ANALYTICAL PROCESS CONTROL

4

LEARNING ACTIVITY PACKET

INTRODUCTION TO ANALYTICAL PROCESS CONTROL

AMATROL®

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INTRODUCTION TO ANALYTICAL PROCESS CONTROL

INTRODUCTION

Many processes are designed to control or modify the chemical properties of a substance. The control of chemical properties is called analytical process control. Proper control of chemical properties is important to industries such as pharmaceutical companies, beverage companies, and refineries.

This LAP introduces the fundamentals of analytical process control. These fundamentals include: common chemical properties, analytical process safety, and some of the special pumps used in analytical process control applications.

ITEMS NEEDED

Amatrol Supplied
- T5554 Analytical Process Control Learning System
  - 1 Sodium Bisulfate Solution (Acid)
  - 1 Sodium Carbonate Solution (Base)

School Supplied
- 1 Municipal Water Supply

FIRST EDITION, LAP 4, REV. A

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ANALYTICAL CONTROL CONCEPTS

OBJECTIVE 1 DEFINE ANALYTICAL PROCESS CONTROL AND EXPLAIN ITS IMPORTANCE

Analytical process control systems measure and control certain chemical properties of a process fluid or material. Often, precise measurement and control of the chemical properties of a material is critical in producing a safe and reliable product.

Analytical process control is particularly important in the pharmaceutical industry. If a drug does not have the correct chemical properties, the drug may be ineffective or even dangerous.

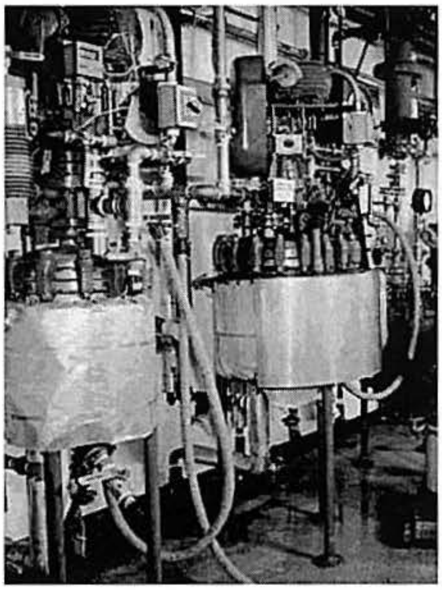

Figure 1. Pharmaceutical Industry Process Devices

The control of chemical properties is also critical in the petrochemical industry, the paper industry, and the brewing industry. Proper control results in a safe and high quality product.

OBJECTIVE 2 DESCRIBE FOUR COMMON ANALYTICAL PROCESS VARIABLES AND GIVE AN APPLICATION OF EACH

Read This

There is a wide range of analytical process variables controlled in processes today. Four common analytical process variables are:

- pH
- Oxidation Reduction Potential (ORP)
- Dissolved Oxygen (DO)
- Conductivity

pH

pH is the measurement of the acidity or alkalinity of a material. A common application of pH measurement is in wastewater treatment, shown in figure 2. Many manufacturing processes use water as part of the process. As a result, the pH of the water is changed by the process. The wastewater must be properly treated, to return the pH to a safe level, before returning it to the environment.

Figure 2. Wastewater Treatment

Oxidation Reduction Potential (ORP)

ORP is a measure of water's ability to break down contaminants. In general terms, ORP is a measure of water's cleanliness.

ORP measurement is critical in water treatment, where the water must be disinfected before it is supplied to users. This reduces the possibility of transmitting pathogens through the water supply.

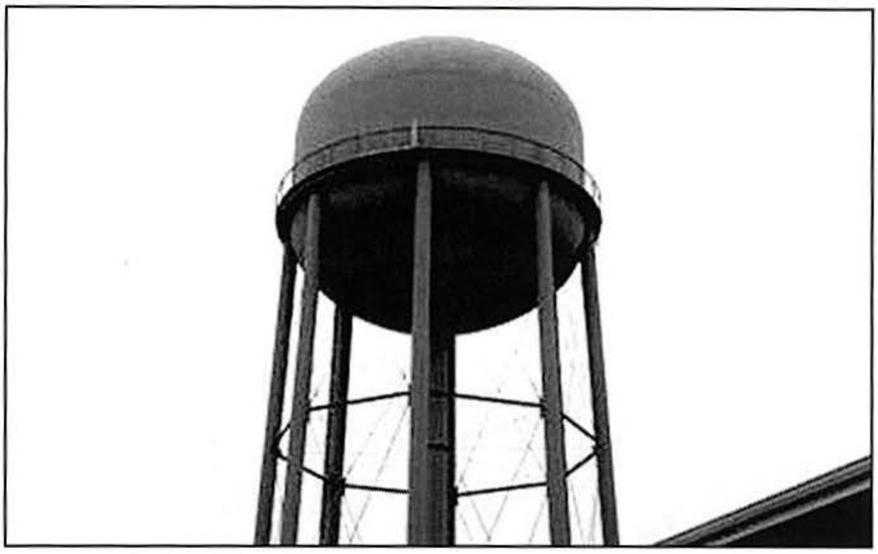

Figure 3. Water Supply Tower

Dissolved Oxygen (DO)

DO is the measure of the amount of oxygen dissolved in a volume of water. DO measurement is common in sewage treatment where bacteria are used to speed decomposition of solid waste in the sewage. If the DO content is too low, the bacteria die and decomposition stops.

Figure 4. Sewage Treatment Tank

Conductivity

Conductivity is the measure of a substance's ability to conduct electric current. For fluids, the amount of current a substance can conduct is determined by the concentration of ions. A high concentration of ions results in high conductivity, while a low concentration of ions results in low conductivity.

Conductivity measurement is often used to determine the purity of water. Pure water such as distilled water has a very low concentration of ions and is not a good conductor. However, as impurities begin to build in water, the concentration of ions begins to increase, resulting in higher conductivity.

Figure 5. Distilled Water

OBJECTIVE 3 DESCRIBE THREE STEPS THAT SHOULD BE PERFORMED BEFORE STARTING UP A PROCESS

The initial startup of any process has potential hazards and dangers involved. Therefore, it is extremely important that all safety procedures are observed. Facilities are often regulated by several organizations including the Food and Drug Administration (FDA), the International Standards Organization (ISO), and the Occupational Safety and Health Administration (OSHA).

The FDA and ISO help to ensure that the products are safe for use. OSHA focuses on the safety of the workers involved with the process.

Figure 6. Hazardous Material Warning

Before even starting up a process, the following steps should be performed:

- **Make sure all process documentation is available -** All process documentation should be complete and up-to-date before attempting a startup. This documentation includes: P&IDs, process flow diagrams, installation diagrams, electrical wiring diagrams, instrument specifications, software documentation (i.e. programs or ladder logic), calibration data sheets, etc. For example, figure 7 shows a typical instrument specification (spec) sheet. The instrument spec sheet identifies specific data for an instrument. This data is important when replacing or calibrating an instrument.

	PRESSURE INSTRUMENTS	SHEET ____ OF ____	
	NO | BY | DATE | REVISION	SPEC. NO.	REV.
		CONTRACT	DATE
		REQ. P.O.	
		BY | CHK'D	APPR.

	1	Tag No.	Service
GENERAL	2	Function	Record ☐ Indicate ☐ Control ☐ Blind ☐ Trans ☐ Other ____
	3	Case	MFR STD ☐ Nom Size ____ Color: MFR STD ☐ Other ____
	4	Mounting	Flush ☐ Surface ☐ Yoke ☐ Other ____
	5	Enclosure Class	General Purpose ☐ Weather proof ☐ Explosion proof ☐ Class ____ For Use in Intrin. Safe System ☐ Other ____
	6	Power Supply	117V 60Hz ☐ Other ac ____ dc ____ Volts
	7	Chart	____ Strip ☐ ____ Roll ☐ ____ Fold ☐ Circular ____ Time Marks ____ Range ____ Number ____
	8	Chart Drive	Speed ____ Power ____
	9	Scales	Type ____ Range 1 ____ 2 ____ 3 ____ 4 ____
XMTR	10		4-20 mA ☐ 10-50 mA ☐ 21-103 kPa (3-15 psig) ☐ Other ____ For Receiver See Spec Sheet ____
CONTROLLER	11	Control Modes	P=Prop (Gain) I=Integral (Auto-Reset) D=Derivative (Rate) Sub: s=slow f=fast P☐ PI☐ PD☐ PID☐ I_f☐ D_f☐ I_s☐ D_s☐ Other ____
	12	Action	On Meas. Increase Output: Increases ☐ Decreases ☐
	13	Auto-Man Switch	None ☐ MFR STD ☐ Other ____
	14	Set Point Adj.	Manual ☐ External ☐ Remote ☐ Other ____
	15	Manual Reg.	None ☐ MFR STD ☐ Other ____
	16	Output	4-20mA ☐ 10-50mA ☐ 21-103 kPa (3-15 psig) ☐ Other ____
ELEMENT	17	Service	Gage Press. ☐ Vacuum ☐ Absolute ☐ Compound ☐
	18	Element Type	Diaphragm ☐ Helix ☐ Bourdon ☐ Bellows ☐ Other ____
	19	Material	316 SS ☐ Ber. Copper ☐ Other ____
	20	Range	Fixed ☐ Adj. Range ____ Set at ____ Overrange protection to ____
	21	Process Data	Press: Normal ____ Max ____ Element Range ____
	22	Process Conn.	1/4 in. NPT ☐ 1/2 in. NPT ☐ Other ____ Location: Bottom ☐ Back ☐ Other ____
	23	Alarm Switches	Quantity ____ Form ____ Rating ____
	24	Function	Press ☐ Deviation ☐ Contacts To ____ on Inc. Press.
	25	Options	Filt-Reg. ☐ Sup Gage ☐ Output Gage ☐ ____ Charts Diaph Seal ☐ Type ____ Diaph ____ Bot Bowl ____ Conn ____ Capillary: Length ____ Mtl. ____ Other ____
	26	MFR & Model No.	

Notes:

ISA Form S20.40a

Figure 7. Instrument Spec Sheet

- **Make sure all operating procedures are in place -** All operating procedures must be current and must be available to the personnel involved in the startup. All operating procedures must be observed to ensure the safety of all persons involved and to protect the equipment.
- **Fully train all involved persons to run the process -** It is vital that all persons involved with the initial startup and regular operation of the process be fully trained. Each person should be trained on the safe operation and should have a full understanding of the process. This helps those involved to recognize any possible problems and helps them to notify the appropriate persons before damage or injury occurs.

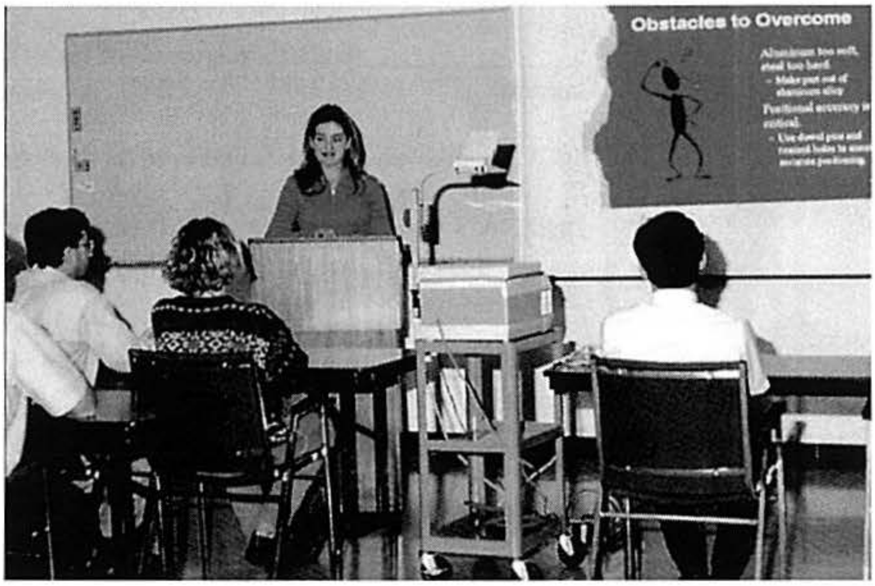

Figure 8. Operating Procedure Training

Following the startup and operating procedures assures a safe transition from the initial startup to the normal operating mode.

SEGMENT 1

SELF REVIEW

Answer This

1. __________ process control systems measure and control certain chemical properties of a process fluid or material.

2. A drug that does not have the correct chemical properties may be ineffective or even ______________.

3. ______________ is the measurement of the acidity or alkalinity of a material.

4. ORP is a measure of water's ability to break down ______________.

5. Dissolved oxygen measurement is common in sewage treatment where ______________ are used to speed decomposition of solid waste in the sewage.

6. ______________ measurement is often used to determine the purity of water.

7. All process ______________ should be complete and up-to-date before attempting a startup.

8. All persons involved with the initial startup and regular operation of the process should be fully ______________ to run the process.

SEGMENT 2

ANALYTICAL PROCESS SAFETY

OBJECTIVE 4 DESCRIBE THE FUNCTION OF THE OSHA PROCESS SAFETY MANAGEMENT STANDARD

Read This

The primary goal of the process safety management standard published by OSHA (Occupational Safety and Health Administration) is to prevent the unwanted release of hazardous chemicals into locations that expose workers and others to serious hazards. Although the standard (OSHA Standard 1910) was written in 1990 for the chemical industry, many other industries have modified their practices and procedures to closely match the standard, where applicable.

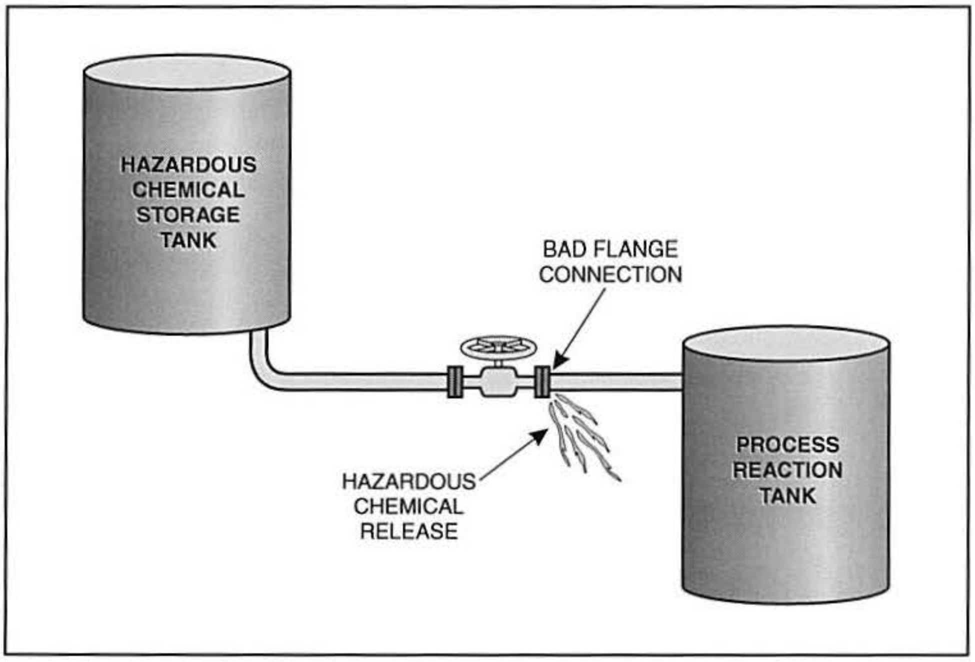

Figure 9. Hazardous Chemical Release

It is extremely important that industries involved in the handling of hazardous chemicals closely observe OSHA's process safety management (PSM) standard. The PSM standard covers many aspects of working around hazardous chemicals.

Figure 10. OSHA Label

The standard is divided into 14 specific points:

- Employee Involvement
- Complete Process Safety Information
- Process Hazard Analysis
- Develop Operating Procedures and Practices
- Employee Training
- Contractor Compliance
- Pre-Startup Safety Reviews
- Mechanical Integrity Program
- Work Authorization Notices
- Managing Change to Process
- Incident Investigation
- Emergency Procedures
- Audits
- Trade Secret Protection

Employee Involvement

All employees should have access to all relevant information and documentation related to the safe operation of the process. This information is typically posted in the control rooms, similar to figure 11. It is also discussed with employees during safety meetings and during training.

7/25/02

Startup/Operation Procedures
Level PID Control

Summary:
- I. **Startup Procedure - Basic**
- II. **Startup Procedure - Level PID Control**

I. Startup Procedure - Basic

1. First check to be sure all of the drain valves are closed.
2. Connect a water hose from the drain line on base unit to the drain on west wall. The other drain lines should be capped off.
3. Now check the water levels. The total amount of water in the reservoir tank and process tank together should be about 50 gallons. Use the scales on side of the tanks to measure. If the combined total is less than 50 gallons, add water to the reservoir tank until the total is 50 gallons.
4. Connect the air supply to both the base unit and the heating/cooling module. Adjust the output of the two pressure regulators on the trainer to about 35 psi.
5. Remove the lockout from the disconnect switch on south wall and toggle power on. The AC and DC control power should now be on. Check the displays on the PLC and instrumentation on the Operator's Station for control power.
6. Depress the Main Power On pushbutton on the Operator's Station to enable main power. The Main Power On indicator should now come on. If not, check the E-Stop switches and retry.
7. Now turn on power to the PC.

Figure 11. Process Documentation Posted

Complete Process Safety Information

The PSM standard requires a company to create and maintain a complete set of documents that cover all safety and operating procedures and considerations. Safety documents include Material Safety Data Sheets (MSDS), which contain information concerning hazardous chemicals. Each chemical must have a MSDS, like the one in figure 12. Other required documents include: piping and instrumentation drawings (P&ID), process flow diagrams (PFD), instrument specification sheets, installation details, piping diagrams, electrical wiring diagrams, and operating procedures.

MATERIAL SAFETY DATA SHEET	MSDS PAGE 1 OF 2 DATE 3/17/94
I. PRODUCT IDENTIFICATION	
Chemical Name: Polypropylene **Chemical Family:** Olefins **Formula:** (-CH2-CH-CH2)n	**Telephone No.** 412-345-8000 **Emergency No.** 412-234-7000
II. HAZARDOUS INGREDIENTS	
Material Based On The U.S. OCCUPATIONAL SAFETY AND HEALTH ACT OF 1970, This product should not be considered hazardous	
III. PHYSICAL DATA	
Boiling Point, 760 mm Hg: N/A **Vapor Pressure:** N/A **Melting Point:** >160°C (320°F) **Specific Gravity (H20 - 1):** 0.88-0.92 **Appearance:** solid pellet, var. colors	**Percent Volatile By Volume (%):** Less Than 0.4 **Evaporation Rate (Butyl Acetate - 1):** N/A
IV. FIRE AND EXPLOSION HAZARD DATA	
Flashpoint: Greater than 329°C (625°F) **Autoignition Temperature:** Greater than 357°C (675°F)	**Extinguishing Media:** Water, Foam, Carbon Dioxide, Or Dry Chemical

Figure 12. Material Safety Data Sheet (MSDS)

Process Hazard Analysis

This is one of the most important parts of process safety management. Process hazard analysis (PHA) is a systematic approach of identifying and controlling possible hazards associated with a process. Employees from different disciplines are brought together to perform a PHA, each bringing their own expertise to the analysis team.

Develop Operating Procedures and Practices

A company must develop written operating procedures for all processes. Once developed, the company must make sure that the procedures are followed by all employees to ensure safety. All employees should be trained on these procedures. The procedures should undergo regular reviews and updates.

Employee Training

It is extremely important that all workers have a full understanding of all safety and health hazards associated with the process. As part of their PSM standard compliance, a company should hold regular training sessions for all employees. This ensures that all employees are aware of and follow current safety procedures.

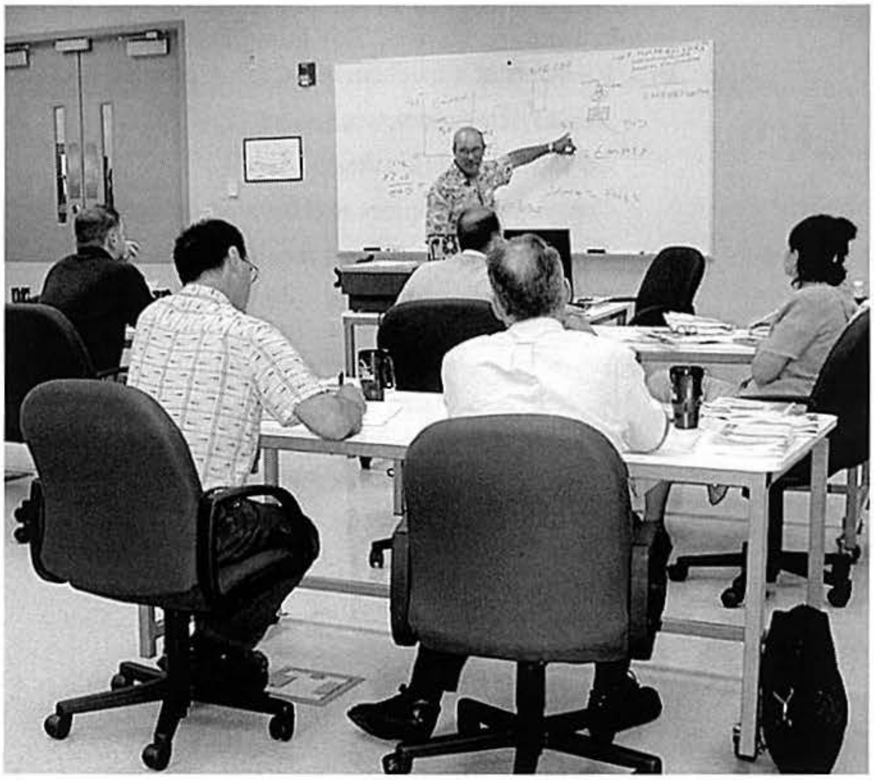

Figure 13. Employee Training

Contractor Compliance

All contractors hired by a company must comply with the PSM standard. Hiring a contractor who does not comply with the PSM standard places the company in a state of non-compliance.

Pre-Startup Safety Reviews

Before starting up a new process, a company should perform a full evaluation of the initial start-up procedures and normal operating procedures. This helps to assure a safe transition from start up to normal operation.

Mechanical Integrity Program

It is important that all equipment used in a process be properly designed, built, installed and maintained. This minimizes the risks of releasing hazardous chemicals. Elements of a mechanical integrity program include:

Identify/categorize equipment

Perform inspections/tests

Develop maintenance and training procedures

Establish acceptable test result criteria

Document manufacturer recommendations

Work Authorization Notices

These describe the steps necessary for maintenance supervisors, contractors, and other authorized personnel to obtain clearance to start a job. Work authorization notices cover procedures such as lockout/tagout, line breaking, confined space entry, and hot work authorizations.

Managing Change to Process

Processes sometimes need to be changed. It is important for a company to have a management-of-change (MOC) procedure in place to ensure that related process documentation and procedures are updated to reflect any changes, as figure 14 shows. For example, changing the type of control valve affects several documents including the P&ID, the process flow diagram, startup and operating procedures, the piping diagram, and the electrical diagram.

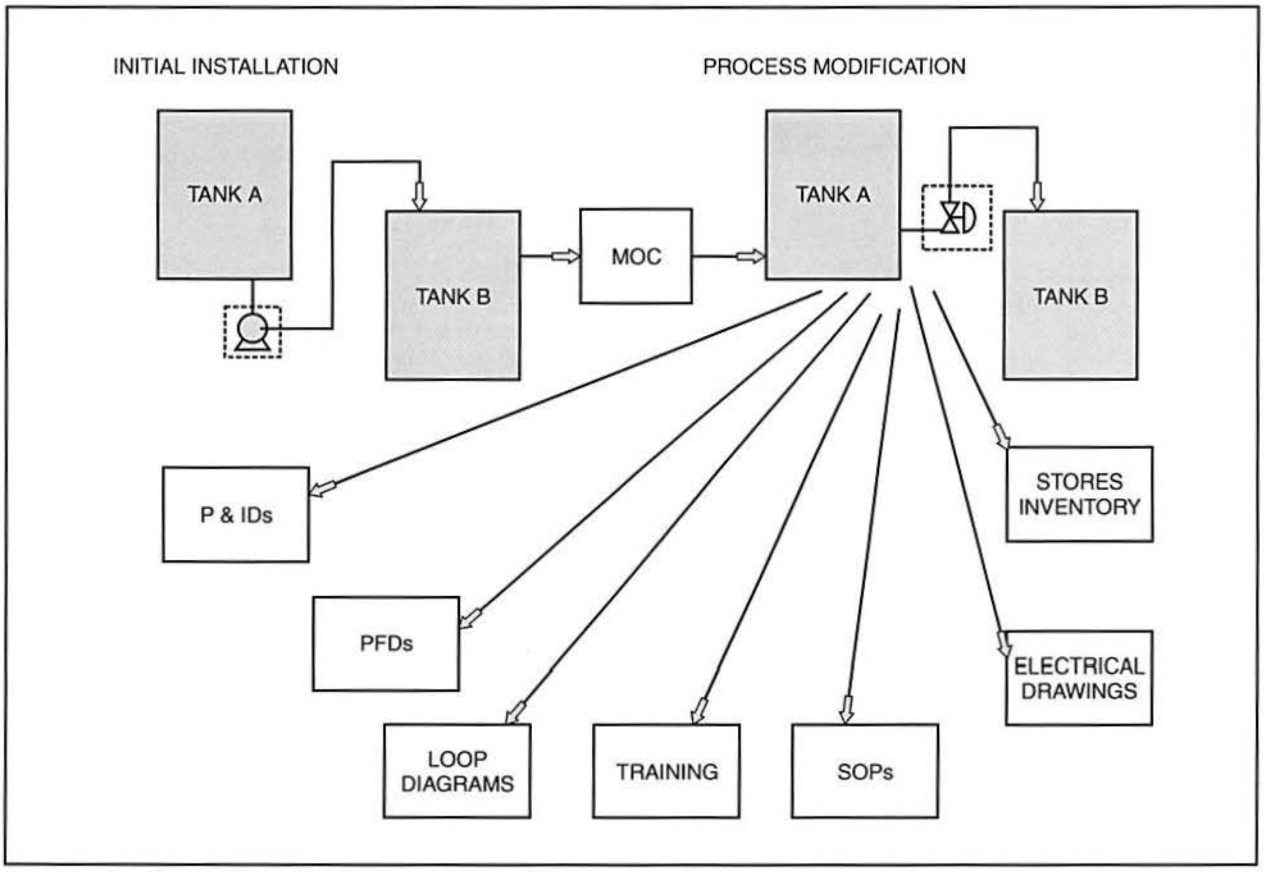

Figure 14. Documents Affected by Change in Process

Incident Investigation

Unfortunately, accidents and near misses occur during start up and operation of a process. It is extremely important to thoroughly investigate any accident or incident to identify the causes. Once the causes are identified, steps are identified and implemented to prevent similar occurrences.

Emergency Procedures

A company must have emergency procedures in place and all employees should be trained on these procedures. The level of preparedness is elevated by conducting drills, training exercises and simulations.

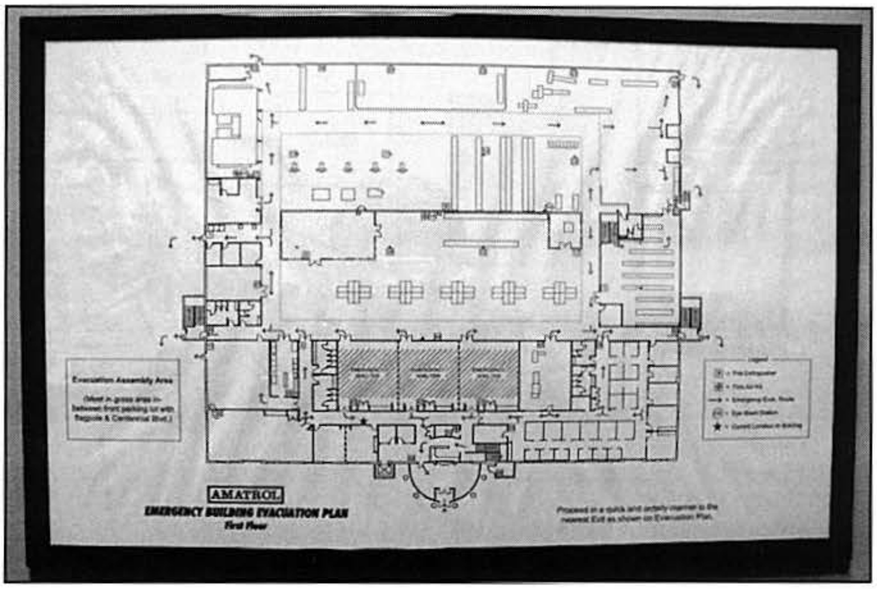

Figure 15. Emergency Evacuation Plan

Audits

According to OSHA guidelines, a company must certify its compliance with the PSM standard at least every three years by conducting an audit. Members from all disciplines should make up the audit team. All audits should be systematic. All findings and procedures should be thoroughly documented.

Trade Secret Protection

A company must make all information available to those involved in the implementation of the PSM standard. In some cases, this includes highly sensitive information. Persons entrusted with this information must often sign a confidentiality agreement. This agreement is a legally binding document that prohibits a person from discussing sensitive information about the company to anyone outside of the company.

OBJECTIVE 5 DESCRIBE THREE REQUIRED CATEGORIES OF PROCESS SAFETY INFORMATION

A company must compile and maintain process safety information and documentation to comply with the PSM standard. This information falls into three categories:

- Hazardous Chemical Information
- Process Technology Information
- Process Equipment Information

Hazardous Chemical Information

It is a requirement to have information available to all employees concerning any hazardous chemicals that may be present. This information is typically contained in a Material Safety Data Sheet (MSDS), like the one in figures 16 and 17. A MSDS is required for every chemical or other hazardous material. Some of the information provided on a MSDS includes:

- Toxicity data
- Permissible exposure limits
- Physical data
- Reactivity data
- Corrosive data
- Thermal stability data
- Chemical stability data

MATERIAL SAFETY DATA SHEET	
I. IDENTIFICATION	
PRODUCT: Polystyrene **CHEMICAL FAMILY:** Rubber Modified Polystyrene Thermoplastic Polymer **FORMULA:** (C2, H2, C4, H6)	
II. INGREDIENTS	
HAZARDOUS COMPONENTS	**APPROX. WT. PERCENTAGE**
Styrene (Residual)	<0.3%
NONHAZARDOUS COMPONENTS	
Mineral Oil	<0.7%
Antioxidant	<1%
External & Internal Lubricants	<0.9%
III. HEALTH INFORMATION	
GENERAL: normal handling with general ventilation would not expose operators to safety or health hazards **EYE CONTACT:** May cause mechanical irritation INHALATION: Dust may cause mechanical irritation. Standard operating temperatures at dies and molds would involve only minimal exposure to residual styrene vapors. Under normal industrial use there is no exposure to dust or vapor above health hazard limits. **SKIN CONTACT:** None Known **INGESTION:** Biologically Inert **MEDICAL CONDITIONS AGGRAVATED:** None Known	
IV. OCCUPATIONAL EXPOSURE LIMITS	
EXPOSURE LIMITS: None established for polystyrene Normal handling would involve only minimal exposure. **PEL (OSHA):** None 3-hour twa **TLY (ACGIB):** 10 for nuisance dust 3 for respirable dust	
V. EMERGENCY FIRST AID PROCEDURE	
EYES: Irrigate with water to wash out any particles. **INHALATION:** None Expected **SKIN:** Wash with soap and water to remove particles. **INGESTION:** Notify medical personnel	

Figure 16. Information on a MSDS (Page 1 of 2)

MATERIAL SAFETY DATA SHEET

VI. PHYSICAL DATA

BOILING POINT: N/A
VAPOR PRESSURE: N/A
MELTING POINT: Softens at 100°F TO 217°F
SPECIFIC GRAVITY: (H20 = 1): 1.04 - 1.06
APPEARANCE: Solid, milky white or colored
VOLATILE BY VOLUME: N/A
EVAPORATION RATE: N/A

VII. FIRE AND EXPLOSION HAZARDS

FLASH POINT: Does not apply
EXTINGUISH MEDIA: Water, Fog, Carbon Dioxide, or Dry Chemical
SPECIAL FIRE FIGHTING INSTRUCTIONS: Use approved self-contained breathing apparatus respirator and approved personal protective clothing.
UNUSUAL HAZARDS: Fire gives off dense black smoke, carbon monoxide, and carbon dioxide

VIII. REACTIVITY

STABILITY: Stable
HAZARDOUS POLYMERIZATION: None
HAZARDOUS DECOMPOSITION: Carbon Monoxide, Carbon Dioxide, Carbon, Water

IX. EMPLOYEE PROTECTION

RESPIRATORY PROTECTION: Not required under normal operating conditions.
SKIN PROTECTION: None under normal conditions.
EYE PROTECTION: ANSI-Approved safety glasses with side shields.

X. ENVIRONMENTAL HAZARDS AND PROTECTION

ENVIRONMENTAL HAZARDS: Fish may eat pellets and obstruct digestive tracts.
DISPOSAL METHOD: Recycle, incinerate or landfill per local and state regulations.

CHEMKIE, INC.
2584 CHEMISTRY ROAD
LEXINGTON, NY 22521
TELEPHONE NO. 555-452-5586
EMERGENCY NO. 555-452-5590

Figure 17. MSDS Page 2 of 2

Process Technology Information

The process technology information helps users to better understand the process. Common process technology information includes:

- Block diagrams
- Process Flow Diagrams
- Safe upper/lower limits for process variables (temperature, pressure, flow, level, chemical composition)
- Evaluation of consequences of process deviations

Figure 18 shows an example of a process flow diagram.

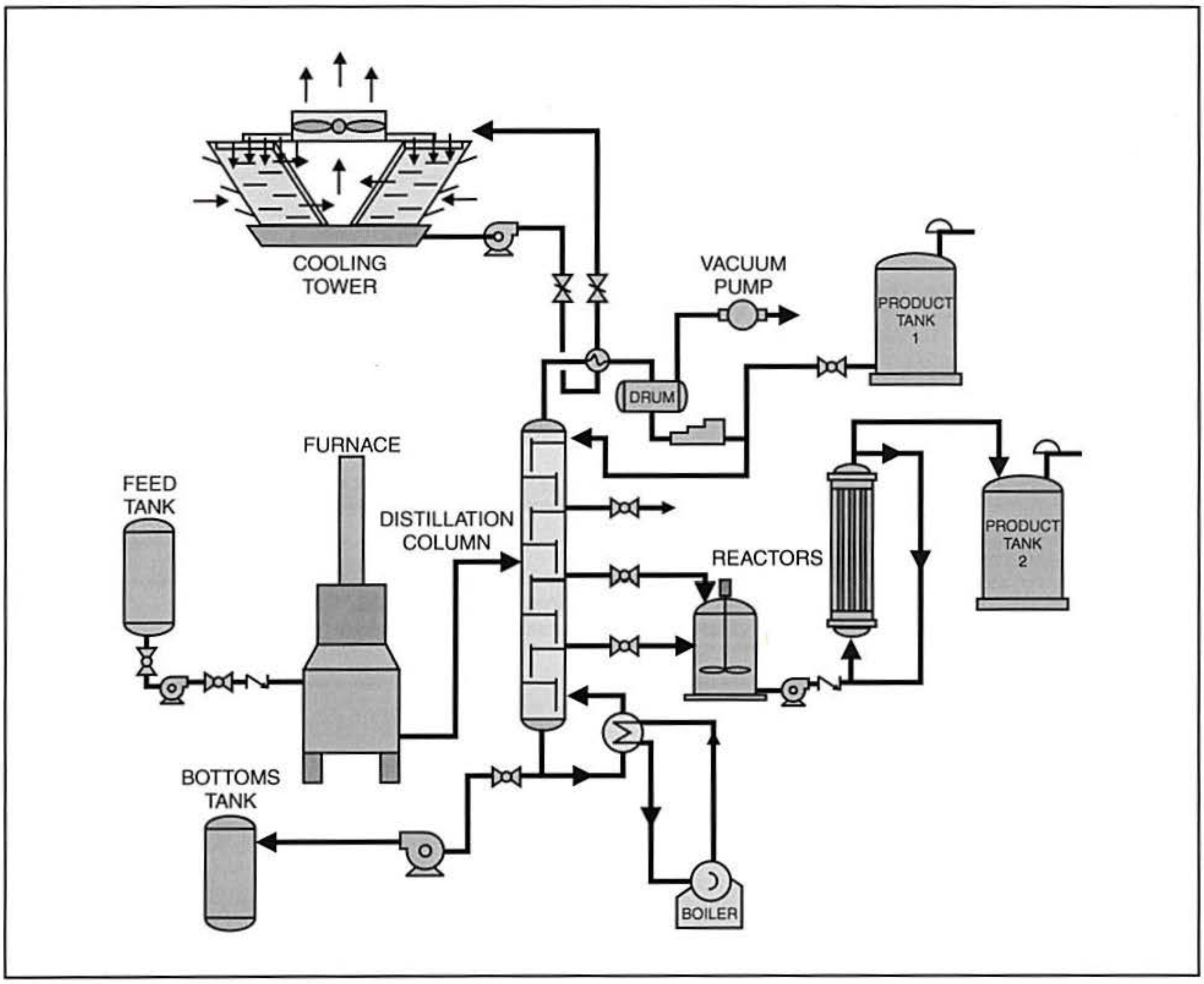

Figure 18. Process Flow Diagram

Process Equipment Information

A company must document that all equipment complies with recognized good engineering practices. This involves stating which codes or standards are observed. Examples of process equipment information include:

- Materials of construction
- P&IDs
- Electrical classifications
- Relief system design and design basis
- Ventilation system design
- Design codes and standards used
- Material and energy balances (for processes built after May 26, 1992)
- Safety systems (e.g. interlocks, detection systems, suppression systems)

It is necessary to have all of the process safety information up-to-date and available when performing a process hazard analysis.

OBJECTIVE 6 DESCRIBE THE FUNCTION OF A PROCESS HAZARD ANALYSIS

Read This

Performing a process hazard analysis (PHA) provides a means to identify, evaluate, and control the possible hazards in a process. A PHA focuses on all aspects of the process. The aspects include: the equipment, instrumentation, utilities, routine and non-routine procedures, and any external factors that may impact the process.

Figure 19. Process Equipment and Instrumentation

OSHA requires that all process hazard analyses be updated and revalidated at least every five years.

OBJECTIVE 7 DESCRIBE HOW TO PERFORM A PROCESS HAZARD ANALYSIS

Read This

Performing a process hazard analysis involves the following steps:

- Assemble a team
- Determine method(s) to use
- Make the analysis
- Develop an implementation plan

Assemble a Team

The first step of a PHA is to assemble a team to perform the analysis, as figure 20 shows. The team is made up of plant personnel from various disciplines including: management, process engineers, process technicians, and process operators.

It is extremely important to have at least one team member who is familiar with the theory and operation of the process. It is also necessary that at least one person on the team be familiar with the analysis methods.

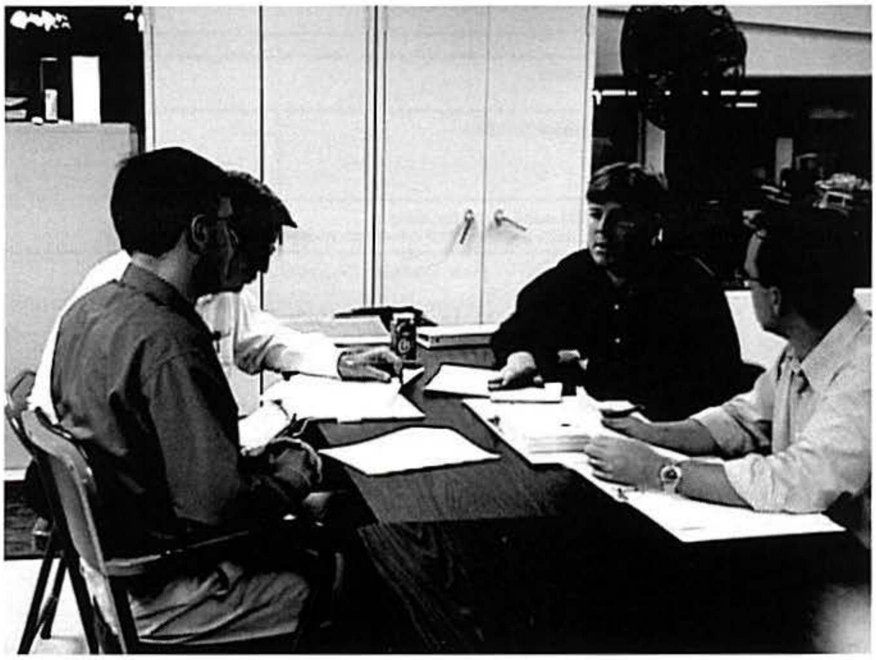

Figure 20. PHA Team Assembled

Determine Method(s) to Use

A process hazard analysis may be performed using one or more of the following methods:

- What If Scenarios
- Checklists
- Hazard and Operability Study (HAZOP)
- Failure Mode and Effects Analysis (FMEA)
- Fault Tree Analysis

In most cases, a combination of methods provides the most thorough analysis. It is up to the PHA team along with the company management to decide which method or methods should be used. The methods chosen often depend on the type of process. For example, figure 21 shows a typical HAZOP form.

HAZOP CHECK SHEET

Plant	Date
Drawings referred to	Author

Equipment	Tag Nos	
Equipment Function	Temp °C Press bar (g)	

Special conditions for Hazop:
none, start-up, abnormal operation, maintenance, other (details):

Properties: Flow Pressure Temperature

Guide Words: No More Less Opposite Also Other (Early Late)

Line no.	Function	°C	bar (g)

Figure 21. HAZOP Form

Regardless of the method(s) chosen, the PHA must address the following issues:

- Hazards of the process
- Identification of any previous incidents and possible consequences
- Engineering/Administrative controls applicable to the hazards (i.e. detection sensors, detection methods, alarms, etc.)
- Consequences of engineering/administrative control failures
- Human factors
- Evaluation of possible safety and health effects on employees due to failure of controls

Make the Analysis

Once the team is assembled and the analysis method is determined, the team can perform the analysis. The team should make a complete and thorough analysis. The analysis process must include all of the team members. The team should review all work and documentation and all should agree on the results of the analysis. It is also up to the team to make sure that all applicable forms and reports are filled out correctly.

Figure 22. PHA Team Reviewing Results

Develop an Implementation Plan

Once the PHA team presents their analysis and recommendations, the company must develop an implementation plan. The implementation plan must ensure that all issues and recommendations are addressed in a timely manner and that all resolutions are properly documented.

The company should develop a written schedule of what actions need to take place and when those actions should be completed. This information is shared with all employees involved with the process (i.e. operators, technicians, maintenance, engineers, etc.).

A company must keep all PHA documentation on file and make it available to OSHA when requested.

SKILL 1 PERFORM A PROCESS HAZARD ANALYSIS FOR THE T5554 ANALYTICAL PROCESS CONTROL SYSTEM

Procedure Overview

In this procedure, you will form teams and perform a process hazard analysis on the T5554 Analytical Process Control System. As a team, you will decide which method or methods to use to perform the analysis. You will then perform the analysis according to the chosen methods. Finally, you will document and report your findings and recommendations.

- ❑ 1. Notify your instructor when you are ready to perform the process hazard analysis.

  The instructor will assign you to a team. Each team will be made up of four to six members. Your instructor will also inform you which methods you will use to perform the analysis.

- ❑ 2. Meet with the other members of your team and discuss how you want to proceed. Come up with a plan and present it to your instructor.
- ❑ 3. Collect all relevant process documentation.

  This includes the P&ID, MSDS sheets, flow diagram, instrument specifications, operating procedures, etc.

- ❑ 4. After receiving approval from your instructor, go to the T5554 Analytical Process Control System, as shown in figure 23, and perform your analysis using the assigned methods.

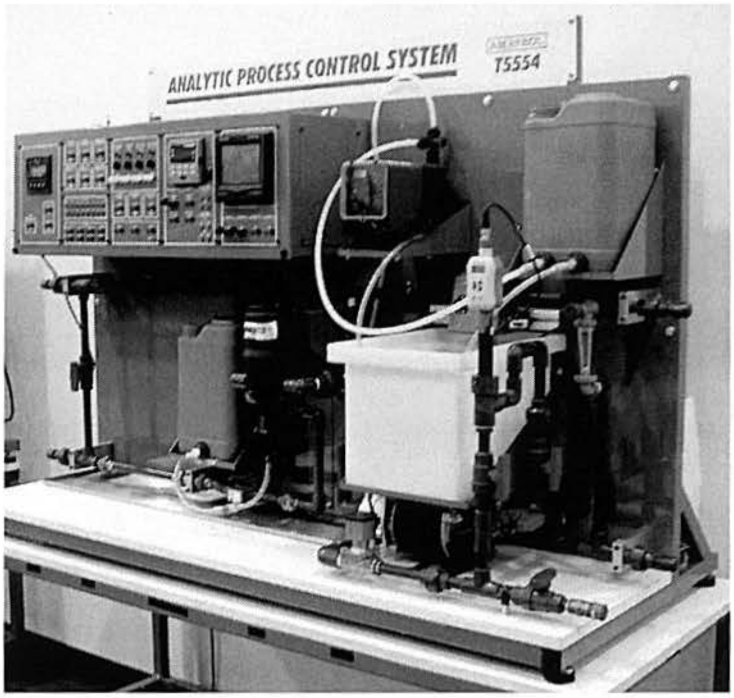

Figure 23. T5554 Analytical Process Control System

☐ 5. Be sure to thoroughly document all findings as you perform the analysis. You will make a presentation of your findings later.

Make sure the PHA addresses all relevant issues:

- Hazards of the process
- Identification of any previous incidents and possible consequences
- Engineering/Administrative controls applicable to the hazards (i.e. detection sensors, detection methods, alarms, etc.)
- Consequences of engineering/administrative control failures
- Human factors
- Evaluation of possible safety and health effects on employees due to failure of controls

☐ 6. Create an implementation plan based on the findings in your PHA. You will also present this plan when you make your presentation later.

☐ 7. Select a person or persons to present the findings of your teams PHA.

☐ 8. When instructed to do so, make your presentation.

Try to keep the presentation as brief as possible. However, be sure to cover all of your findings.

Once all of the presentations have been made, the instructor will work with the class to make a comprehensive list of the PHA findings and solutions. This list will include findings from each group.

SEGMENT 2

SELF REVIEW

1. The primary goal of the ______________________________ standard published by OSHA is to prevent the unwanted release of hazardous chemicals.

2. OSHA's PSM standard is divided into _____ points.

3. One type of safety document is a __________, which contains information concerning hazardous chemicals.

4. ________________ is a systematic approach of identifying and controlling possible hazards associated with a process.

5. A company must develop written ___________ procedures for all processes.

6. The three categories of process safety documentation are: hazardous chemical information, ____________________ information, and process equipment information.

7. Performing a _______________ provides a means to identify, evaluate, and control the possible hazards in a process.

8. OSHA requires that all PHAs be updated and revalidated at least every _________ years.

9. A(n) ____________ plan must ensure that all issues and recommendations from a PHA are addressed in a timely manner and that all resolutions are properly documented.

SEGMENT 3

CHEMICAL PUMPS

OBJECTIVE 8 DESCRIBE THE FUNCTION OF TWO CHEMICAL PUMPS USED IN ANALYTICAL PROCESSES AND GIVE AN APPLICATION

Read This

There are a number of special pumps designed to add chemicals to a process at a controlled rate. These pumps are used to adjust certain properties of the process fluid so they are within the desired range. Two common types of chemical pumps are eductor pumps and metering pumps.

Eductor Pump

An eductor pump, also called an injection pump, is a positive-displacement type chemical pump. This type of pump injects a specified volume of a chemical into the process at a frequency that is based on the flow rate of the process fluid.

Figure 24. An Eductor (Injection) Chemical Pump

For example, a common application of eductor pumps is in agriculture. Eductor pumps are often used to control the mixing of chemicals when the proper mix of chemicals is essential for good plant health and growth.

Figure 25. An Agricultural Example

Metering Pump

A metering pump is another positive-displacement type pump that injects a chemical into the process based on a specified stroke length and stroke rate. A metering pump typically does not depend on the flow rate of the process fluid to determine the frequency of injection.

Metering pumps are used in applications where the amount of the chemical injected is based on volume. For example, they are frequently used in the purification of municipal water supplies. Metering pumps inject chemicals that reduce or eliminate contaminates in the water supply.

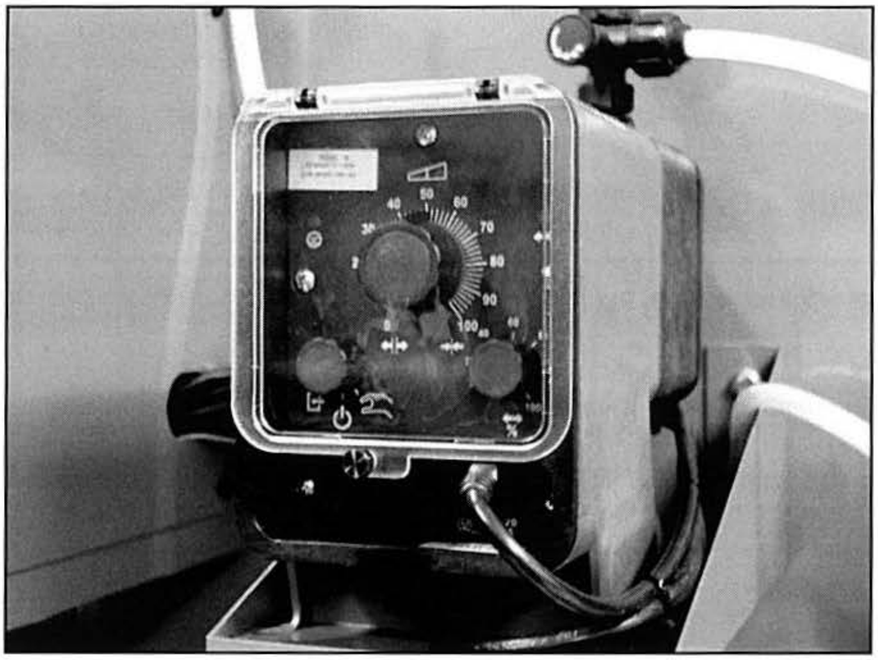

Figure 26. A Metering Chemical Pump

OBJECTIVE 9 DESCRIBE THE OPERATION OF AN EDUCTOR PUMP

An eductor pump is typically connected directly into the process piping, as shown in figure 27, to chemically treat water as it passes through the pump. A chemical used to treat a process fluid is referred to as a reagent. The reagent changes the chemical properties of the process fluid, for example pH.

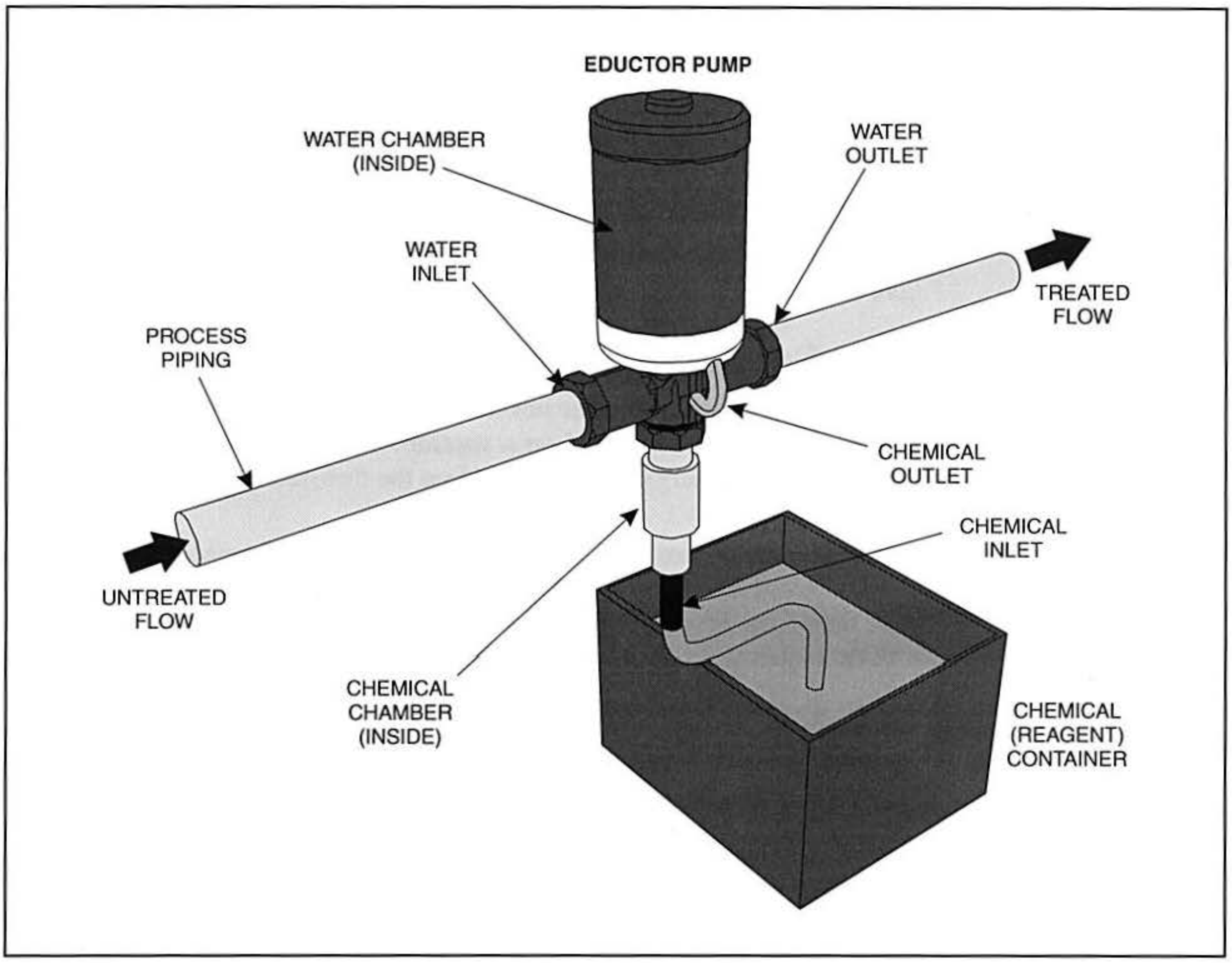

Figure 27. Operation of an Eductor Pump

Inside the pump are two pistons connected to the same shaft, as figure 28 shows. The water piston allows incoming water to fill the water chamber when the inlet check valve opens. At the same time, the check valve in the chemical inlet opens, allowing the dosage piston to draw the reagent into the chemical chamber.

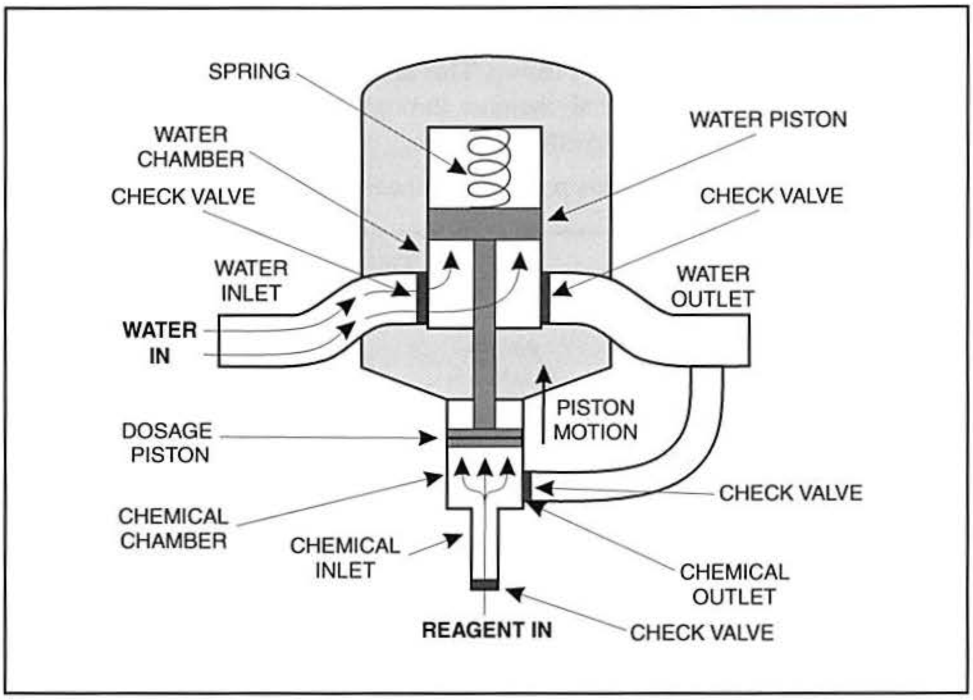

Figure 28. Pistons Allow Chambers to Fill

As water enters the pump through the water inlet, it fills the water chamber inside the pump. As water fills the water chamber, the chemical (reagent) is drawn into the chemical chamber. The amount of reagent that enters the chemical chamber is a specified ratio of the water in the water chamber.

When the water chamber is filled, the water is pumped out of the chamber through the water outlet. At the same time, the reagent is pumped from the chemical chamber through the chemical outlet and into the outgoing water.

When the water piston reaches full stroke, the water inlet check valve closes and the spring tension causes the piston to reverse. This causes the water outlet check valve to open, allowing the water to escape through the water outlet, as figure 29 shows. This also causes the dosage piston to push the reagent out of the chemical chamber through the chemical outlet check valve, where it is injected into the outgoing flow.

This process continues as long as there is sufficient flow in the process piping.

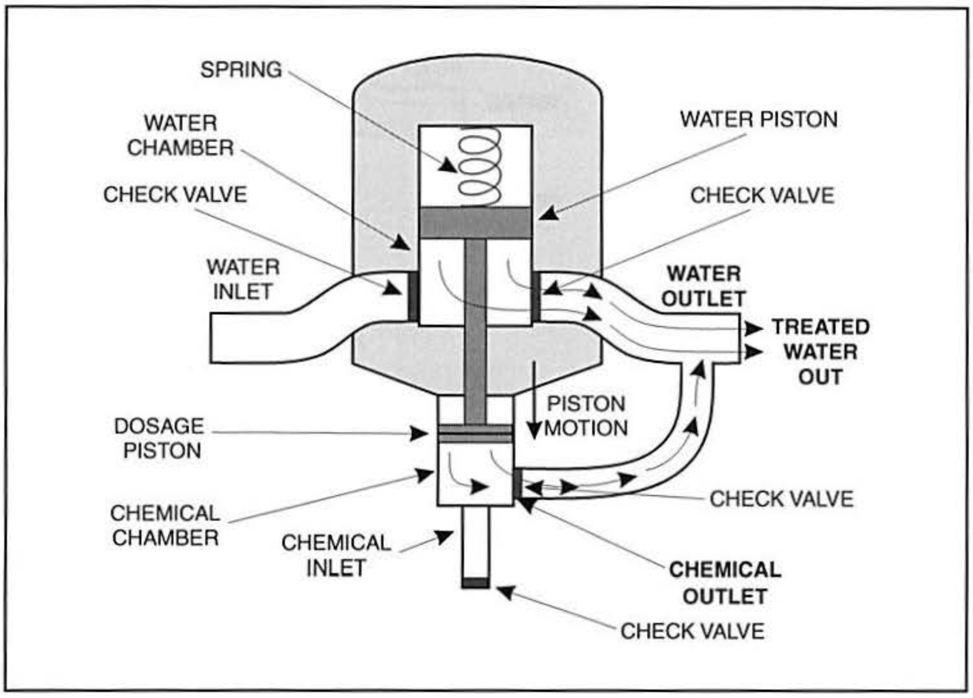

Figure 29. Pistons Force Water and Reagent Out of Chambers

The ratio of the reagent that is injected into the exiting water is controlled by an injection ratio control on the pump, similar to figure 30. For example, the ratio control in figure 30 has a range from 100:1 (1%) to 500:1 (0.2%).

To better understand the effect of the ratio control, suppose that the water chamber of the pump holds 950 mL (1 quart). A ratio control setting of 100:1 (1%) would result in 9.5 mL (950 <@180> 0.01 = 9.5) of reagent being injected into the outgoing water from the pump.

Figure 30. The Injection Ratio Control Dial

Some eductor pumps include a bypass valve, similar to figure 31, that allows water to flow through the pump without injecting the reagent. The bypass valve opens a special path around the water chamber. Some pumps now include an on/off switch that controls when the pump injects reagent (on) or lets the process fluid pass through unaffected (off).

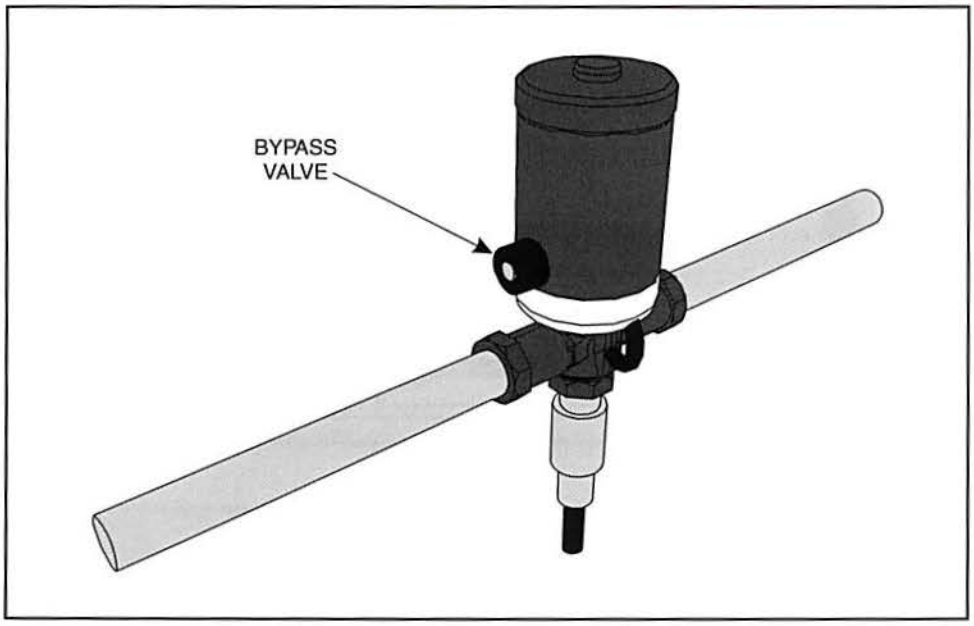

Figure 31. Bypass Valve

Procedure Overview

In this procedure, you will set the injection ratio control of the Dosmatic MiniDos eductor pump on the T5554 Analytical Process Control System.

❑ 1. Perform a lockout/tagout on the main power circuit breaker of the T5554.

❑ 2. Perform the following substeps to fill the reactor tank with fresh tap water.

If the tank currently has water in it, the water must be drained from the tank before filling it with fresh water.

A. If the tank needs to be drained, close the drain shutoff valve shown in figure 32. Observe the labels on the handle of the valve to determine the shutoff position.

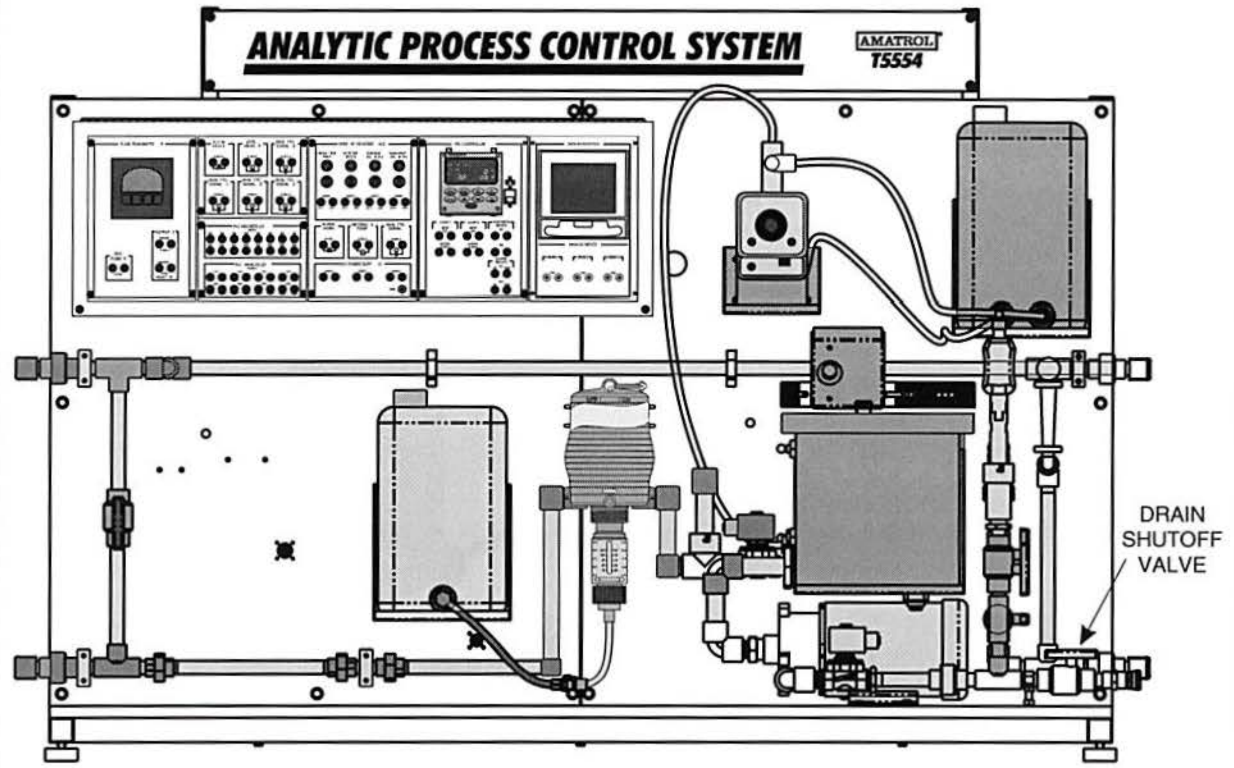

Figure 32. Drain Shutoff Valve

You can either drain the reactor tank using a hose or you can drain into a bucket.

B. Remove the drain cap from the drain connector, shown in figure 33, by turning it counterclockwise.

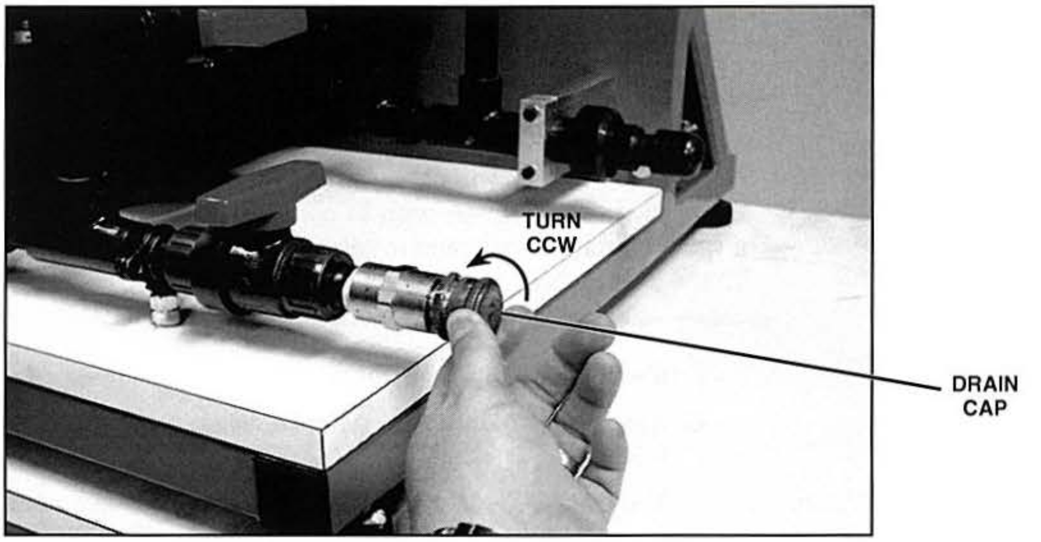

Figure 33. Remove Drain Cap

C. To use a hose, connect one end of the hose to the drain connector, as shown in figure 34, and place the other end of the hose in a sink or near a drain in the floor.

If you are draining into a bucket, simply hold the bucket beneath the drain connector and use the shutoff valve to start and stop the draining.

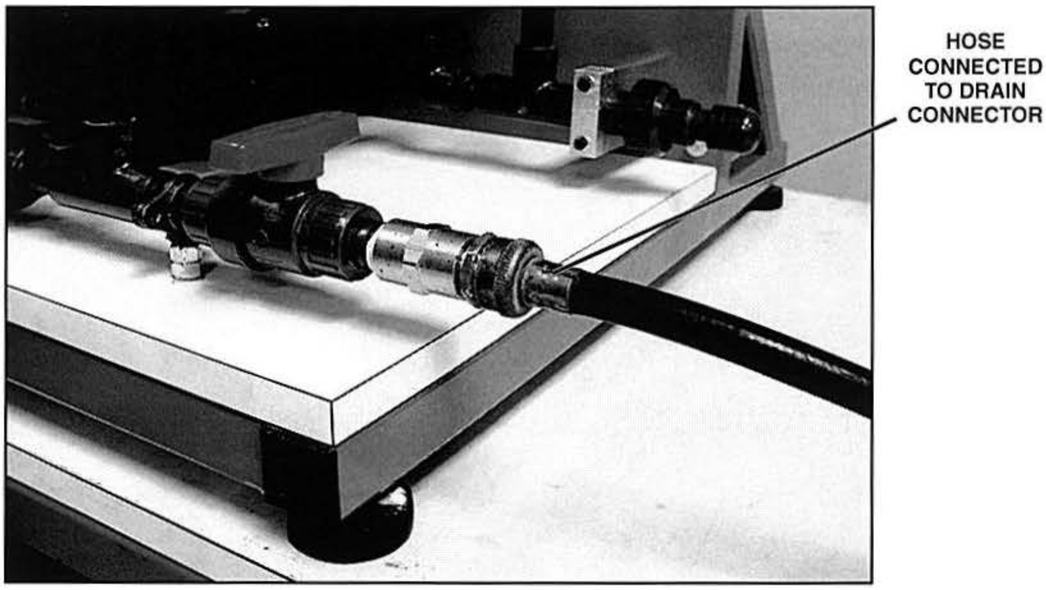

Figure 34. A Hose Connected to the Drain Connector

D. When ready, open the drain shutoff valve to allow the water to flow out of the reactor tank. If you are using a bucket, you must close the shutoff valve each time the bucket fills.

E. When the tank has drained, close the drain shutoff valve.

NOTE

The reactor tank will not completely drain due to the location of the drain fitting in the tank. If you wish to completely empty the tank, you must use a sponge or a shop vacuum to remove the water that remains. Although the T5554 does not use dangerous chemicals, rubber gloves are advised.

F. If you are using a hose, disconnect it from the drain connector.

G. Replace the drain cap on the drain connector by turning it clockwise until it is tight.

You can fill the tank with fresh water using either a hose connected to a faucet (if the water supply is close by) or using a bucket.

H. Fill the reactor tank with fresh tap water until the level is just below the high level switch, as shown in figure 35.

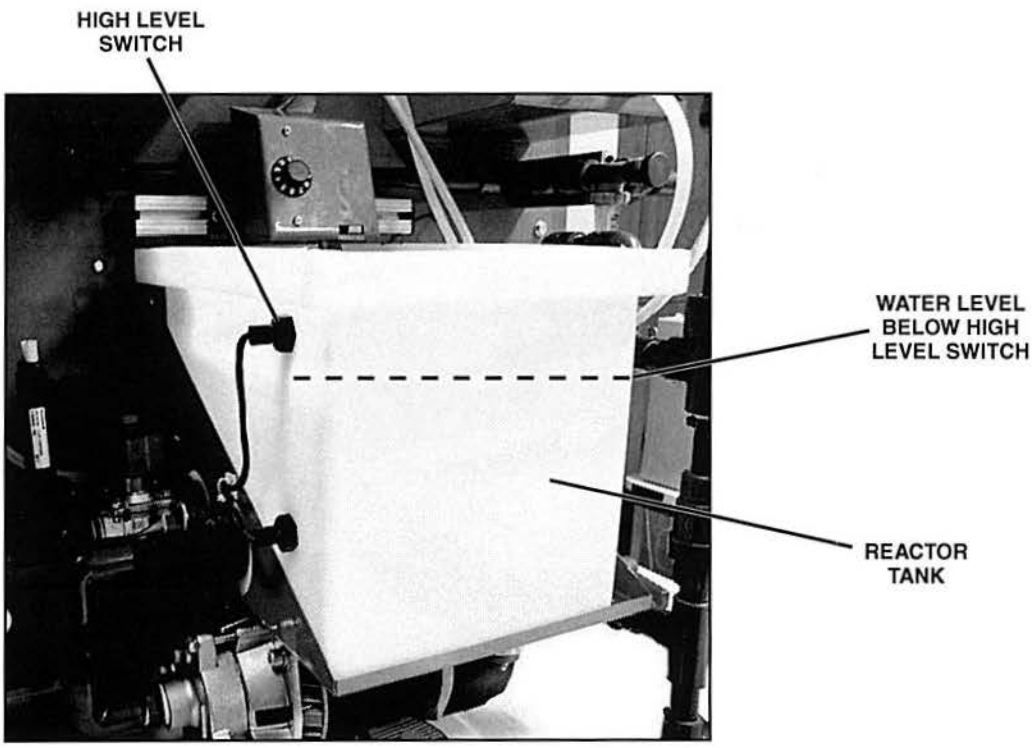

Figure 35. Water Level Just Below the High Level Switch

- [ ] 3. Make sure the reagent tank for the main process loop is at least 1/4 full. If not, add more of the reagent (sodium bisulfate solution) until the tank is at least 1/4 full.

  The sodium bisulfate solution is mixed with water at a 10:1 ratio, 10 parts water to 1 part sodium bisulfate powder, measured by weight.

  If necessary, you can remove the tank from its support bracket, as shown in figure 36, and place it on the table to fill it.

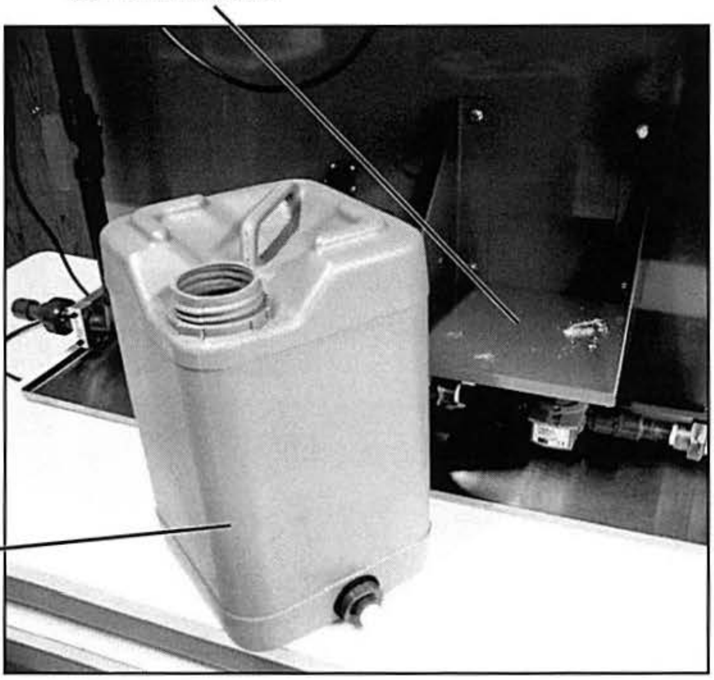

Figure 36. Main Process Loop Reagent Tank Removed from Support Bracket

❑ 4. Make sure the reagent tank for the pH control loop is at least 1/4 full. If not, add more of the reagent (sodium carbonate solution) until the tank is at least 1/4 full.

The sodium carbonate solution is mixed with water at a 10:1 ratio, 10 parts water to 1 part sodium carbonate powder, measured by weight.

This tank can also be removed from its support bracket. However, to set in on the table, you must disconnect the two hoses from the tank. To do this, you must press the release tabs on the connectors, shown in figure 37, and pull the hoses out of the connectors. The connectors are positive shutoff type connectors and will not allow the tank to leak when the hoses are removed.

To replace the hoses, simply push them into the connectors until they snap into place.

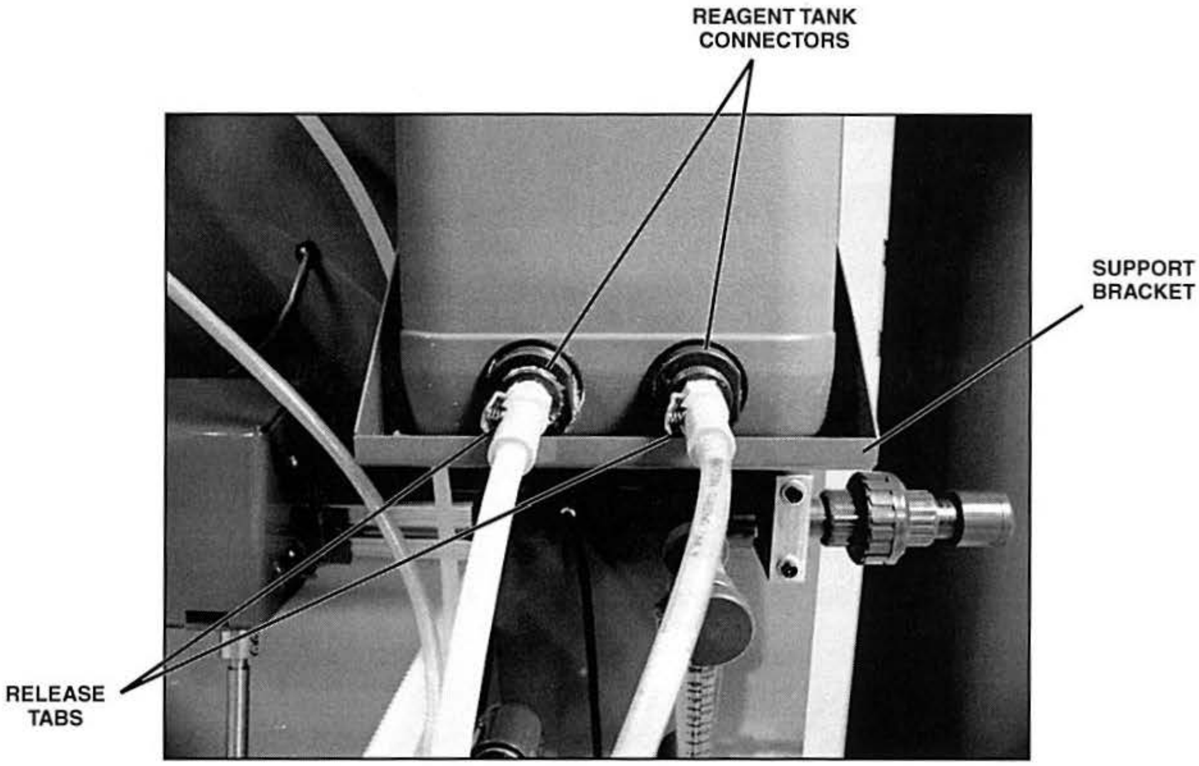

Figure 37. Release Tabs on the Reagent Tank Connectors

Now that all of the tanks have been checked and filled (if necessary), you can safely operate the system.

❑ 5. Perform the following substeps to set the injection ratio for the eductor pump.

NOTE

If the injection ratio is already set to 100:1, you can skip to the next step.

A. Locate the locking pin for the pump and remove it by pulling it out of the holes, as shown in figure 38.

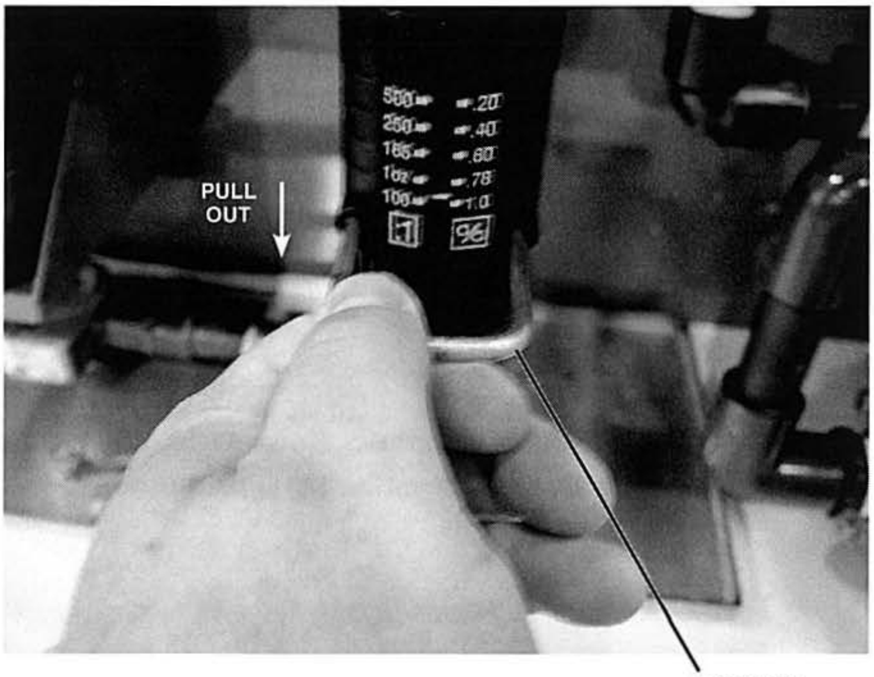

Figure 38. Removing the Locking Pin

The pin will be hard to remove so you may need a screwdriver blade to help start it.

B. Set the ratio control dial to a ratio of 100:1, as shown in figure 39.

To do this, you must rotate the dial counterclockwise to decrease the ratio and clockwise to increase the ratio.

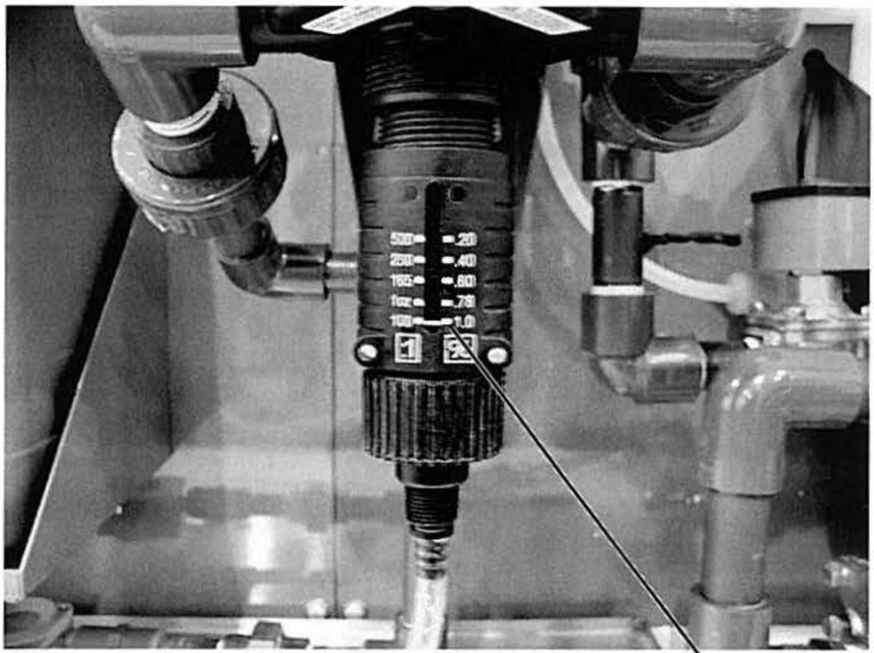

Figure 39. Ratio Control Dial Set to 100:1 Ratio

C. When the dial is set to the desired ratio (100:1), replace the locking pin by pushing it into the holes beneath the ratio control dial, as shown in figure 40.

NOTE

The locking pin only goes in one direction. If the pin will not go in, rotate the dial 180° in either direction and try again.

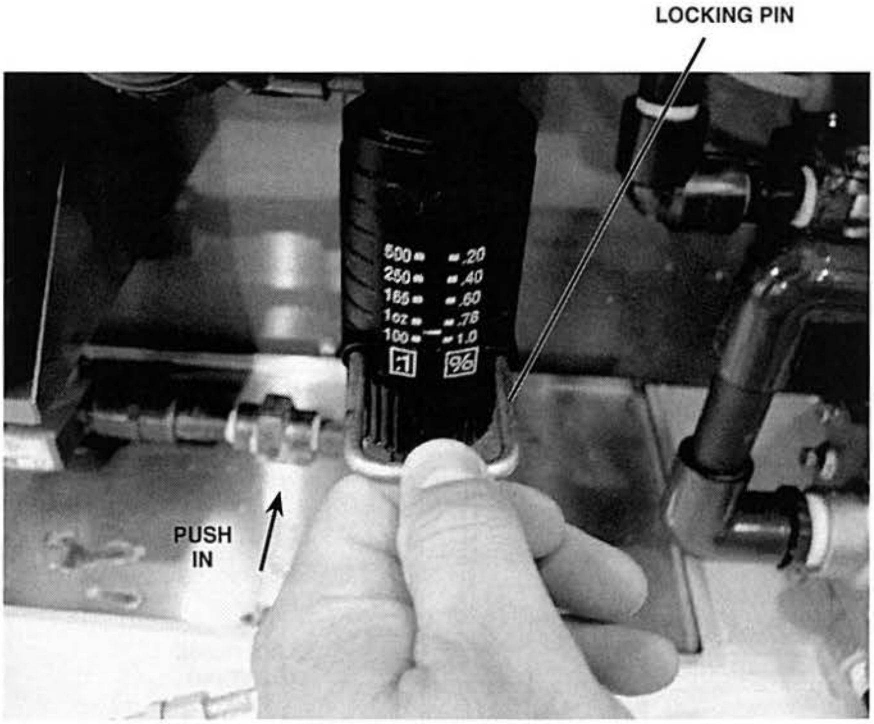

Figure 40. Inserting the Locking Pin

The pin will be difficult to push in. You will need to exert a good amount of force.

❑ 6. Remove the lockout/tagout.

OBJECTIVE 10 DESCRIBE THE OPERATION OF ANELECTRONIC METERING PUMP

Read This

An electronic metering pump outputs a reagent at a specified volume and rate. This differs from the eductor/injector type pump because the rate (frequency) at which the reagent is pumped by the electronic metering pump is not determined by the flow rate of the process fluid. An electronic metering pump is connected between the reagent tank and the reactor tank through process piping similar to figure 41, so that it can pump the reagent into the process as required.

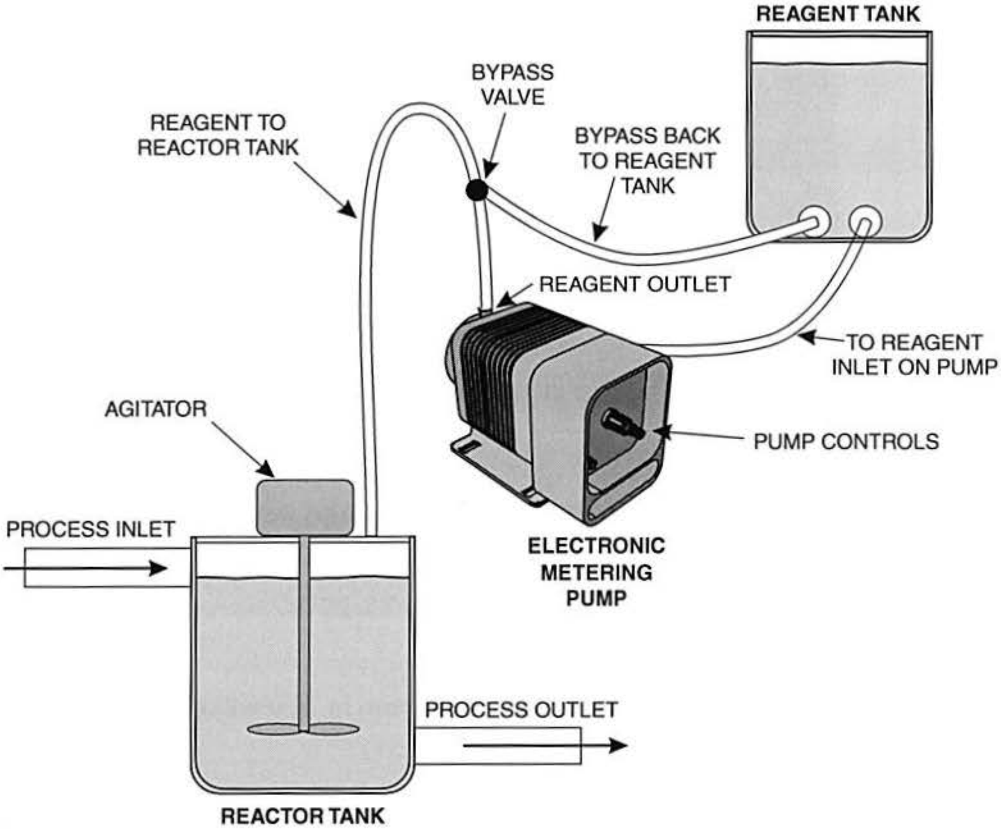

Figure 41. Operation of an Electronic Metering Pump

An electronic metering pump is comprised of two different sections: the pump and the control section, as shown in figure 42. The pump is attached to the back of the controls housing and pumps the reagent into the process. The control section contains all of the control devices necessary to electronically control the operation of the pump.

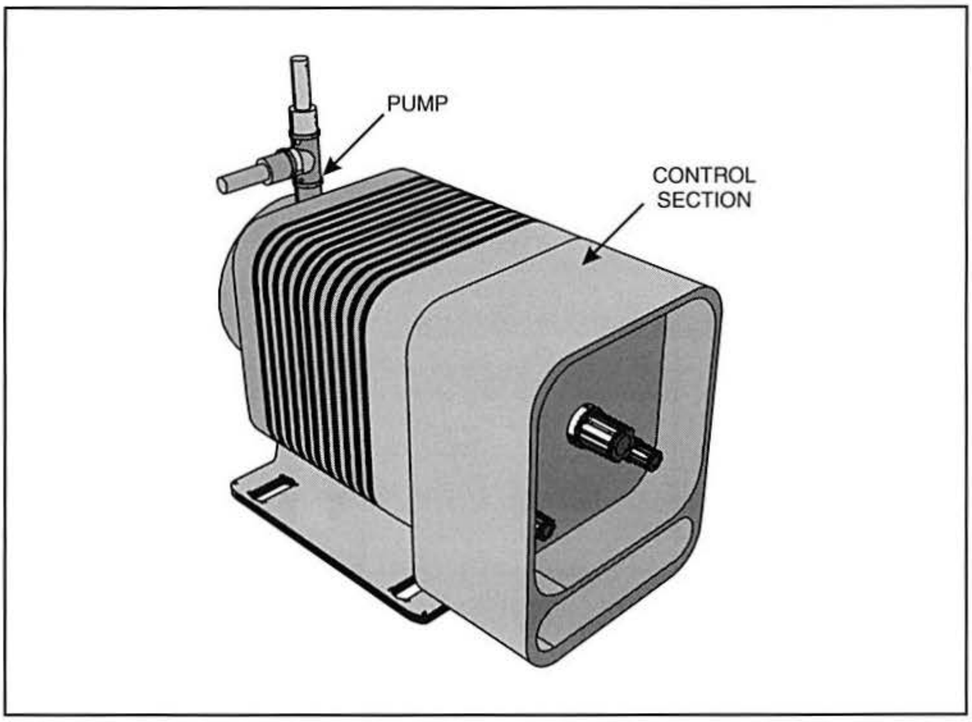

Figure 42. Two Sections of an Electronic Metering Pump

Pump Operation

The reagent enters the pump through the reagent inlet during the suction stroke of the pump.

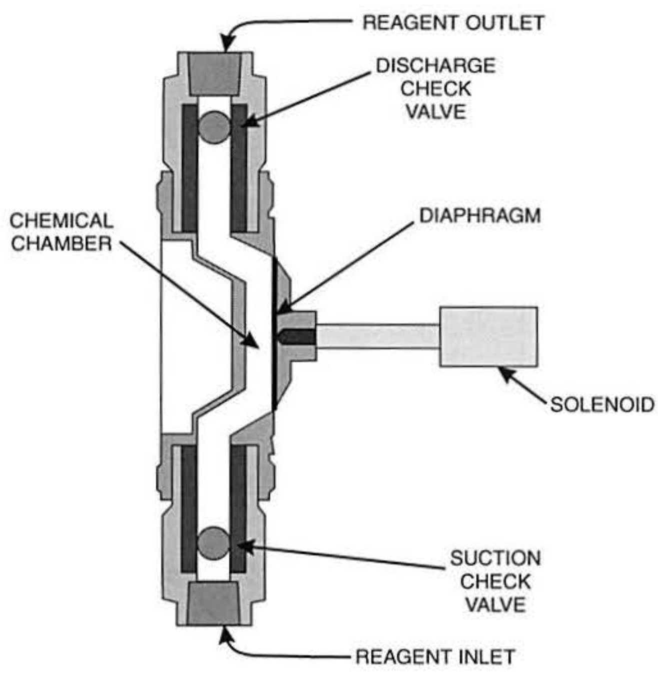

Figure 43. Components of the Pump

The solenoid controls the stroking of the pump by moving the diaphragm back and forth. When the diaphragm is retracted (suction stroke), the suction check valve opens and allows the reagent to flow into the chemical chamber.

When the diaphragm is extended (discharge stroke), the suction valve closes and the discharge check valve opens. This forces the reagent out of the chemical chamber through the discharge valve and the reagent outlet. This process continues as long as the solenoid continues to reciprocate the diaphragm.

Control Section Operation

The components of the control section shown in figure 44 are:

- Mode Selector Dial
- Percent Stroke Length Dial
- Stroke Rate Percent Dial
- 4-20mA Input Terminal

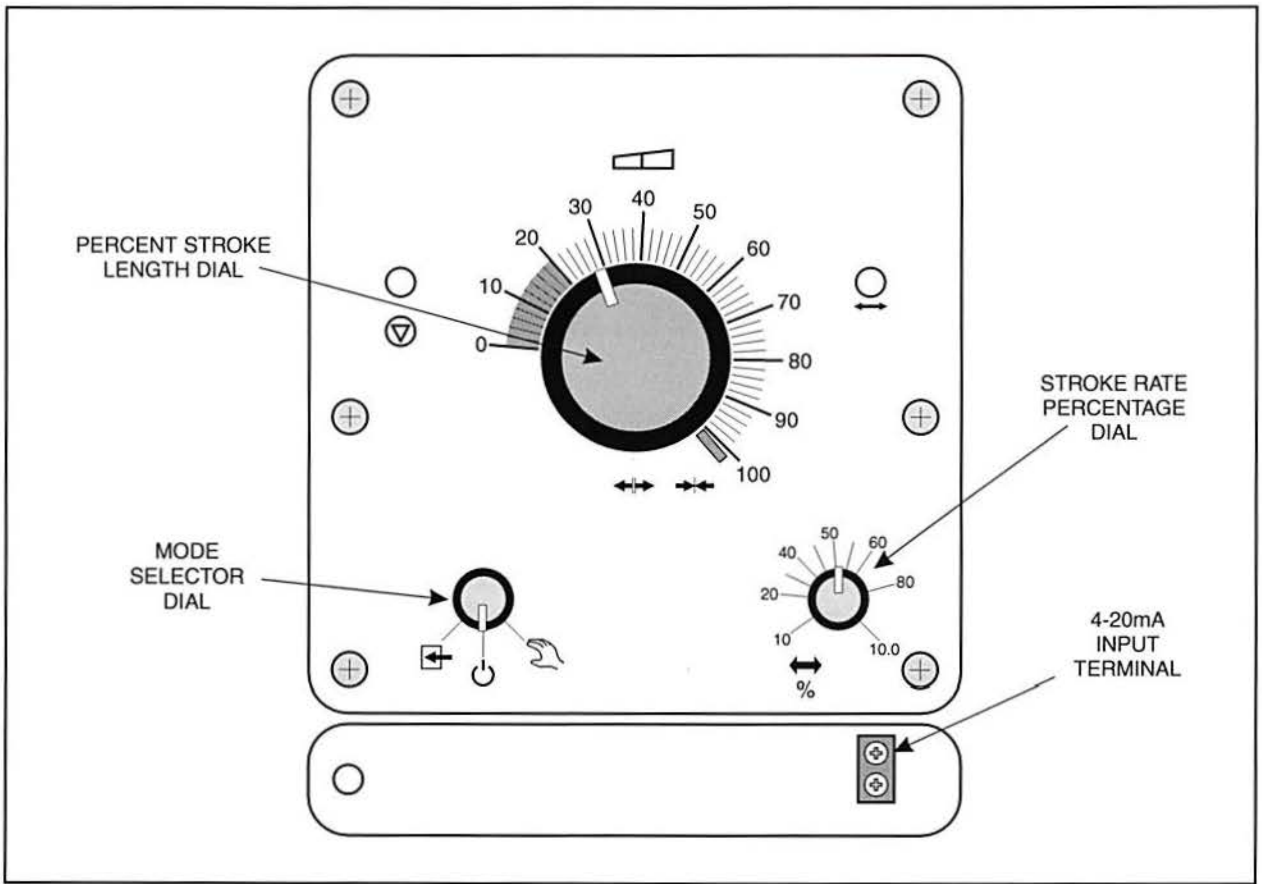

Figure 44. Control Section Components

An electronic metering pump typically has three modes of operation: manual, automatic, and standby. The desired mode is selected using the mode selector dial, similar to figure 45.

When manual mode is selected, the pumps diaphragm is stroked based on the stroke rate percentage setting. When the automatic mode is selected, the pumps diaphragm is stroked based on the level of the input signal (4-20 mA) provided by an external controller. When placed in the standby mode, the pump does not operate.

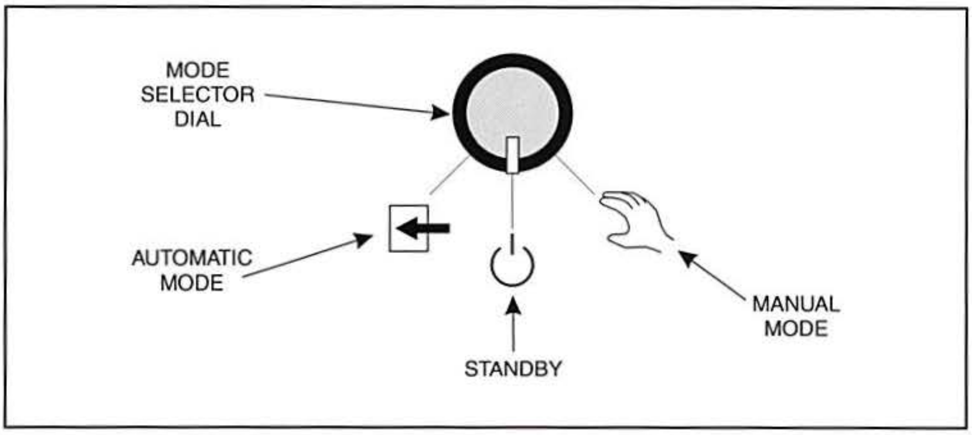

Figure 45. Mode Selector Settings

The stroke length for the solenoid and diaphragm is controlled by the percent stroke length setting. The range is from 0% to 100% of full stroke, as figure 46 shows. The stroke length determines the volume of the reagent pumped out with each stroke of the diaphragm for both the manual and automatic modes.

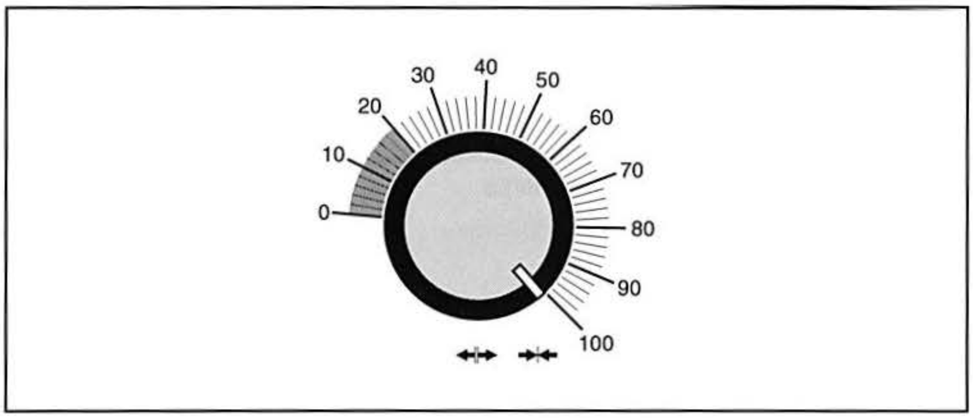

Figure 46. Percent Stroke Length Control

When the electronic metering pump is in the manual mode, the stroke rate percentage setting shown in figure 47 establishes the frequency at which the diaphragm strokes. The range is typically from 0% to 100% of the maximum stroke rate, which is specified by the manufacturer.

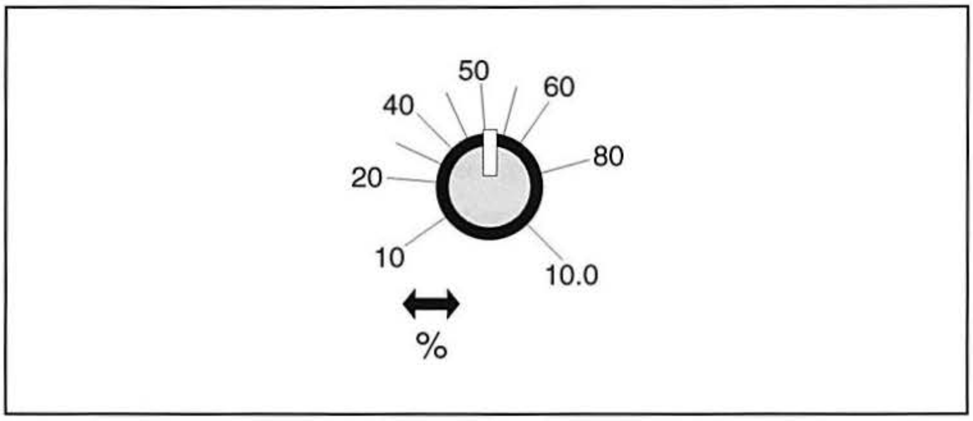

Figure 47. Stroke Rate Percentage Control

When the automatic control mode is used, the 4-20mA input terminal allows the analog signal (4-20mA) from an external control device to be connected to the metering pump to control the stroke rate instead of the stroke rate percent setting. Figure 48 shows the linear relationship between the stroke rate and the 4-20mA signal. For example, a 5.6mA signal results in a stroke rate of 10% of the maximum rate.

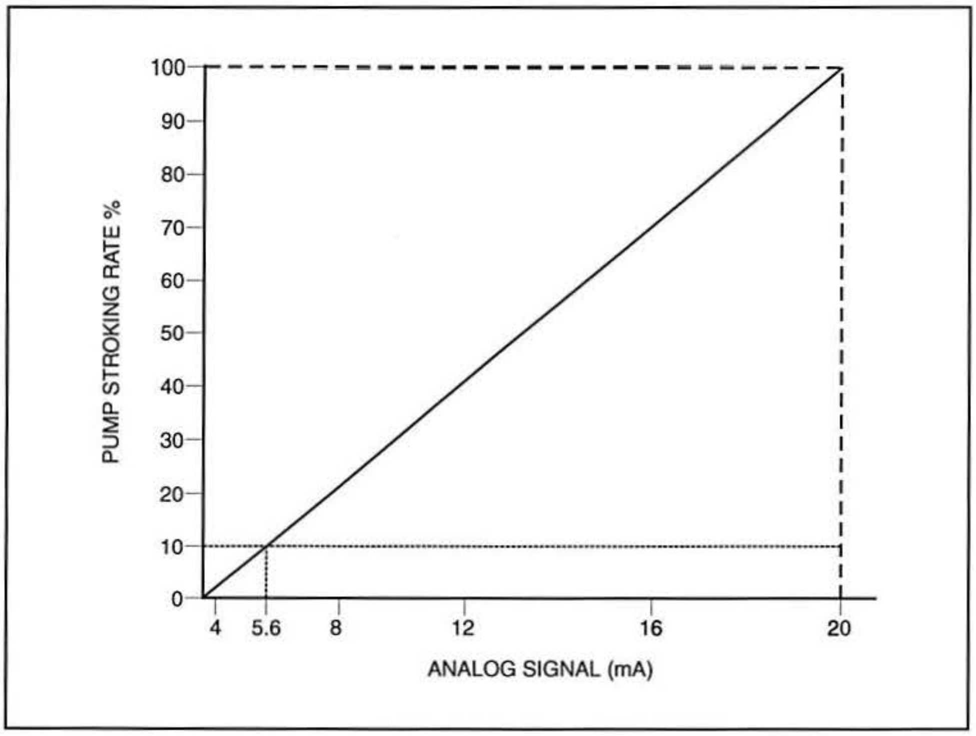

Figure 48. Stroke Rate vs. 4-20mA Signal

Pump Priming

If the pump is new or has not been used in a while, it may be necessary to prime the pump. Priming the pump purges any air from the pump. Air trapped in the pump prevents the pump from pumping the reagent.

Typically, a bypass valve is used on the discharge side of the pump, similar to figure 49, so the output of the pump is diverted from the process and into an open container or back into the reagent tank. Once the bypass valve is open (fully CCW), the percent stroke length setting is adjusted to 0%. This causes the discharge valve to remain open constantly to allow a steady stream from the pump.

When a steady stream with no air bubbles comes out of the bypass tubing, the pump is primed and ready to connect to the process. To do this, the percent stroke length setting is adjusted to the desired percentage and the bypass valve is closed (fully CW).

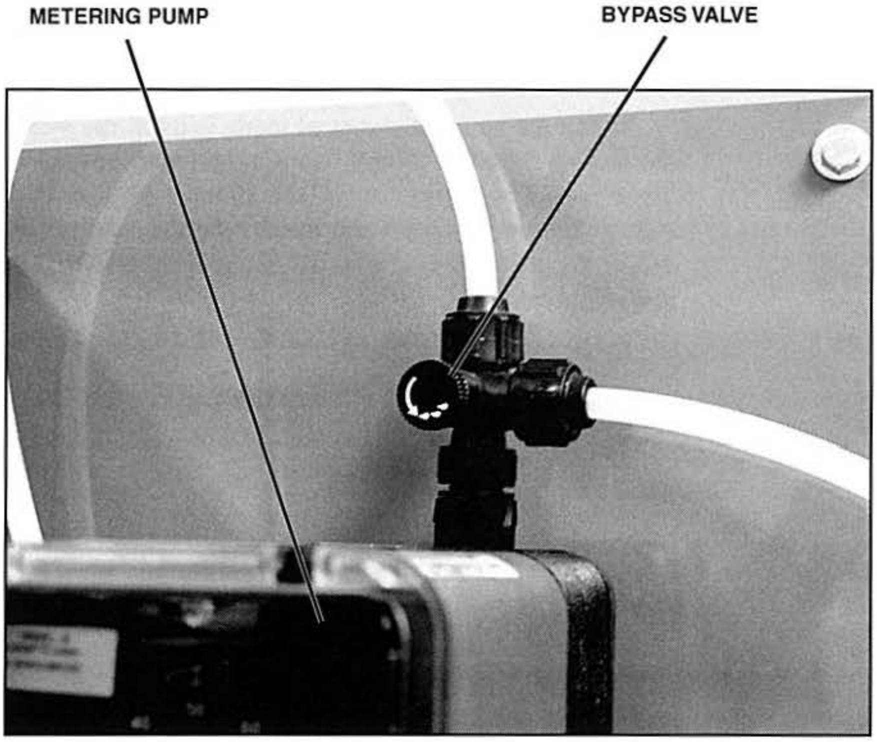

Figure 49. Bypass Valve Used for Priming the Pump

SKILL 3 MANUALLY SET AND CONTROL A METERING PUMP

Procedure Overview

In this procedure, you will set and operate the metering pump on the T5554 Analytical Process Control System in the manual mode. As a part of this procedure, you will perform the steps to prime the pump.

❑ 1. Perform a lockout/tagout.

❑ 2. Perform the following substeps to set up the T5554, as shown in figure 50.

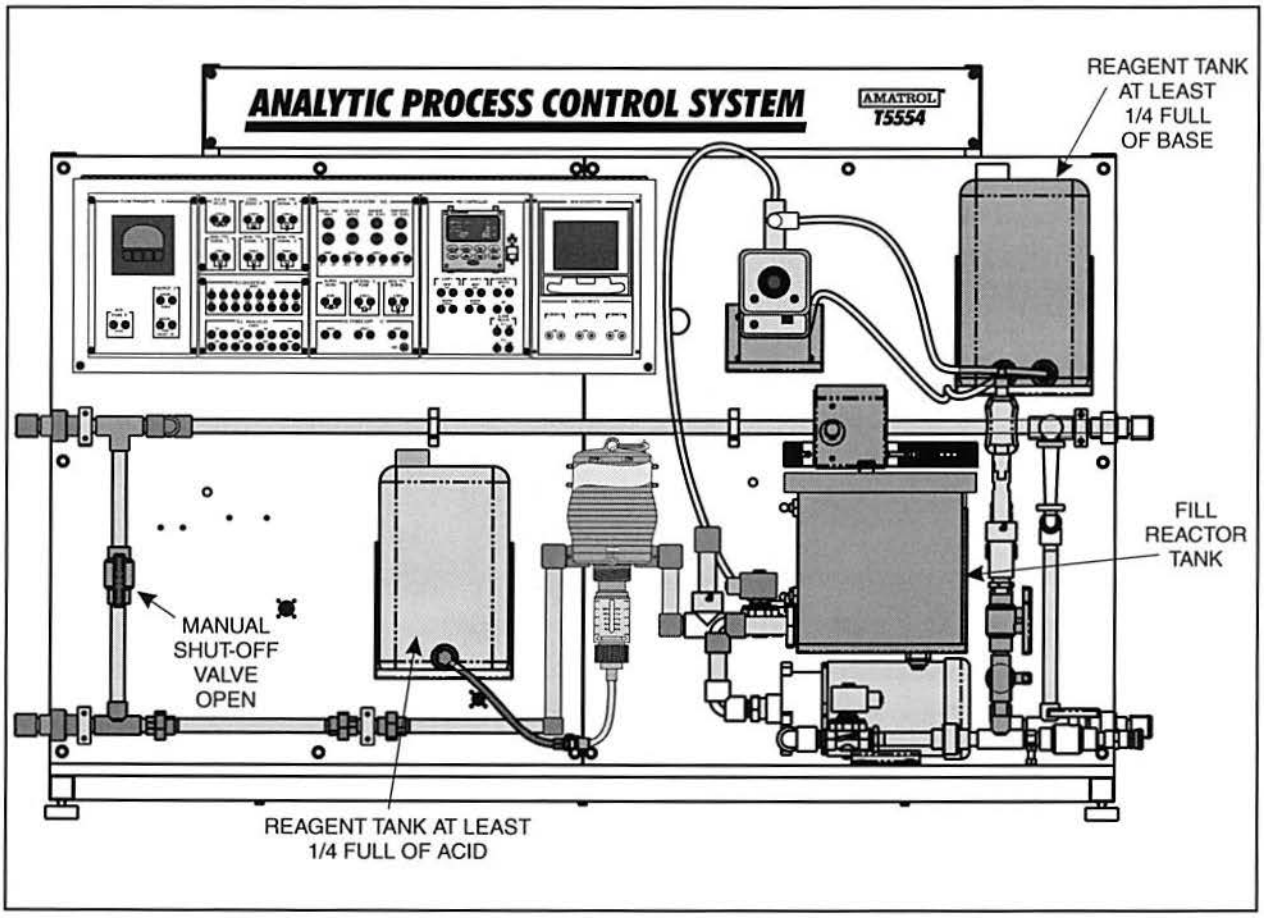

Figure 50. Setup for T5554

A. Make sure the reactor tank is filled with water to a level between the high and low level sensors.

B. Make sure the main process reagent tank is at least 1/4 filled with the reagent (sodium bisulfate solution). If not, fill the tank as necessary.

C. Make sure the pH control loop reagent tank is at least 1/4 filled with the reagent (sodium carbonate solution). If not, fill as necessary.

D. Make sure the manual shutoff valve in the main process loop is open.

❑ 3. Perform the following substeps to prime the electronic metering pump.

A. Locate the bypass valve for the electronic metering pump and set it to the bypass position (fully CCW), as shown in figure 51.

Setting the bypass valve to the bypass position causes the reagent to be pumped back into the reagent tank instead of into the reactor tank. This allows you to prime the pump without affecting the process fluid in the reactor tank.

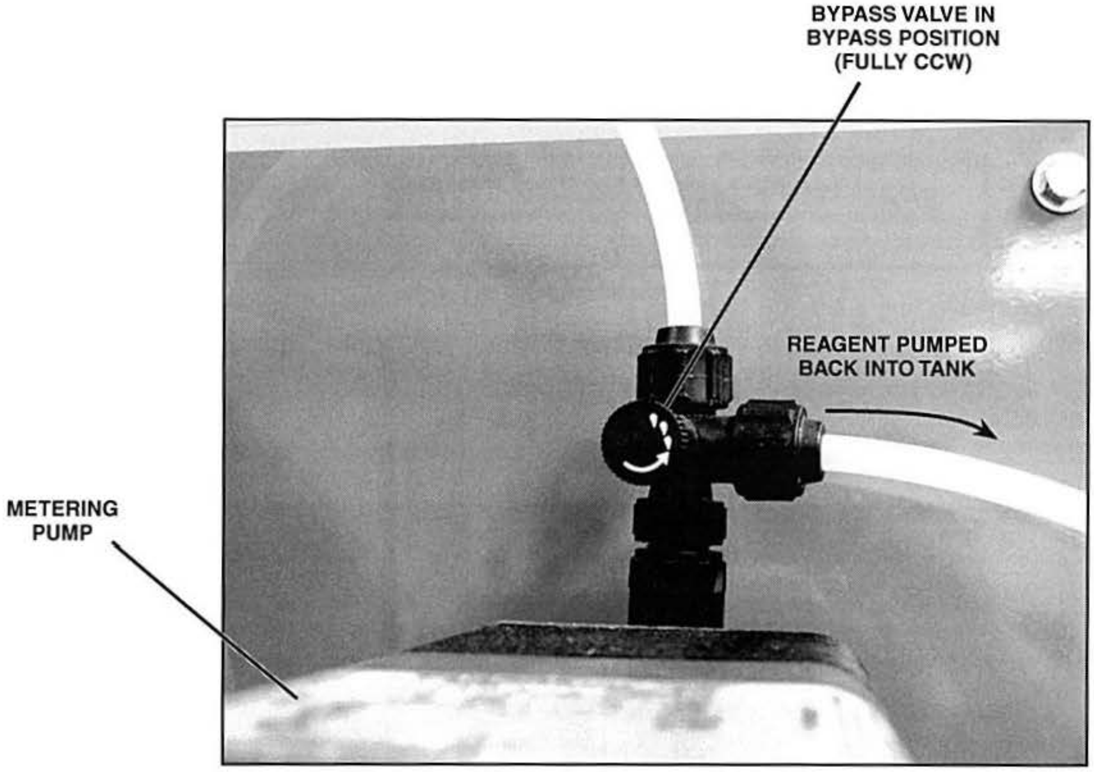

Figure 51. Bypass Valve Set to Bypass Position

B. Remove the lockout/tagout and turn on the main power circuit breaker.

C. Open the plastic cover over the electronic metering pump controls, shown in figure 52.

To do this, turn the locking screw, shown in figure 52, counterclockwise and lift the cover.

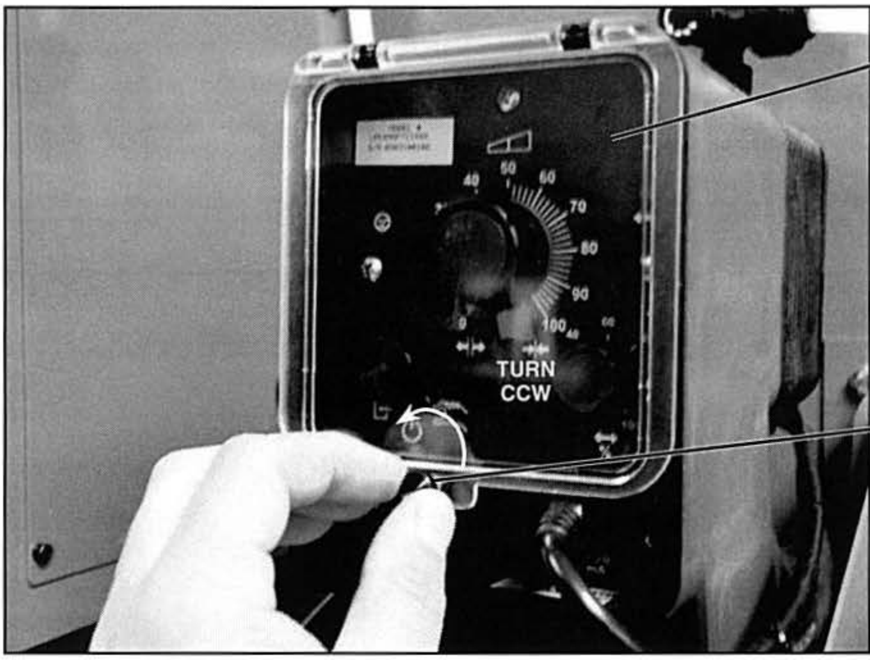

Figure 52. The Plastic Cover Over the Controls

D. Set the mode selector dial to the Manual position, as shown in figure 53.

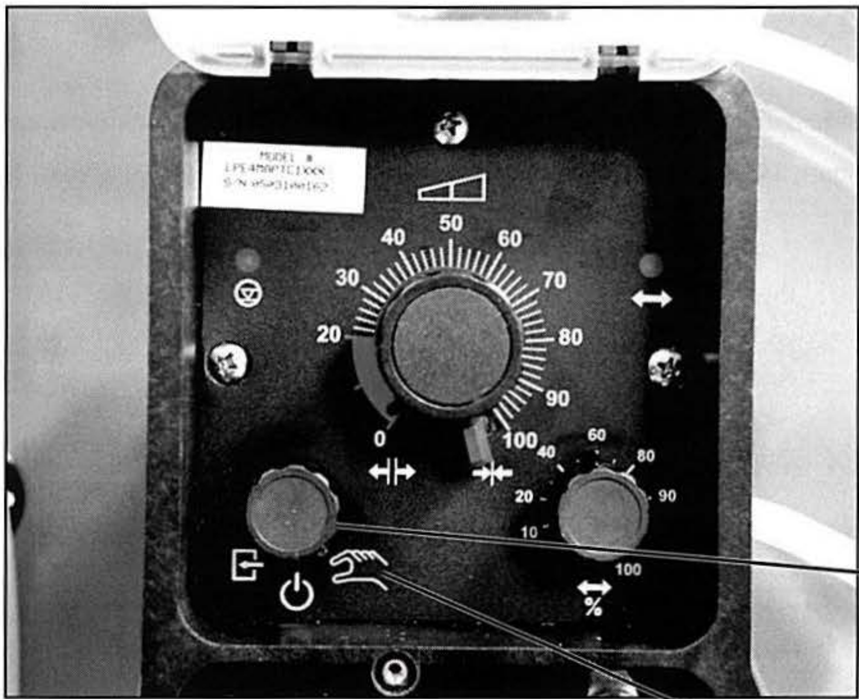

Figure 53. Mode Selector Dial Set to Manual

E. Unlock the locking lever for the percent stroke length dial, shown in figure 54, by moving the lever to the unlock position (left most position).

F. Turn the percent stroke length dial clockwise to 50%.

This allows the pump to pump out the reagent through the discharge valve. However, since the bypass is in the bypass position, the reagent is pumped back into the reagent tank.

At this point, the exact setting of the stroke rate percent dial is not important.

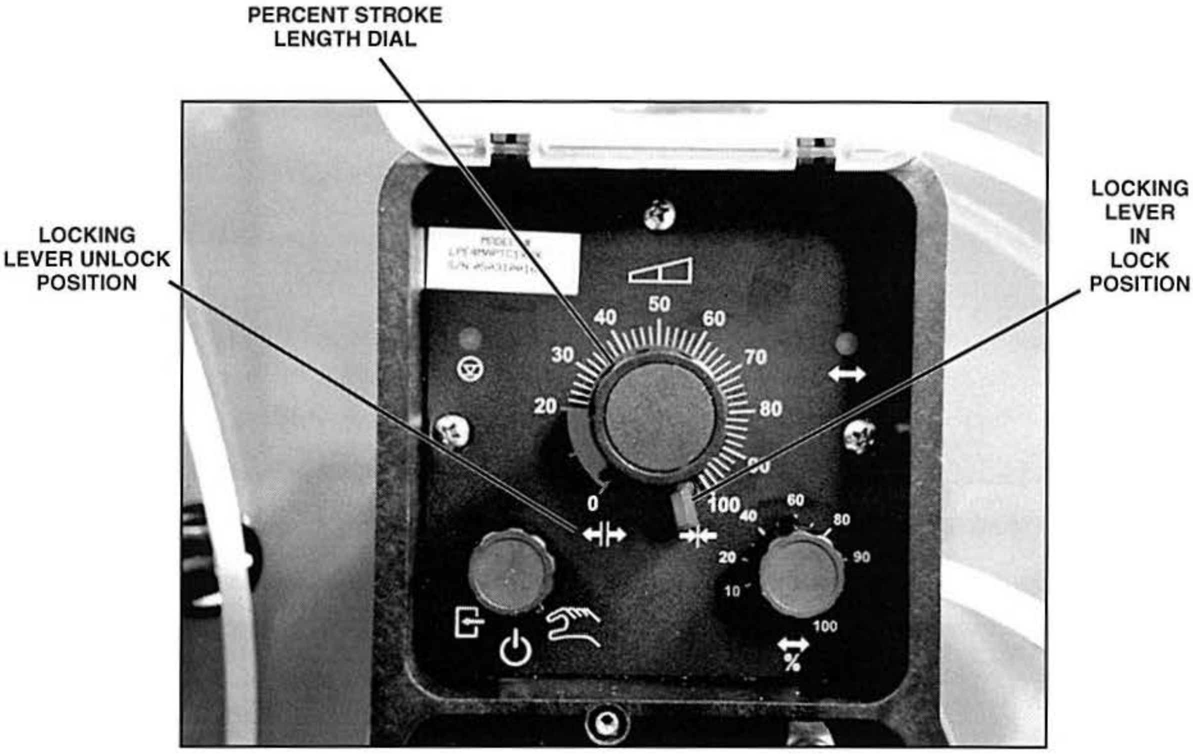

Figure 54. Percent Stroke Length Dial and Locking Lever

G. Observe the tubes that run from the reagent tank to the metering pump, shown in figure 55.

When the stream of reagent in the tubes is steady, with no bubbles, the pump is primed and ready for operation.

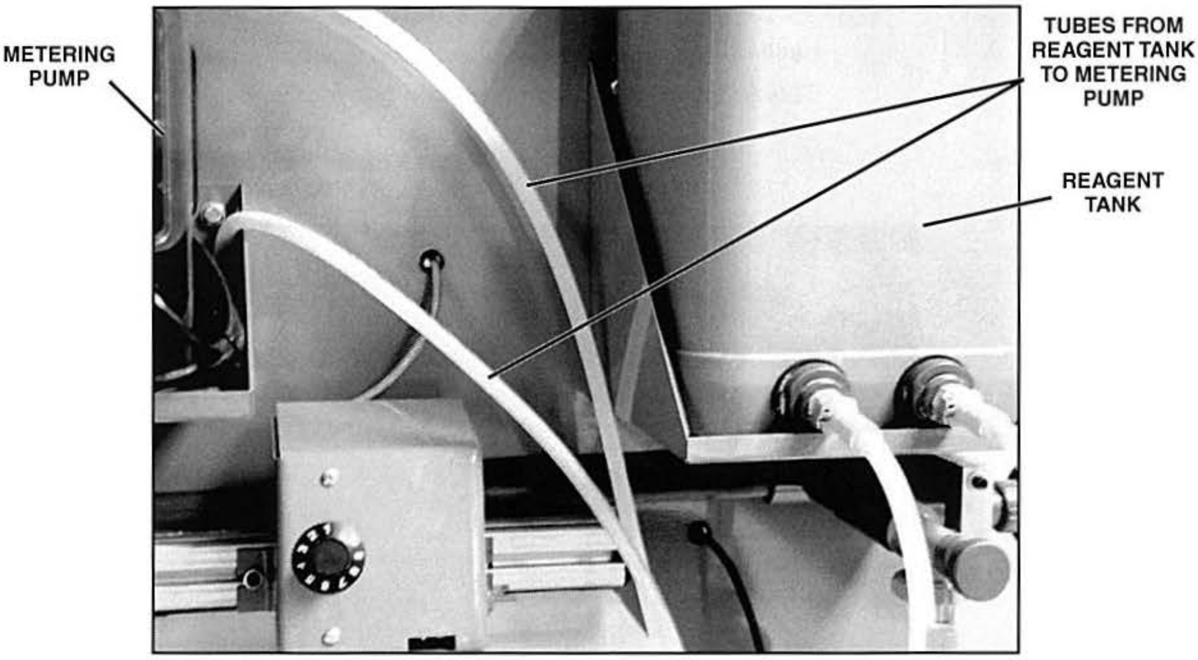

Figure 55. Tubes Between the Reagent Tank and the Metering Pump

H. Once the pump is primed, leave the percent stroke length dial to **50%** and place the locking lever back in the lock position (right).

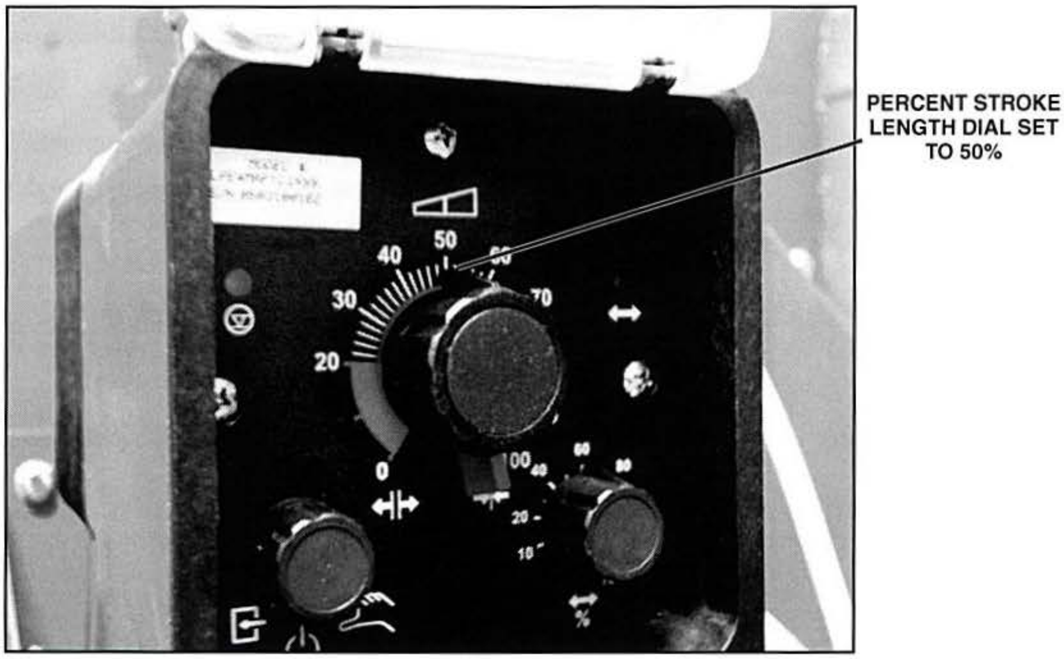

Figure 56. Percent Stroke Length Dial Set to 50%

❑ 4. Perform the following substeps to operate the metering pump in the manual mode.

You will leave the bypass valve set to bypass so the reagent is pumped back into the reagent tank instead of into the reactor tank.

A. Set the stroke rate percent dial to maximum setting (100%), as shown in figure 57.

This results in the maximum stroke rate for the diaphragm.

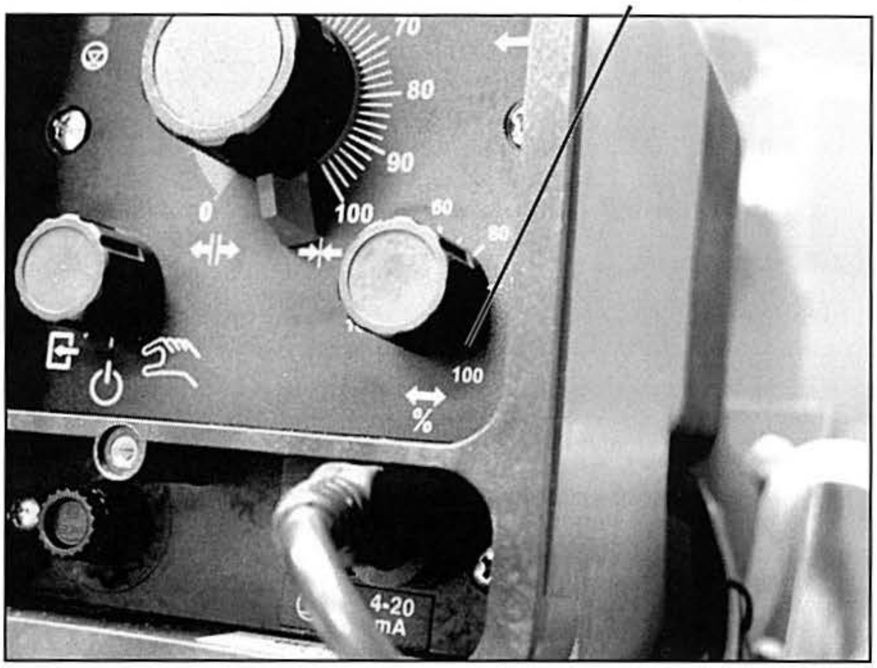

Figure 57. The Stroke Rate Percent Dial Set to Maximum

B. Observe the frequency of the strokes of the diaphragm.

You should find that the frequency of the strokes is high for the maximum setting.

C. Now set the stroke rate percent dial to the 50% setting, as shown in figure 58, and again observe the stroke frequency.

You should find that the stroke frequency is 1/2 of the rate you observed in the previous substep.

STROKE RATE PERCENT
DIAL SET TO 50%

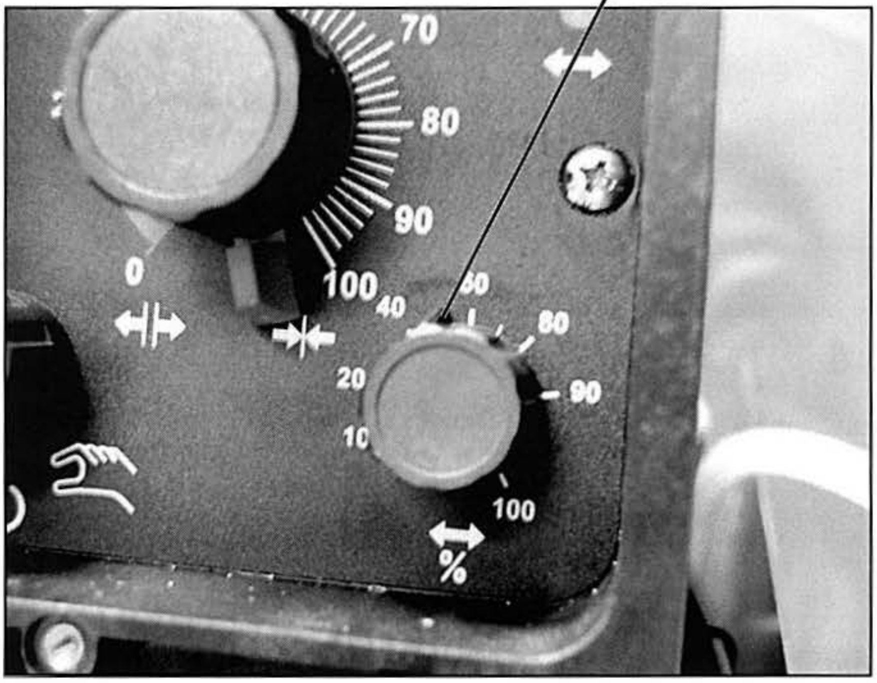

Figure 58. Stroke Rate Percent Dial Set to 50%

D. Repeat for other settings of the stroke rate percent dial.

❑ 5. Perform the following substeps to shut down the T5554.

A. Set the metering pump's mode selector dial to the Standby position, as shown in figure 59.

MODE SELECTOR DIAL IN STANDBY POSITION

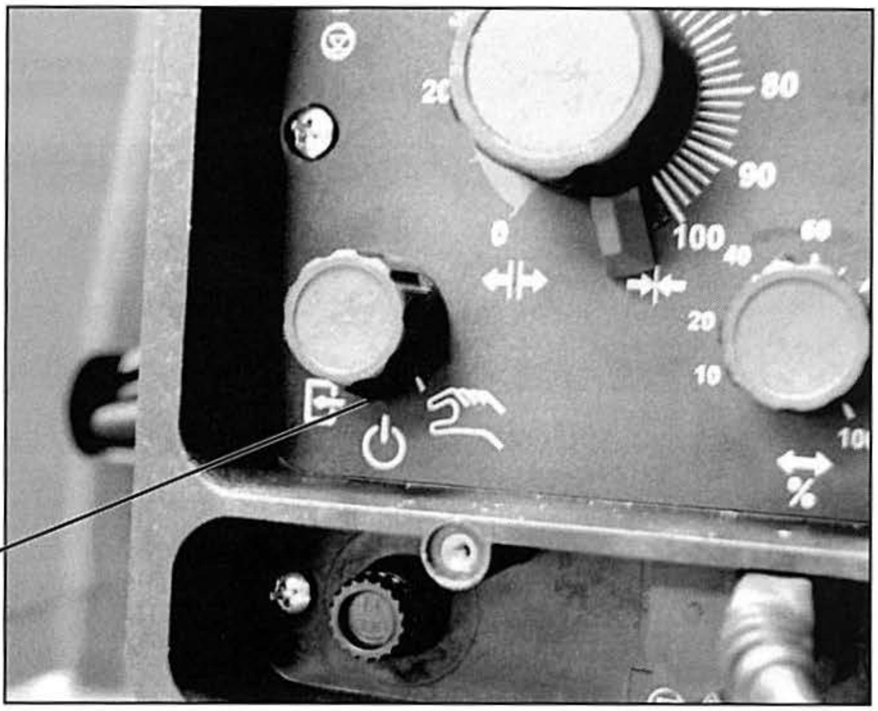

Figure 59. Mode Selector Dial Set to Standby

B. Close and secure the plastic cover over the metering pump controls. Turn the securing screw clockwise to secure the cover.

C. Turn off the main power circuit breaker.

SEGMENT 3

SELF REVIEW

1. A(n) ____________________ pump injects a specified volume of a chemical into the process at a frequency that is based on the flow rate of the process fluid.

2. ____________________ pumps are frequently used in the purification of municipal water supplies.

3. A chemical used to treat a process fluid is referred to as a ________________.

4. The ________________ piston is attached to the same cylinder as the water piston for an eductor pump.

5. A(n) ________________ pump outputs a reagent at a specified volume and rate.

6. When the diaphragm is retracted during the suction stroke, the __________ valve opens.

7. The three possible modes for an electronic metering pump are: manual, automatic, and ________________.

8. If an electronic metering pump is new or has not been used in a while, it may be necessary to ________________ the pump.