3 | 10 |
| SS | 300E | 20 | 10.0 | 28.4 | 658 | 1 | 3 | 10 |
| SS | 300E | 20 | 20.0 | 28.4 | 123 | 1 | 3 | 10 |
| SS | 300E | 20 | 30.0 | 27.8 | 58.1 | 1 | 3 | 10 |
| SS | 300E | 20 | 0.0 | 28.9 | 10000 | 2 | 3 | 10 |
| SS | 300E | 20 | 10.0 | 29.1 | 752 | 2 | 3 | 10 |
| SS | 300E | 20 | 20.0 | 30.6 | 69.6 | 2 | 3 | 10 |
| SS | 300E | 20 | 30.0 | 31.5 | 12.1 | 2 | 3 | 10 |
| SS | 300E | 20 | 0.0 | 29.2 | 10000 | 3 | 3 | 10 |
| SS | 300E | 20 | 10.0 | 28.1 | 653 | 3 | 3 | 10 |
| SS | 300E | 20 | 20.0 | 27.6 | 192 | 3 | 3 | 10 |
| SS | 300E | 20 | 30.0 | 27.8 | 10.2 | 3 | 3 | 10 |
| SS | 300E | 20 | 0.0 | 29.2 | 10000 | 4 | 3 | 10 |
| SS | 300E | 20 | 10.0 | 28.8 | 582 | 4 | 3 | 10 |
| SS | 300E | 20 | 20.0 | 28.8 | 52.2 | 4 | 3 | 10 |
| SS | 300E | 20 | 30.0 | 28.0 | 8.46 | 4 | 3 | 10 |
| SS | 300E | 30 | 0.0 | 28.1 | 10000 | 1 | 3 | 10 |
| SS | 300E | 30 | 10.0 | 28.9 | 578 | 1 | 3 | 10 |
| SS | 300E | 30 | 20.0 | 29.0 | 185 | 1 | 3 | 10 |
| SS | 300E | 30 | 30.0 | 29.9 | 16.6 | 1 | 3 | 10 |
| SS | 300E | 30 | 0.0 | 29.5 | 10000 | 2 | 3 | 10 |
| SS | 300E | 30 | 10.0 | 28.5 | 627 | 2 | 3 | 10 |
| SS | 300E | 30 | 20.0 | 28.0 | 116 | 2 | 3 | 10 |
| SS | 300E | 30 | 30.0 | 27.8 | 18.3 | 2 | 3 | 10 |
| SS | 300E | 30 | 0.0 | 28.7 | 10000 | 3 | 3 | 10 |
| SS | 300E | 30 | 10.0 | 29.2 | 528 | 3 | 3 | 10 |
| SS | 300E | 30 | 20.0 | 29.5 | 138 | 3 | 3 | 10 |
| SS | 300E | 30 | 30.0 | 29.4 | 12.4 | 3 | 3 | 10 |
| SS | 300E | 40 | 0.0 | 28.9 | 10000 | 1 | 3 | 10 |
| SS | 300E | 40 | 10.0 | 29.9 | 558 | 1 | 3 | 10 |
| SS | 300E | 40 | 20.0 | 30.1 | 30.0 | 1 | 3 | 10 |
| SS | 300E | 40 | 30.0 | 30.8 | 2.19 | 1 | 3 | 10 |
| SS | 300E | 40 | 0.0 | 28.5 | 10000 | 2 | 3 | 10 |
| SS | 300E | 40 | 10.0 | 28.9 | 472 | 2 | 3 | 10 |
| SS | 300E | 40 | 20.0 | 28.9 | 24.5 | 2 | 3 | 10 |
| SS | 300E | 40 | 30.0 | 28.4 | 1.61 | 2 | 3 | 10 |
| SS | 300E | 40 | 0.0 | 28.8 | 10000 | 3 | 3 | 10 |
| SS | 300E | 40 | 10.0 | 27.7 | 497 | 3 | 3 | 10 |
| SS | 300E | 40 | 20.0 | 27.3 | 22.4 | 3 | 3 | 10 |
| SS | 300E | 40 | 30.0 | 26.9 | 2.01 | 3 | 3 | 10 |
| SS | 300E | 50 | 0.0 | 26.7 | 10000 | 1 | 3 | 10 |
| SS | 300E | 50 | 10.0 | 26.6 | 579 | 1 | 3 | 10 |
| SS | 300E | 50 | 20.0 | 26.8 | 21.5 | 1 | 3 | 10 |
| SS | 300E | 50 | 30.0 | 27.5 | 2.63 | 1 | 3 | 10 |

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|---|---|---|---|---|---|---|---|---|
| SS | 300E | 50 | 0.0 | 27.5 | 10000 | 2 | 3 | 10 |
| SS | 300E | 50 | 10.0 | 27.6 | 575 | 2 | 3 | 10 |
| SS | 300E | 50 | 20.0 | 27.7 | 23.9 | 2 | 3 | 10 |
| SS | 300E | 50 | 30.0 | 27.4 | 3.68 | 2 | 3 | 10 |
| SS | 300E | 50 | 0.0 | 27.7 | 10000 | 3 | 3 | 10 |
| SS | 300E | 50 | 10.0 | 27.1 | 573 | 3 | 3 | 10 |
| SS | 300E | 50 | 20.0 | 26.8 | 18.1 | 3 | 3 | 10 |
| SS | 300E | 50 | 30.0 | 27.4 | 1.52 | 3 | 3 | 10 |
| SS | 300E | 20 | 0.0 | 27.8 | 10000 | 1 | 3 | 5 |
| SS | 300E | 20 | 5.0 | 27.6 | 1060 | 1 | 3 | 5 |
| SS | 300E | 20 | 10.0 | 27.8 | 49.0 | 1 | 3 | 5 |
| SS | 300E | 20 | 15.0 | 27.9 | 5.29 | 1 | 3 | 5 |
| SS | 300E | 20 | 0.0 | 27.7 | 10000 | 2 | 3 | 5 |
| SS | 300E | 20 | 5.0 | 27.6 | 1020 | 2 | 3 | 5 |
| SS | 300E | 20 | 10.0 | 27.7 | 38.8 | 2 | 3 | 5 |
| SS | 300E | 20 | 15.0 | 27.6 | 9.58 | 2 | 3 | 5 |
| SS | 300E | 20 | 0.0 | 27.7 | 10000 | 3 | 3 | 5 |
| SS | 300E | 20 | 5.0 | 27.4 | 891 | 3 | 3 | 5 |
| SS | 300E | 20 | 10.0 | 27.3 | 45.0 | 3 | 3 | 5 |
| SS | 300E | 20 | 15.0 | 27.2 | 3.51 | 3 | 3 | 5 |
| SS | 300E | 30 | 0.0 | 26.2 | 10000 | 1 | 3 | 5 |
| SS | 300E | 30 | 5.0 | 27.0 | 993 | 1 | 3 | 5 |
| SS | 300E | 30 | 10.0 | 27.7 | 44.9 | 1 | 3 | 5 |
| SS | 300E | 30 | 15.0 | 27.9 | 2.70 | 1 | 3 | 5 |
| SS | 300E | 30 | 0.0 | 26.3 | 10000 | 2 | 3 | 5 |
| SS | 300E | 30 | 5.0 | 26.6 | 747 | 2 | 3 | 5 |
| SS | 300E | 30 | 10.0 | 25.5 | 39.7 | 2 | 3 | 5 |
| SS | 300E | 30 | 15.0 | 25.6 | 1.00 | 2 | 3 | 5 |
| SS | 300E | 30 | 0.0 | 26.3 | 10000 | 3 | 3 | 5 |
| SS | 300E | 30 | 5.0 | 27.3 | 849 | 3 | 3 | 5 |
| SS | 300E | 30 | 10.0 | 28.2 | 27.6 | 3 | 3 | 5 |
| SS | 300E | 30 | 15.0 | 28.6 | 1.00 | 3 | 3 | 5 |
| SS | 300E | 40 | 0.0 | 27.4 | 10000 | 1 | 3 | 5 |
| SS | 300E | 40 | 5.0 | 26.9 | 911 | 1 | 3 | 5 |
| SS | 300E | 40 | 10.0 | 26.5 | 42 | 1 | 3 | 5 |
| SS | 300E | 40 | 15.0 | 26.4 | 4.97 | 1 | 3 | 5 |
| SS | 300E | 40 | 0.0 | 27.5 | 10000 | 2 | 3 | 5 |
| SS | 300E | 40 | 5.0 | 27.2 | 830 | 2 | 3 | 5 |
| SS | 300E | 40 | 10.0 | 27.2 | 27.1 | 2 | 3 | 5 |
| SS | 300E | 40 | 15.0 | 27.2 | 1.00 | 2 | 3 | 5 |
| SS | 300E | 40 | 0.0 | 27.3 | 10000 | 3 | 3 | 5 |
| SS | 300E | 40 | 5.0 | 27.1 | 1030 | 3 | 3 | 5 |
| SS | 300E | 40 | 10.0 | 26.7 | 42.4 | 3 | 3 | 5 |
| SS | 300E | 40 | 15.0 | 26.6 | 1.95 | 3 | 3 | 5 |

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| SS | 300E | 40 | 0.0 | 28.2 | 10000 | 4 | 3 | 5 |
| SS | 300E | 40 | 5.0 | 27.2 | 1210 | 4 | 3 | 5 |
| SS | 300E | 40 | 10.0 | 26.8 | 51.0 | 4 | 3 | 5 |
| SS | 300E | 40 | 15.0 | 26.7 | 2.18 | 4 | 3 | 5 |
| SS | 300E | 50 | 0.0 | 27.7 | 10000 | 1 | 3 | 5 |
| SS | 300E | 50 | 5.0 | 27.8 | 996 | 1 | 3 | 5 |
| SS | 300E | 50 | 10.0 | 27.9 | 41.2 | 1 | 3 | 5 |
| SS | 300E | 50 | 15.0 | 27.9 | 3.81 | 1 | 3 | 5 |
| SS | 300E | 50 | 0.0 | 27.5 | 10000 | 2 | 3 | 5 |
| SS | 300E | 50 | 5.0 | 27.3 | 958 | 2 | 3 | 5 |
| SS | 300E | 50 | 10.0 | 26.8 | 30.4 | 2 | 3 | 5 |
| SS | 300E | 50 | 15.0 | 26.7 | 1.00 | 2 | 3 | 5 |
| SS | 300E | 50 | 0.0 | 28.2 | 10000 | 3 | 3 | 5 |
| SS | 300E | 50 | 5.0 | 27.2 | 1250 | 3 | 3 | 5 |
| SS | 300E | 50 | 10.0 | 26.8 | 52.7 | 3 | 3 | 5 |
| SS | 300E | 50 | 15.0 | 26.6 | 5.81 | 3 | 3 | 5 |
| SS | 300E | 20 | 0.0 | 25.2 | 10000 | 1 | 2 | 10 |
| SS | 300E | 20 | 15.0 | 26.1 | 379 | 1 | 2 | 10 |
| SS | 300E | 20 | 30.0 | 26.4 | 34.8 | 1 | 2 | 10 |
| SS | 300E | 20 | 0.0 | 26.9 | 10000 | 2 | 2 | 10 |
| SS | 300E | 20 | 15.0 | 25.4 | 323 | 2 | 2 | 10 |
| SS | 300E | 20 | 30.0 | 25.7 | 24.7 | 2 | 2 | 10 |
| SS | 300E | 20 | 0.0 | 27.1 | 10000 | 3 | 2 | 10 |
| SS | 300E | 20 | 15.0 | 26.0 | 315 | 3 | 2 | 10 |
| SS | 300E | 20 | 30.0 | 27.4 | 27.4 | 3 | 2 | 10 |
| SS | 300E | 30 | 0.0 | 27.0 | 10000 | 1 | 2 | 10 |
| SS | 300E | 30 | 15.0 | 27.1 | 342 | 1 | 2 | 10 |
| SS | 300E | 30 | 30.0 | 27.7 | 15.2 | 1 | 2 | 10 |
| SS | 300E | 30 | 0.0 | 27.0 | 10000 | 2 | 2 | 10 |
| SS | 300E | 30 | 15.0 | 26.7 | 413 | 2 | 2 | 10 |
| SS | 300E | 30 | 30.0 | 26.5 | 21.5 | 2 | 2 | 10 |
| SS | 300E | 30 | 0.0 | 27.1 | 10000 | 3 | 2 | 10 |
| SS | 300E | 30 | 15.0 | 26.2 | 325 | 3 | 2 | 10 |
| SS | 300E | 30 | 30.0 | 26.2 | 15.5 | 3 | 2 | 10 |
| SS | 300E | 40 | 0.0 | 27.7 | 10000 | 1 | 2 | 10 |
| SS | 300E | 40 | 15.0 | 27.8 | 413 | 1 | 2 | 10 |
| SS | 300E | 40 | 30.0 | 28.0 | 14.1 | 1 | 2 | 10 |
| SS | 300E | 40 | 0.0 | 28.0 | 10000 | 2 | 2 | 10 |
| SS | 300E | 40 | 15.0 | 27.2 | 284 | 2 | 2 | 10 |
| SS | 300E | 40 | 30.0 | 26.8 | 17.9 | 2 | 2 | 10 |
| SS | 300E | 40 | 0.0 | 28.1 | 10000 | 3 | 2 | 10 |
| SS | 300E | 40 | 15.0 | 27.1 | 372 | 3 | 2 | 10 |
| SS | 300E | 40 | 30.0 | 26.5 | 16.5 | 3 | 2 | 10 |

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| SS | 300E | 50 | 0.0 | 28.2 | 10000 | 1 | 2 | 10 |
| SS | 300E | 50 | 15.0 | 26.3 | 267 | 1 | 2 | 10 |
| SS | 300E | 50 | 30.0 | 25.7 | 16.1 | 1 | 2 | 10 |
| SS | 300E | 50 | 0.0 | 28.3 | 10000 | 2 | 2 | 10 |
| SS | 300E | 50 | 15.0 | 26.7 | 355 | 2 | 2 | 10 |
| SS | 300E | 50 | 30.0 | 28.3 | 28.5 | 2 | 2 | 10 |
| SS | 300E | 50 | 0.0 | 28.8 | 10000 | 3 | 2 | 10 |
| SS | 300E | 50 | 15.0 | 29.5 | 352 | 3 | 2 | 10 |
| SS | 300E | 50 | 30.0 | 29.9 | 23.9 | 3 | 2 | 10 |
| SS | 300E | 20 | 0.0 | 28.6 | 10000 | 1 | 2 | 5 |
| SS | 300E | 20 | 7.5 | 30.9 | 729 | 1 | 2 | 5 |
| SS | 300E | 20 | 15.0 | 31.9 | 29.1 | 1 | 2 | 5 |
| SS | 300E | 20 | 0.0 | 29.2 | 10000 | 2 | 2 | 5 |
| SS | 300E | 20 | 7.5 | 29.4 | 675 | 2 | 2 | 5 |
| SS | 300E | 20 | 15.0 | 29.0 | 30.4 | 2 | 2 | 5 |
| SS | 300E | 20 | 0.0 | 29.1 | 10000 | 3 | 2 | 5 |
| SS | 300E | 20 | 7.5 | 28.3 | 644 | 3 | 2 | 5 |
| SS | 300E | 20 | 15.0 | 27.8 | 25.1 | 3 | 2 | 5 |
| SS | 300E | 30 | 0.0 | 29.1 | 10000 | 1 | 2 | 5 |
| SS | 300E | 30 | 7.5 | 27.7 | 707 | 1 | 2 | 5 |
| SS | 300E | 30 | 15.0 | 27.2 | 25.3 | 1 | 2 | 5 |
| SS | 300E | 30 | 0.0 | 29.1 | 10000 | 2 | 2 | 5 |
| SS | 300E | 30 | 7.5 | 28.0 | 583 | 2 | 2 | 5 |
| SS | 300E | 30 | 15.0 | 27.9 | 20.8 | 2 | 2 | 5 |
| SS | 300E | 30 | 0.0 | 29.2 | 10000 | 3 | 2 | 5 |
| SS | 300E | 30 | 7.5 | 27.5 | 620 | 3 | 2 | 5 |
| SS | 300E | 30 | 15.0 | 26.9 | 22.6 | 3 | 2 | 5 |
| SS | 300E | 40 | 0.0 | 29.1 | 10000 | 1 | 2 | 5 |
| SS | 300E | 40 | 7.5 | 28.0 | 806 | 1 | 2 | 5 |
| SS | 300E | 40 | 15.0 | 27.8 | 22.1 | 1 | 2 | 5 |
| SS | 300E | 40 | 0.0 | 29.1 | 10000 | 2 | 2 | 5 |
| SS | 300E | 40 | 7.5 | 28.4 | 535 | 2 | 2 | 5 |
| SS | 300E | 40 | 15.0 | 28.5 | 19.0 | 2 | 2 | 5 |
| SS | 300E | 40 | 0.0 | 29.1 | 10000 | 3 | 2 | 5 |
| SS | 300E | 40 | 7.5 | 28.0 | 585 | 3 | 2 | 5 |
| SS | 300E | 40 | 15.0 | 27.7 | 21.5 | 3 | 2 | 5 |
| SS | 300E | 50 | 0.0 | 29.2 | 10000 | 1 | 2 | 5 |
| SS | 300E | 50 | 7.5 | 29.6 | 583 | 1 | 2 | 5 |
| SS | 300E | 50 | 15.0 | 30.2 | 30.2 | 1 | 2 | 5 |
| SS | 300E | 50 | 0.0 | 29.2 | 10000 | 2 | 2 | 5 |
| SS | 300E | 50 | 7.5 | 28.2 | 617 | 2 | 2 | 5 |
| SS | 300E | 50 | 15.0 | 27.9 | 22.2 | 2 | 2 | 5 |

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| SS | 300E | 50 | 0.0 | 29.2 | 10000 | 3 | 2 | 5 |
| SS | 300E | 50 | 7.5 | 28.6 | 610 | 3 | 2 | 5 |
| SS | 300E | 50 | 15.0 | 28.4 | 26.4 | 3 | 2 | 5 |
| SS | 300E | 20 | 0.0 | 29.2 | 10000 | 1 | 1 | 10 |
| SS | 300E | 20 | 30.0 | 28.9 | 202 | 1 | 1 | 10 |
| SS | 300E | 20 | 0.0 | 29.0 | 10000 | 2 | 1 | 10 |
| SS | 300E | 20 | 30.0 | 30.9 | 137 | 2 | 1 | 10 |
| SS | 300E | 20 | 0.0 | 29.0 | 10000 | 3 | 1 | 10 |
| SS | 300E | 20 | 30.0 | 31.3 | 142 | 3 | 1 | 10 |
| SS | 300E | 30 | 0.0 | 30.3 | 10000 | 1 | 1 | 10 |
| SS | 300E | 30 | 30.0 | 28.1 | 142 | 1 | 1 | 10 |
| SS | 300E | 30 | 0.0 | 30.1 | 10000 | 2 | 1 | 10 |
| SS | 300E | 30 | 30.0 | 27.1 | 155 | 2 | 1 | 10 |
| SS | 300E | 30 | 0.0 | 30.1 | 10000 | 3 | 1 | 10 |
| SS | 300E | 30 | 30.0 | 30.0 | 123 | 3 | 1 | 10 |
| SS | 300E | 40 | 0.0 | 29.7 | 10000 | 1 | 1 | 10 |
| SS | 300E | 40 | 30.0 | 28.9 | 161 | 1 | 1 | 10 |
| SS | 300E | 40 | 0.0 | 29.8 | 10000 | 2 | 1 | 10 |
| SS | 300E | 40 | 30.0 | 29.7 | 133 | 2 | 1 | 10 |
| SS | 300E | 40 | 0.0 | 30.1 | 10000 | 3 | 1 | 10 |
| SS | 300E | 40 | 30.0 | 29.6 | 112 | 3 | 1 | 10 |
| SS | 300E | 50 | 0.0 | 30.3 | 10000 | 1 | 1 | 10 |
| SS | 300E | 50 | 30.0 | 26.5 | 178 | 1 | 1 | 10 |
| SS | 300E | 50 | 0.0 | 30.3 | 10000 | 2 | 1 | 10 |
| SS | 300E | 50 | 30.0 | 30.0 | 113 | 2 | 1 | 10 |
| SS | 300E | 50 | 0.0 | 30.3 | 10000 | 3 | 1 | 10 |
| SS | 300E | 50 | 30.0 | 28.3 | 144 | 3 | 1 | 10 |
| SS | 300E | 20 | 0.0 | 30.1 | 10000 | 1 | 1 | 5 |
| SS | 300E | 20 | 15.0 | 28.8 | 332 | 1 | 1 | 5 |
| SS | 300E | 20 | 0.0 | 30.1 | 10000 | 2 | 1 | 5 |
| SS | 300E | 20 | 15.0 | 29.0 | 234 | 2 | 1 | 5 |
| SS | 300E | 20 | 0.0 | 30.2 | 10000 | 3 | 1 | 5 |
| SS | 300E | 20 | 15.0 | 29.1 | 244 | 3 | 1 | 5 |
| SS | 300E | 30 | 0.0 | 30.3 | 10000 | 1 | 1 | 5 |
| SS | 300E | 30 | 15.0 | 30.3 | 358 | 1 | 1 | 5 |
| SS | 300E | 30 | 0.0 | 30.3 | 10000 | 2 | 1 | 5 |
| SS | 300E | 30 | 15.0 | 31.1 | 231 | 2 | 1 | 5 |
| SS | 300E | 30 | 0.0 | 30.4 | 10000 | 3 | 1 | 5 |
| SS | 300E | 30 | 15.0 | 29.7 | 208 | 3 | 1 | 5 |

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| SS | 300E | 40 | 0.0 | 30.4 | 10000 | 1 | 1 | 5 |
| SS | 300E | 40 | 15.0 | 29.7 | 195 | 1 | 1 | 5 |
| SS | 300E | 40 | 0.0 | 30.4 | 10000 | 2 | 1 | 5 |
| SS | 300E | 40 | 15.0 | 30.6 | 195 | 2 | 1 | 5 |
| SS | 300E | 40 | 0.0 | 30.5 | 10000 | 3 | 1 | 5 |
| SS | 300E | 40 | 15.0 | 30.5 | 204 | 3 | 1 | 5 |
| SS | 300E | 50 | 0.0 | 30.6 | 10000 | 1 | 1 | 5 |
| SS | 300E | 50 | 15.0 | 31.0 | 201 | 1 | 1 | 5 |
| SS | 300E | 50 | 0.0 | 30.6 | 10000 | 2 | 1 | 5 |
| SS | 300E | 50 | 15.0 | 30.8 | 197 | 2 | 1 | 5 |
| SS | 300E | 50 | 0.0 | 30.6 | 10000 | 3 | 1 | 5 |
| SS | 300E | 50 | 15.0 | 30.9 | 204 | 3 | 1 | 5 |

# APPENDIX C

Table C1. Summary of statistics using a four-way main effects interaction as an error term. Performance of Spraying Systems nozzle in various capacity sprayer tanks.

| Source | DF | Type III SS | Mean Square | F-Value | Pr>F |
|---|---|---|---|---|---|
| Tank | 4 | 84.3828 | 21.0957 | 81.30 | 0.0001 |
| Psi | 3 | 7.1714 | 2.3905 | 9.21 | 0.0003 |
| Pct | 1 | 42.4737 | 42.4737 | 163.68 | 0.0001 |
| Seq | 2 | 794.4887 | 397.2443 | 1530.84 | 0.0001 |
| Tank*Psi | 12 | 3.8585 | 0.3215 | 1.24 | 0.3145 |
| Tank*Pct | 4 | 15.6087 | 3.9022 | 15.04 | 0.0001 |
| Tank*Seq | 8 | 18.5143 | 2.3143 | 8.92 | 0.0001 |
| Pct*Seq | 2 | 0.7371 | 0.3686 | 1.42 | 0.2612 |
| Psi*Pct | 3 | 0.9303 | 0.3101 | 1.20 | 0.3328 |
| Psi*Seq | 6 | 7.8801 | 1.3133 | 5.06 | 0.0018 |
| Tank*Psi*Pct | 12 | 2.6724 | 0.2227 | 0.86 | 0.5959 |
| Tank*Psi*Seq | 24 | 4.8196 | 0.2008 | 0.77 | 0.7326 |
| Tank*Pct*Seq | 8 | 6.8017 | 0.8502 | 3.28 | 0.0114 |
| Psi*Pct*Seq | 6 | 3.9158 | 0.6526 | 2.52 | 0.0495 |

Table C2. Summary of statistics using a four-way main effects interaction as an error term. Comparison of Spraying Systems and Lechler nozzle performance in a 380-L [100-gal.] cylindrical sprayer tank.

| Source | DF | Type III SS | Mean Square | F-Value | Pr>F |
|---|---|---|---|---|---|
| Noz | 1 | 1.0920 | 1.0920 | 2.59 | 0.1827 |
| Psi | 2 | 1.1927 | 0.5963 | 1.42 | 0.3429 |
| Pct | 1 | 19.6690 | 19.6690 | 46.69 | 0.0024 |
| Seq | 2 | 225.6278 | 112.8139 | 267.81 | 0.0001 |
| Noz*Psi | 2 | 0.3135 | 0.1567 | 0.37 | 0.7109 |
| Noz*Pct | 1 | 0.0619 | 0.0619 | 0.15 | 0.7211 |
| Noz*Seq | 2 | 0.5696 | 0.2848 | 0.68 | 0.5585 |
| Pct*Seq | 2 | 2.3802 | 1.1901 | 2.83 | 0.1718 |
| Psi*Pct | 2 | 1.2334 | 0.6167 | 1.46 | 0.3334 |
| Psi*Seq | 4 | 1.0810 | 0.2702 | 0.64 | 0.6612 |
| Noz*Psi*Pct | 2 | 0.0205 | 0.0102 | 0.02 | 0.9762 |
| Noz*Psi*Seq | 4 | 0.8797 | 0.2199 | 0.52 | 0.7278 |
| Noz*Pct*Seq | 2 | 0.2213 | 0.1107 | 0.26 | 0.7813 |
| Psi*Pct*Seq | 4 | 0.4865 | 0.1216 | 0.29 | 0.8719 |

# APPENDIX D

MidWest Plan Service Rinsate Reduction Practices

- Purchase only the amount of product needed for each season. Avoid overwintering products; freezing renders most products ineffective and they become waste.
- Know the exact area to be treated to calculate the purchase quantity and to minimize unused pesticide mix. Prepare only a sufficient amount for the job.
- Use older products first to minimize deterioration of containers stored for long periods of time.
- Use pesticides for their intended purpose before they are no longer effective.
- Calibrate or modify the sprayer to optimize application rate and minimize leftover spray mix.
- Schedule spraying to allow use of leftover mixture on subsequent jobs to minimize the number and volume of tank rinsates. Schedule field work to reduce rinsing between crops (e.g. corn followed by soybeans).
- Attach water tanks to equipment to wash equipment off in the field instead of at the farmstead. Use high pressure, low volume systems for rinsing the equipment exterior and the interior of spray tanks. Avoid repeated washing in the same location; stay away from wells, surface water bodies, field tiles and inlets.
- Provide temporary storage of pesticide mix that can be used later. Know its mix shelflife and pH status.
- Use rinsate as part of make-up water for subsequent application.
- Use minibulk and SVR containers to reduce the need for many small containers.
- Avoid incompatible mixtures. Check labels for compatibility before mixing pesticides and/or fertilizers. Regard incompatible mixtures as waste and dispose accordingly.
- Return unused, unopened pesticides to the dealer for credit to prevent the need to store them on the farm for long periods of time.
- Store pesticides in original labeled containers at proper storage temperature in locked or otherwise secured building.
- To prevent accidental mixing, store pesticides of like brand or type together and in separate containment tub to catch spills or leaks due to ruptured or punctured packages.
- Identify and dispose unlabeled products.
- Modify equipment to reduce the amount of product left in the empty tank.
- **Do not reuse pesticide containers for any other use. It is illegal.**

# VITA

Jesse L. Davis was born September 23, 1966 in Clinton County, Indiana. He resided in that county until he graduated from Clinton Central High School in May of 1985.

The author entered Purdue University, West Lafayette, Indiana in August 1985 and received a Bachelor of Science degree with a major in Agricultural Mechanization in May, 1990. He entered the Graduate School at The University of Tennessee, Knoxville in August, 1990. He received a Master of Science degree with a major in Agricultural Engineering Technology in December, 1992.