

Gas Chlorination Systems

Operation, Maintenance & Safety

Contact Hours: (5)

What is Chlorine?

- Elemental chlorine does not exist naturally
- Produced through electrolysis of brine
- Produced, collected, compressed & stored
- Stored & shipped as liquefied gas under pressure
- Chemical Symbol: Cl_2

What is Chlorine?

- Non flammable, non explosive
- Pungent Odor irritating to mucous membranes
- Liquid is amber & 1.5x heavier than water
- Liquid boils at -30°f
- Gas is greenish yellow & 2.5x heavier than air

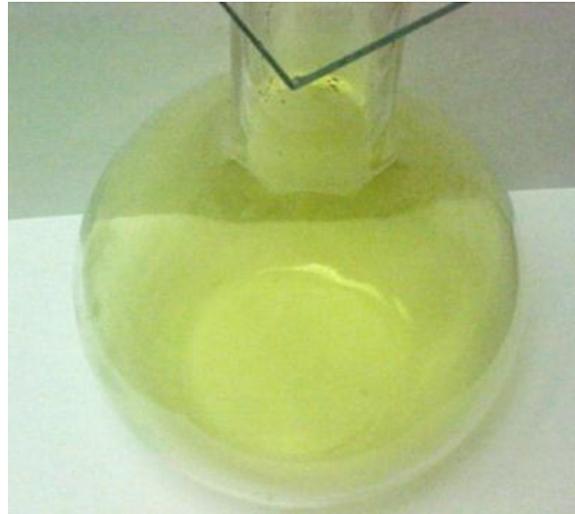
What is Chlorine?



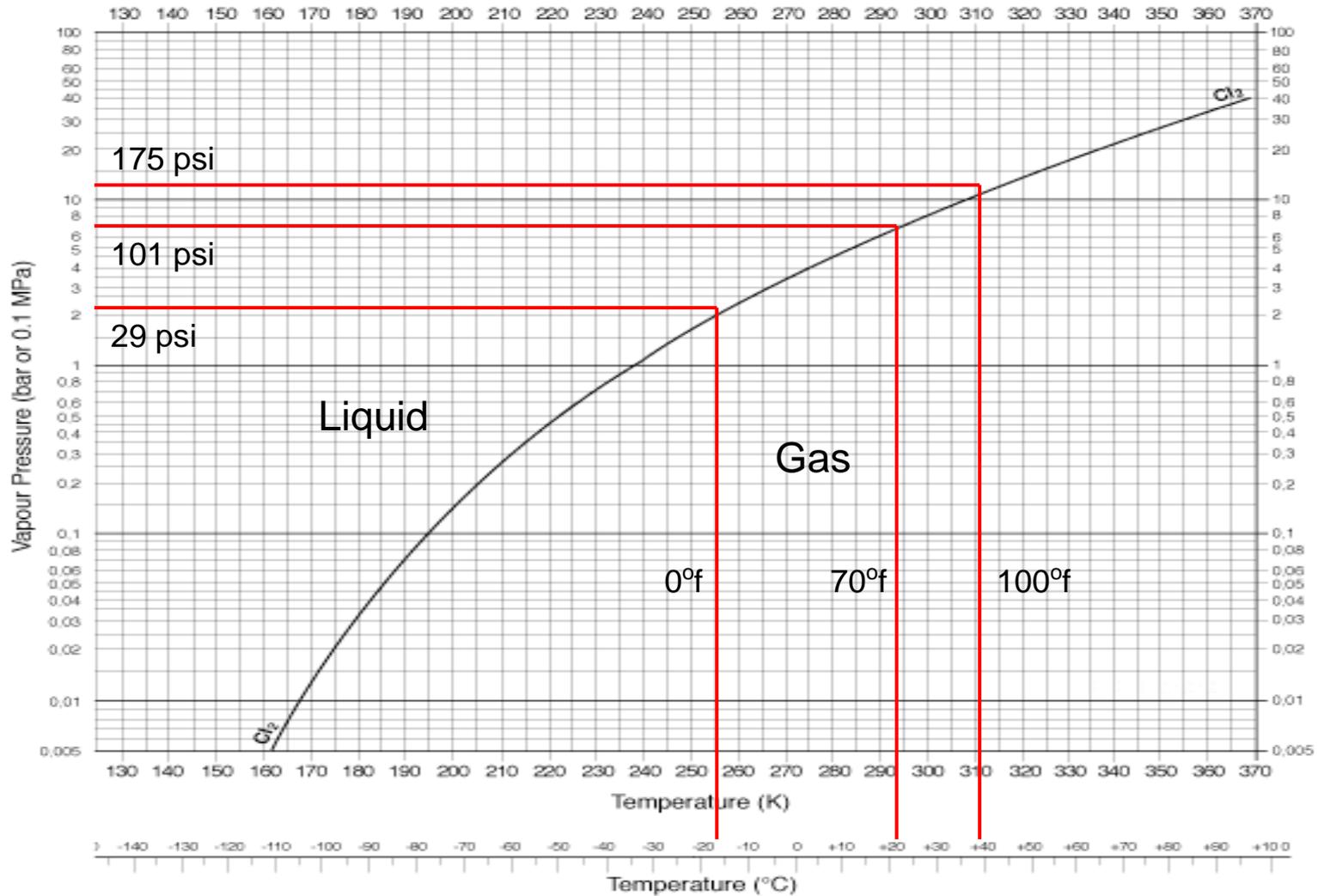
CL2 Gas

CL2 Liquid

CL2 Gas



What is Chlorine?



What is Chlorine?

- Slightly soluble in water 6.93lb/100gal
- CL₂ is highly reactive
- Corrosive in the presence of water
- Corrosive with most metals except:
 - Silver, Tantalum and Tantalum Alloys
- Compatible with most plastics
 - Only under vacuum & in solution

What is Chlorine?

- Physiological Effects

0.2ppm ----- odor threshold (varies with individuals)

0.5ppm ----- 8 hour time-weighted average OSHA max exposure
No known acute or chronic effect

1.0ppm ----- OSHA Ceiling level (mild transient health effects)

1.0-10ppm ----- Irritation of eyes, mucous membranes
Potential irreversible health effects
physical impairment

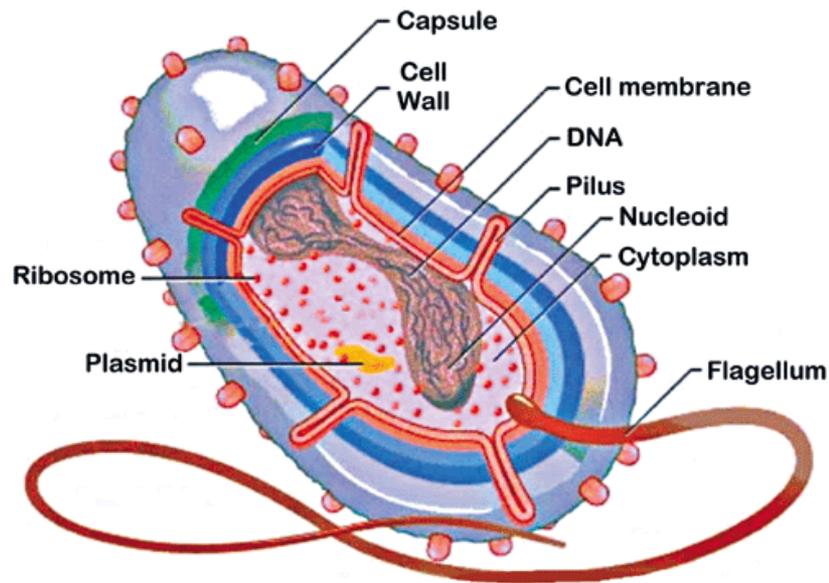
10-20ppm ----- Extreme physical impairment & Life threatening effects

Why Use Chlorine in Water & Wastewater Treatment

- Disinfection
- Taste/odor control
- Color removal
- Oxidation
- Algae/slime control

What is Chlorine?

- Disinfection mechanism
 - Combined with water forms hypochlorous acid and hydrochloric acid
 - Hypochlorous acid attack lipids in cell wall
 - Enter into the cell and oxidize the enzymes



What are Chloramines

- Combination of Chlorine and Ammonia
- Chemical Symbol: NH_2Cl
- Used for secondary disinfection of water
- Less tendency to produce THMs (carcinogens)
- Less taste & odor than free chlorine
- Can cause a slight green color in water
- Longer lasting than free chlorine

Sodium Hypochlorite

- Liquid Bleach - NaClO
- Blend of sodium hydroxide & liquid chlorine
- Generally 12% (household bleach 5.25%)
- 1lb Cl_2 gas = 1.2 gal 12% bleach
- Decompose over time
- Vapors released are Chlorine Monoxide

Calcium Hypochlorite

- Granular or tablets $\text{Ca}(\text{ClO})_2$
- Blend of calcium hydroxide & chlorine gas
- Solution is evaporated and milled to a granule
- Generally 65% available chlorine
- 1lb Cl_2 gas = 1.5lb of Calcium Hypochlorite
- Decompose over time
- Granules highly reactive

How
the
THREE
forms
of
chlorine
compare

gas chlorine

(Cl₂) Chlorine is made from common salt (NaCl). Chlorine is a gas, created without the use of additional by-products. Because of its natural properties, and the methods of administration, gas chlorine is, pound for pound, the most effective chlorine product you can buy.

Gas chlorine is 100% elemental chlorine and remains at full strength no matter how long it is in storage.

calcium hypochlorite

(Ca(OCl)₂) This form of chlorine is available as granules or compressed into tablets. Once a container of calcium hypochlorite has been opened, it loses its strength.

It takes 1.5 lbs. of calcium hypochlorite to equal 1 lb. of gas chlorine.

sodium hypochlorite

(NaOCl) Commonly known as a liquid bleach, it degrades over time. Because of its form and storage, it can lose up to 50% of its potency in the first 90 days. This makes it the most inefficient of all chlorination forms.

It takes 1.2 gals. of sodium hypochlorite to equal 1 lb. of gas chlorine.

100%
AVAILABLE
CHLORINE
PER POUND

65% CONCENTRATION (BY WEIGHT)

65%
AVAILABLE
CHLORINE
PER POUND

12.5% AQUEOUS SOLUTION

11.9%
AVAILABLE
CHLORINE
PER GALLON

Have you
checked
the
strength
of your
chlorine
lately?

Chlorine Dose

- Concentration is measured in parts per million (ppm) or milligrams per liter (mg/l)
- Dosage = amount of CL_2 added, ppd
- $ppd = gpm \times .012 \times ppm$
- Demand = amount of CL_2 consumed
- Residual = amount of CL_2 remaining
- Combined + Free = Total

Chlorine Dose

- Typical chlorine dose:
 - Wastewater raw: 5-25 ppm total chlorine
 - Wastewater final: 5-25 ppm total chlorine
 - Water: 1-5 ppm free chlorine
- Chlorine Byproducts
 - THM Trihalomethanes
 - HAA Haloacetic Acid

The History of Chlorination

- 1774 – Discovered in Sweden
- 1800s – Waterborne diseases
 - Typhoid, Dysentery, and Cholera occurred regularly
 - Over 25,000 died every year in the United States
 - During the civil war an estimated 125,000 died of waterborne disease
- 1900s The advent of chlorine decreased deaths
 - Less than 20 per year by 1960
- 1908 First bleach used in the US at Boonton, NJ
- 1912 First CL₂ gas used in the US at Niagara Falls, NY
- 1950 2,200 WWTPs using CL₂ Gas (30% of all in US)

The History of Chlorination

- Disinfection Today:
 - Chlorine Gas
 - Sodium Hypochlorite
 - On-site storage
 - On-site generation
 - Calcium Hypochlorite
 - Chlorine Dioxide
 - UV Disinfection

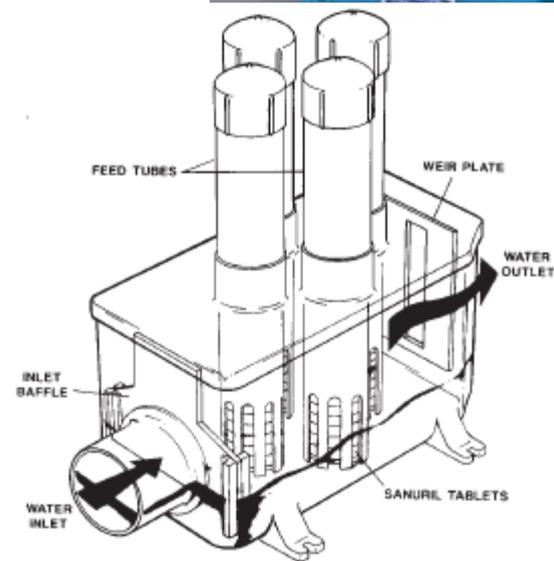
Hypochlorite Generator



UV Disinfection

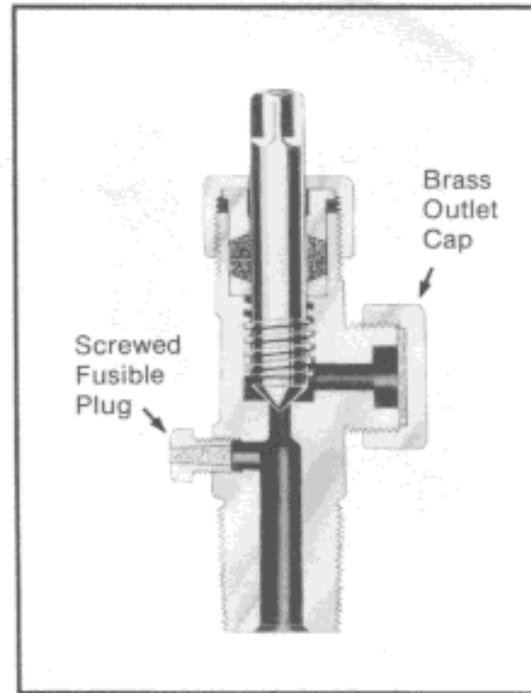
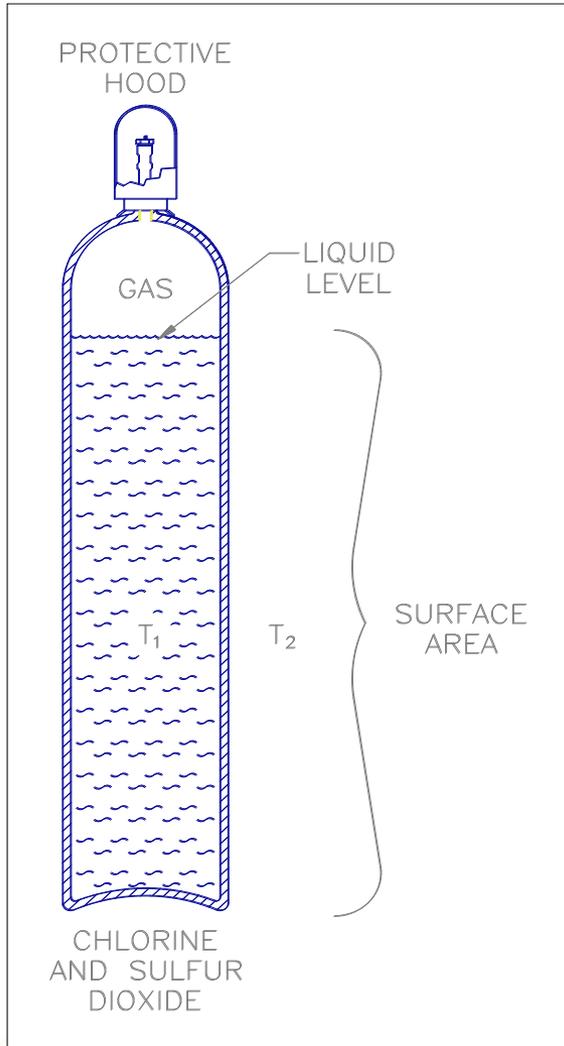


Calcium Hypochlorite - Tablet Feeders

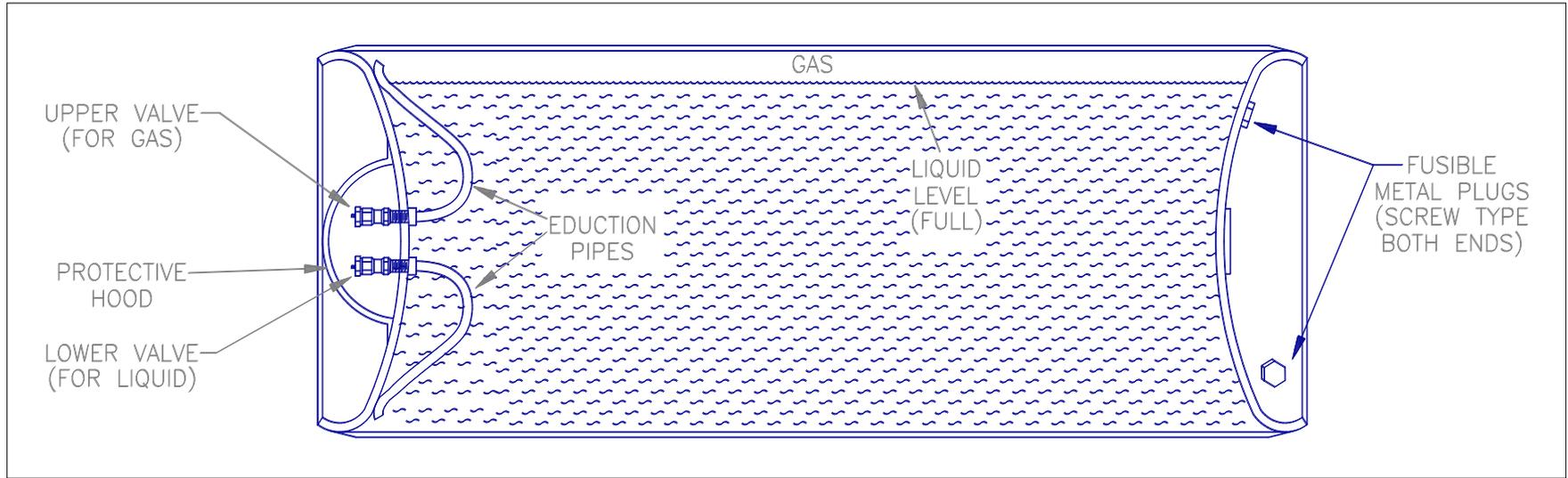


Chlorine Gas Storage

- 150lb cylinders

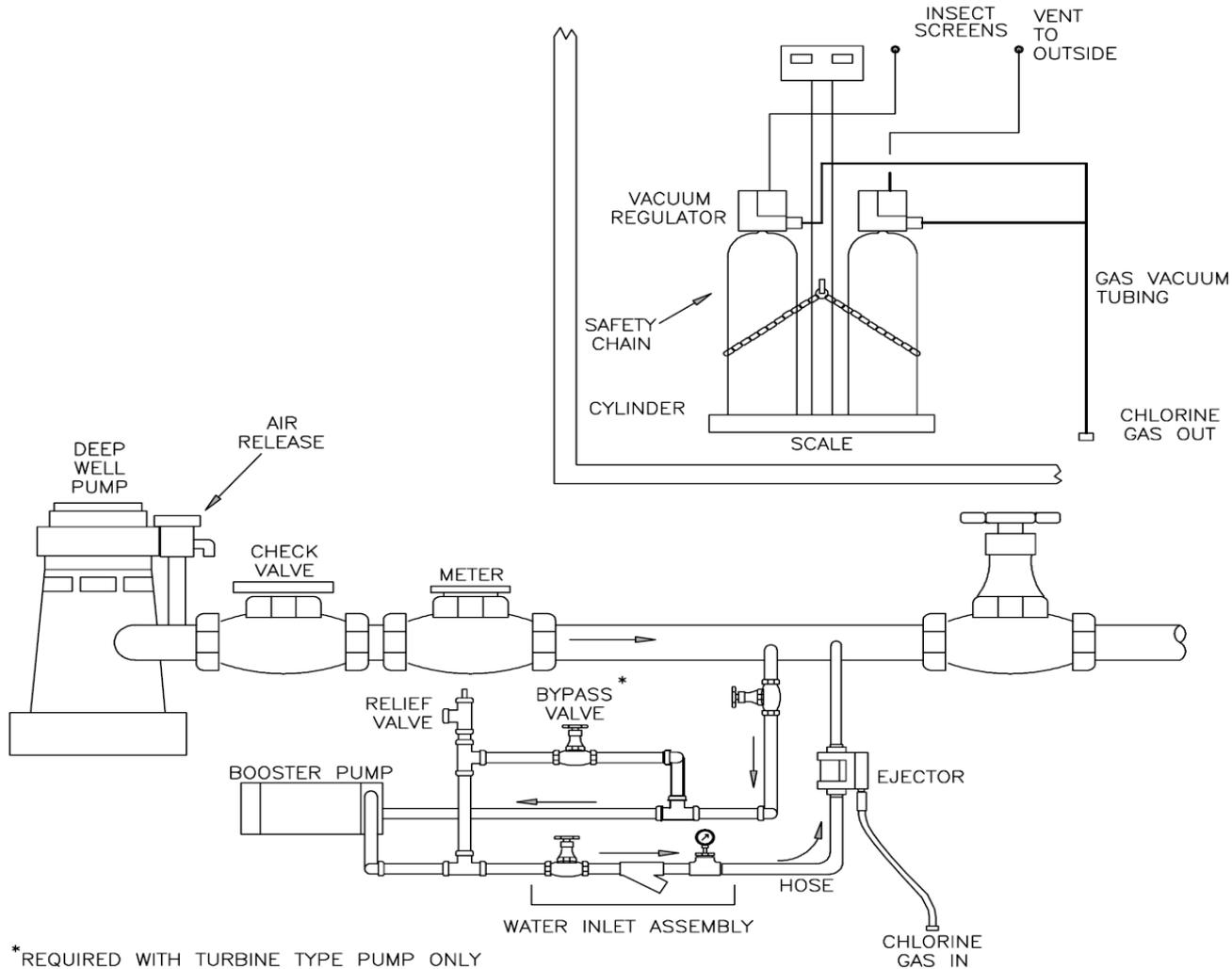


Ton Cylinders



Chlorination System

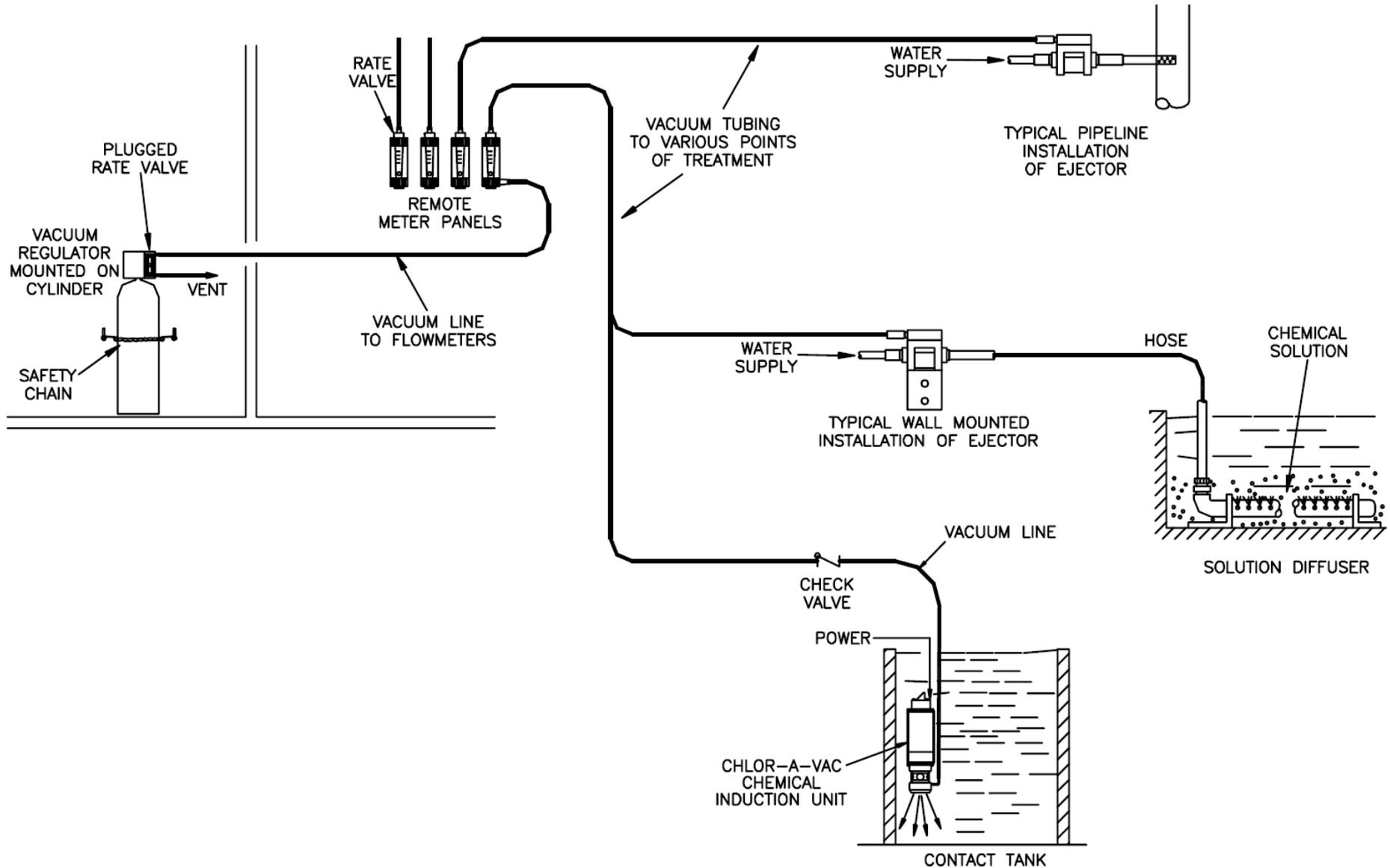
Well Water with Booster Pump



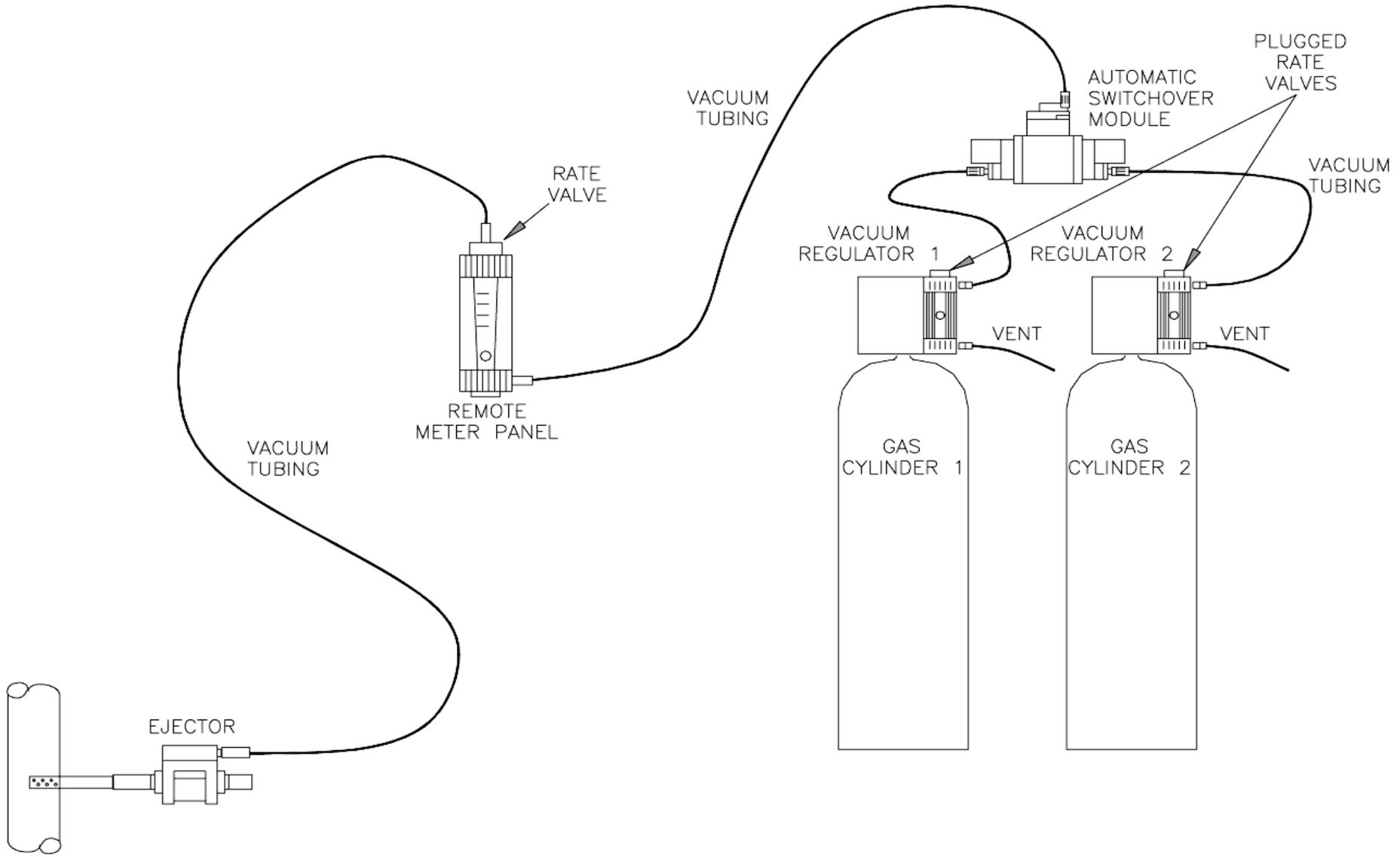
*REQUIRED WITH TURBINE TYPE PUMP ONLY

Chlorination System

Wastewater Installations



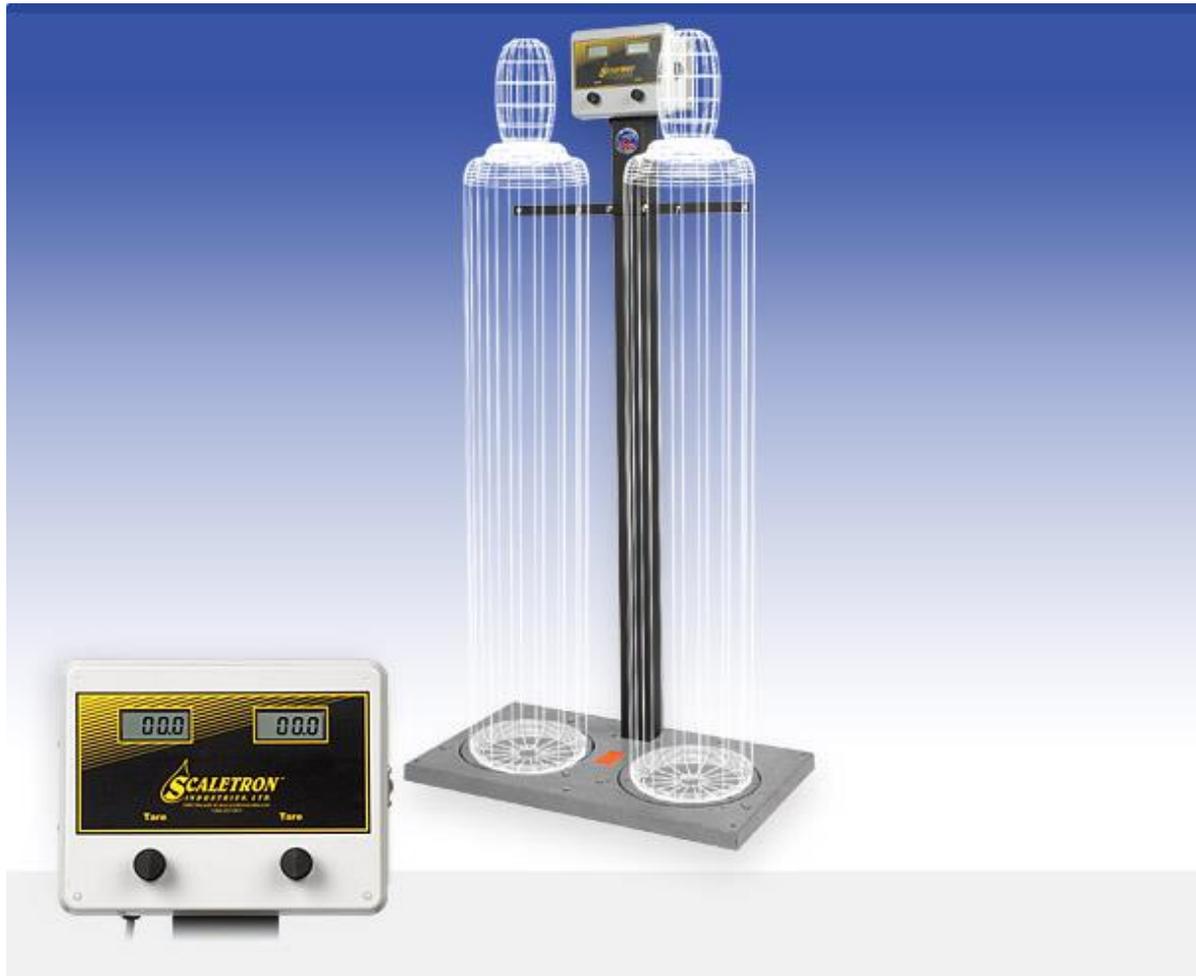
Auto-switchover System



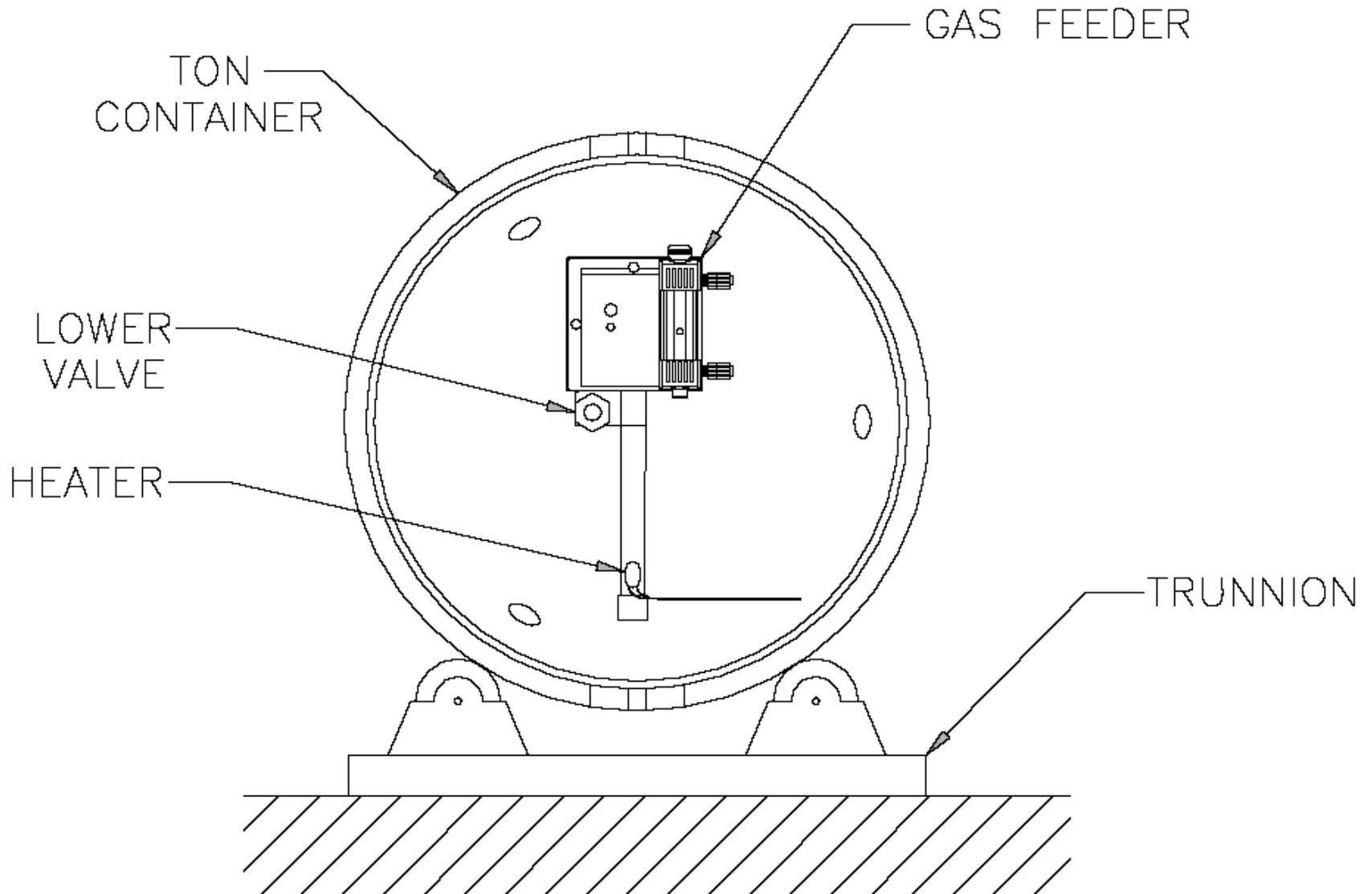
Cylinder Mounted VR



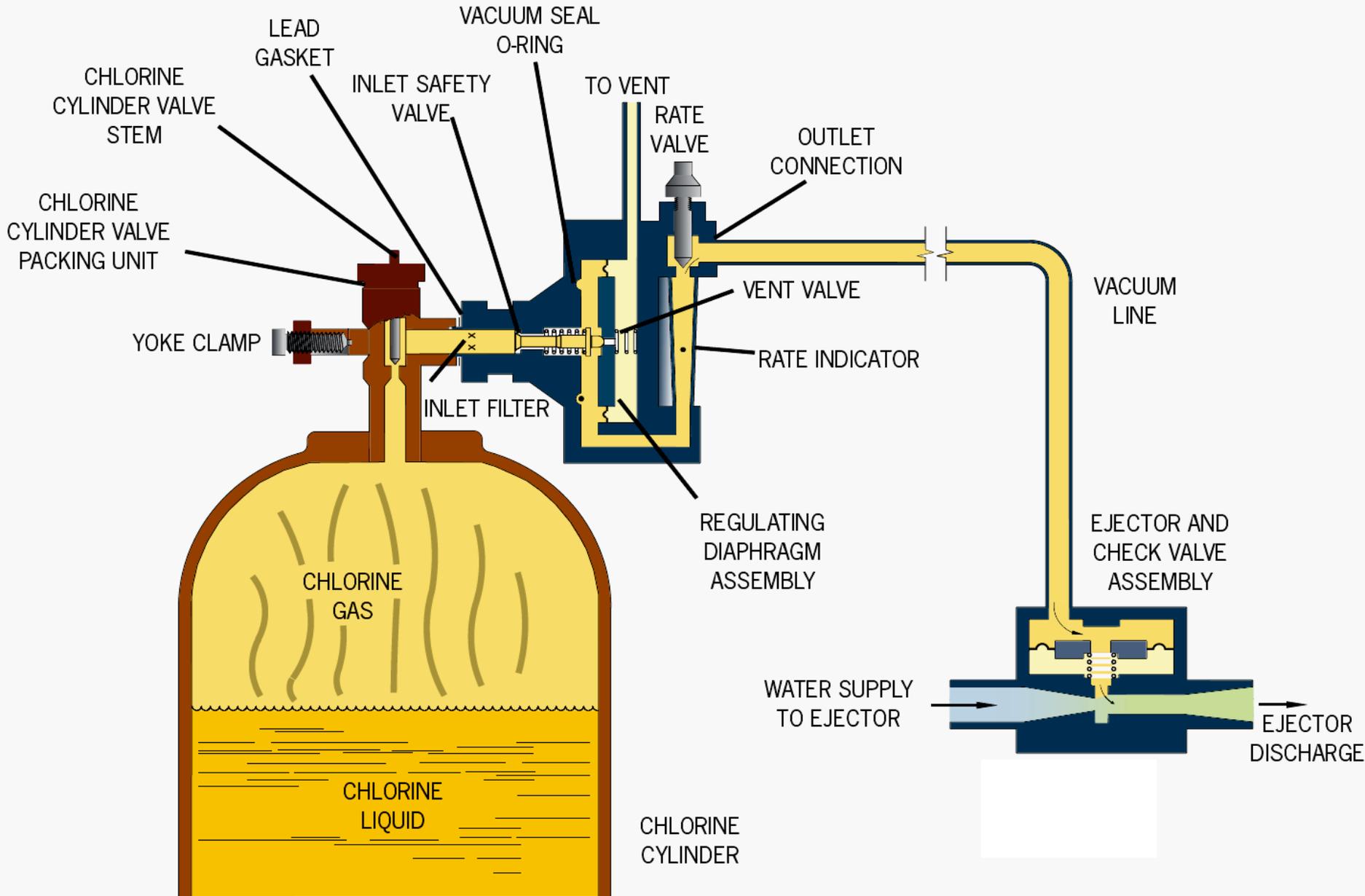
Chlorine Cylinder Scales



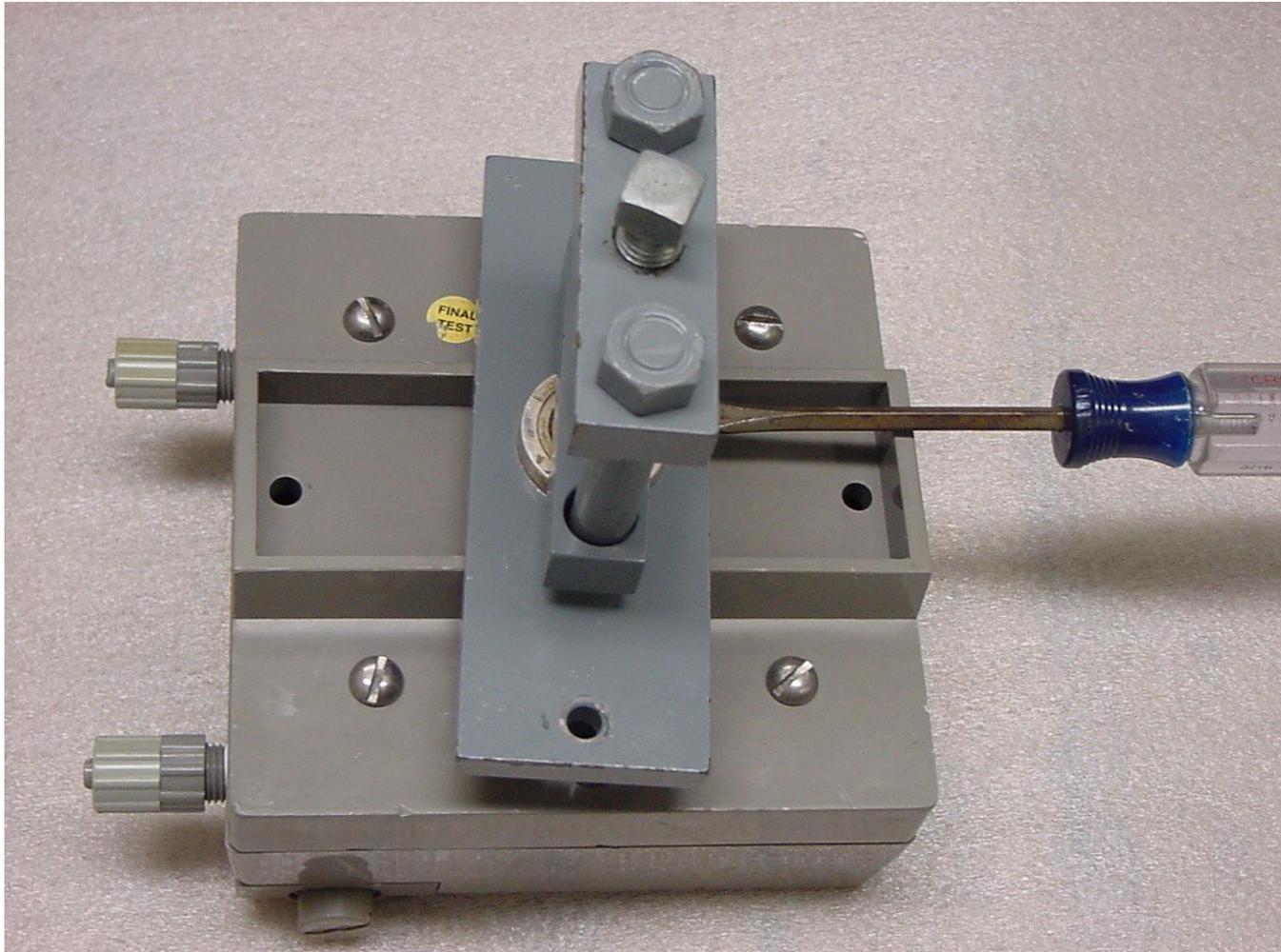
Ton Mounted VR



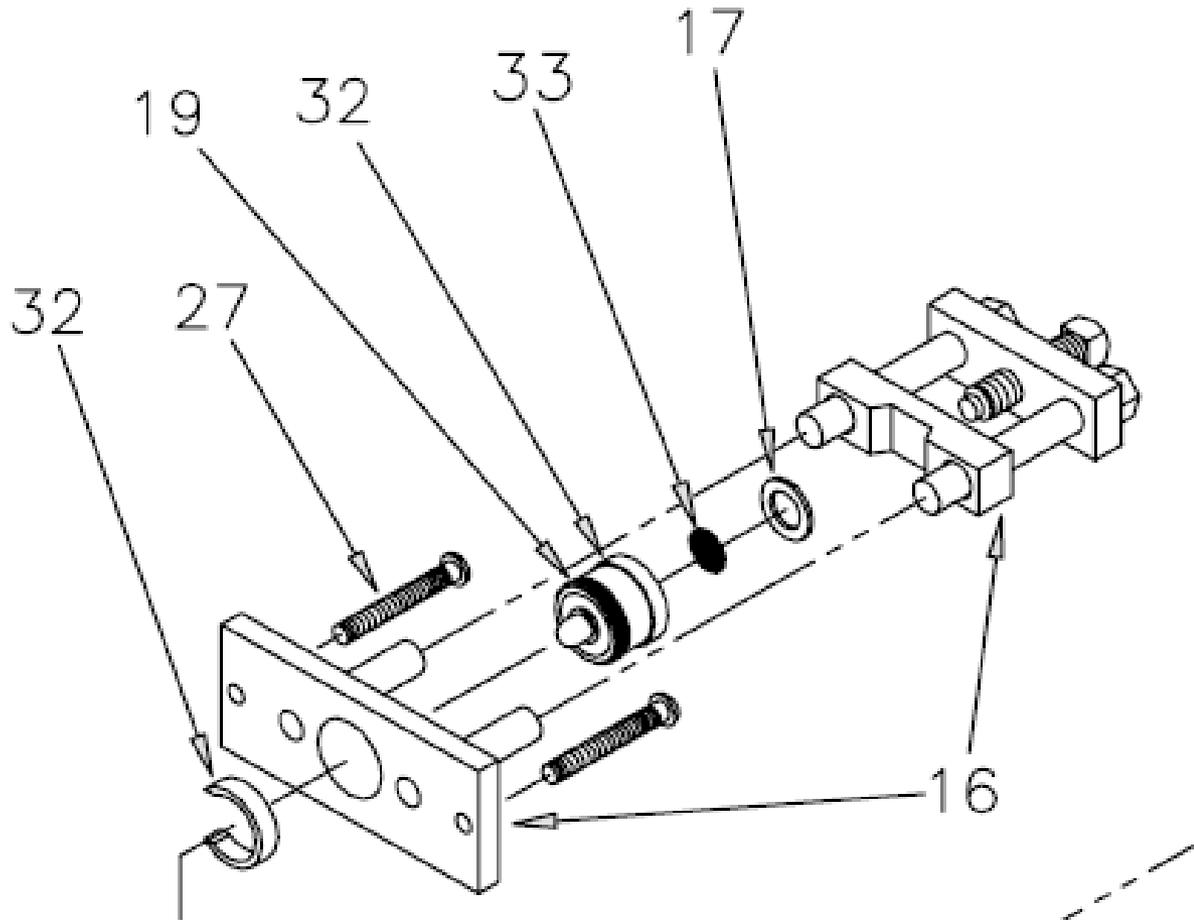
Gas Feed System



Inlet Valve Assembly



Inlet Valve Assembly



Inlet Valve Assembly



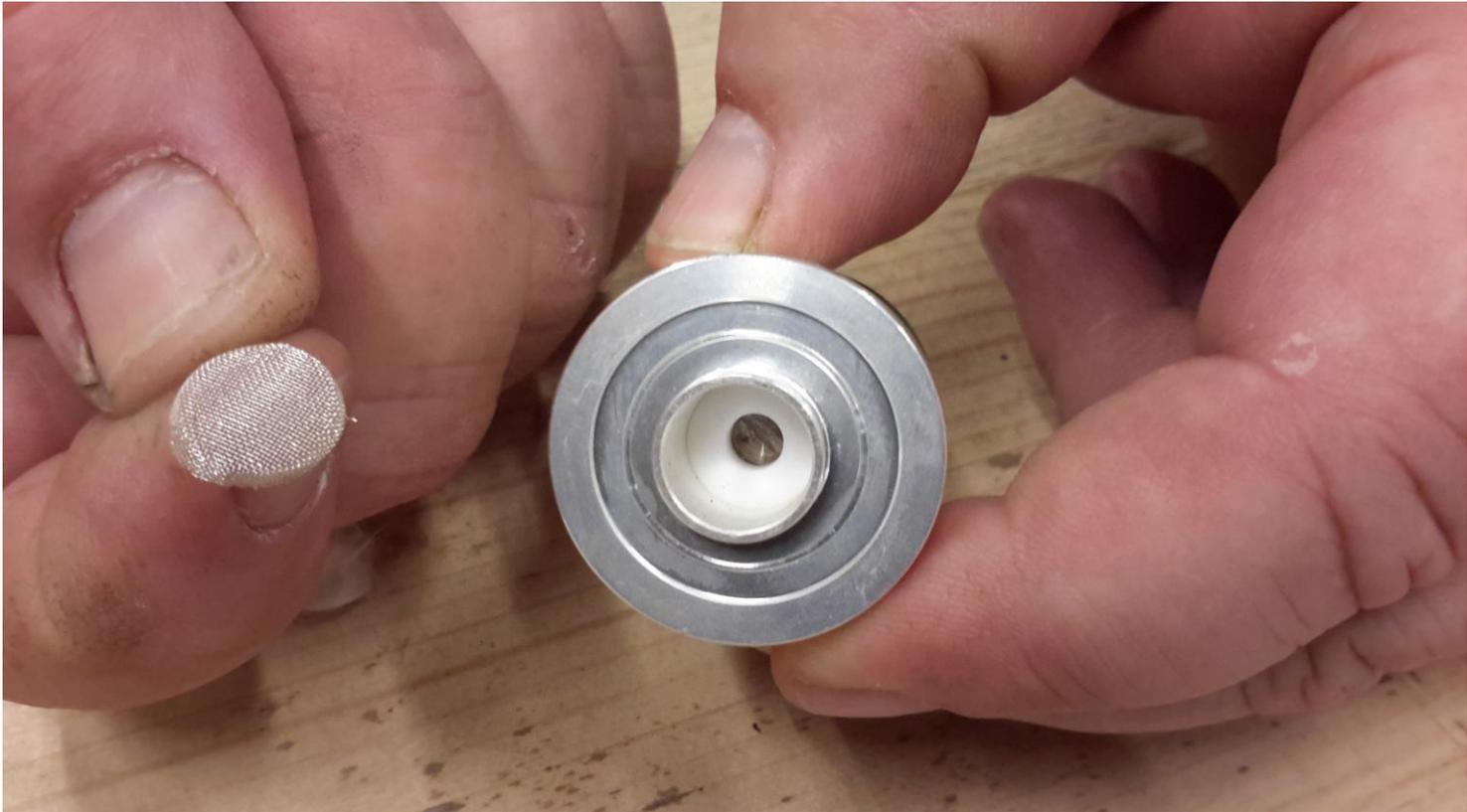
Inlet Valve Assembly



Inlet Valve Assembly



Inlet Valve Assembly



Inlet Valve Assembly



Inlet Valve Assembly



Inlet Valve Assembly



Inlet Valve Assembly



Inlet Valve Assembly



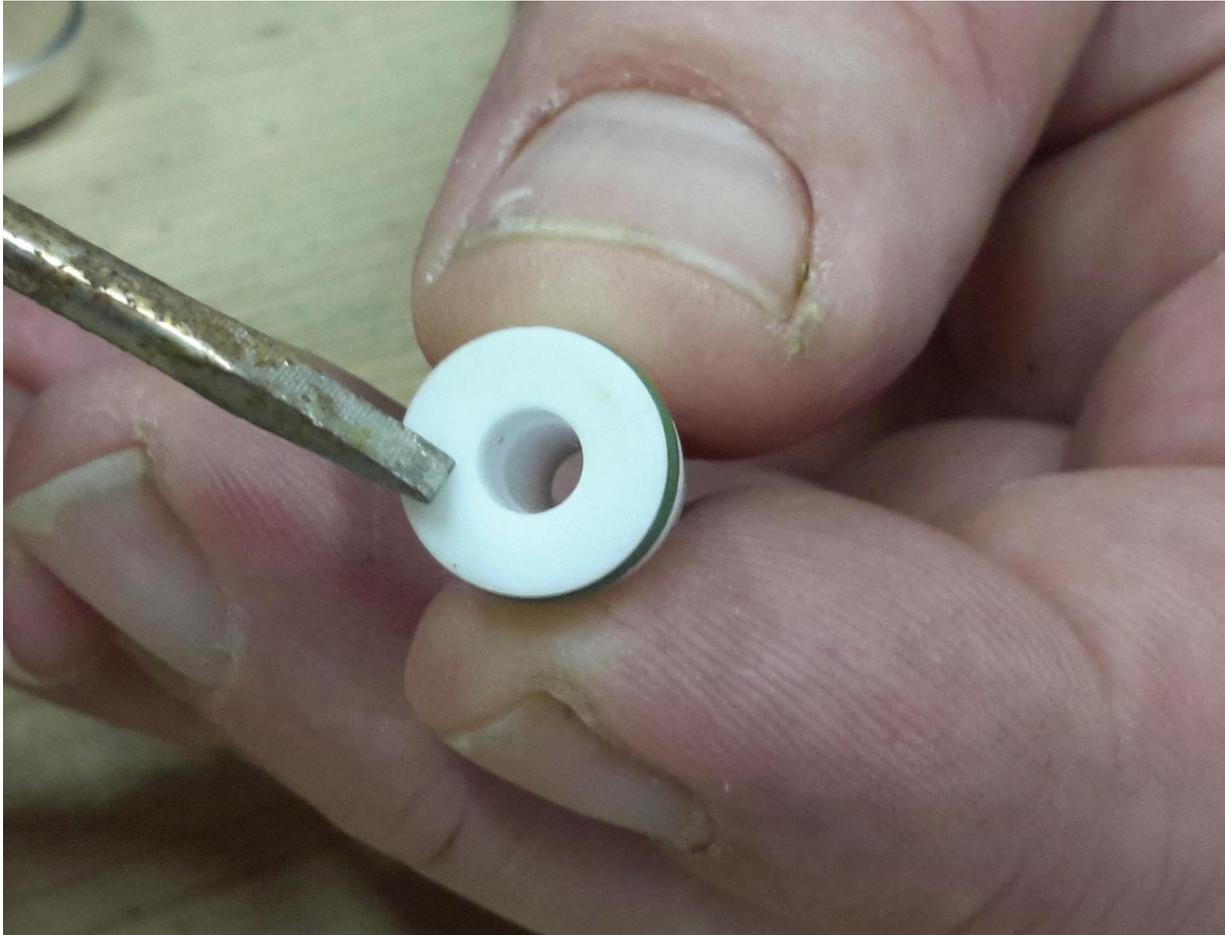
Inlet Valve Assembly



Inlet Valve Assembly



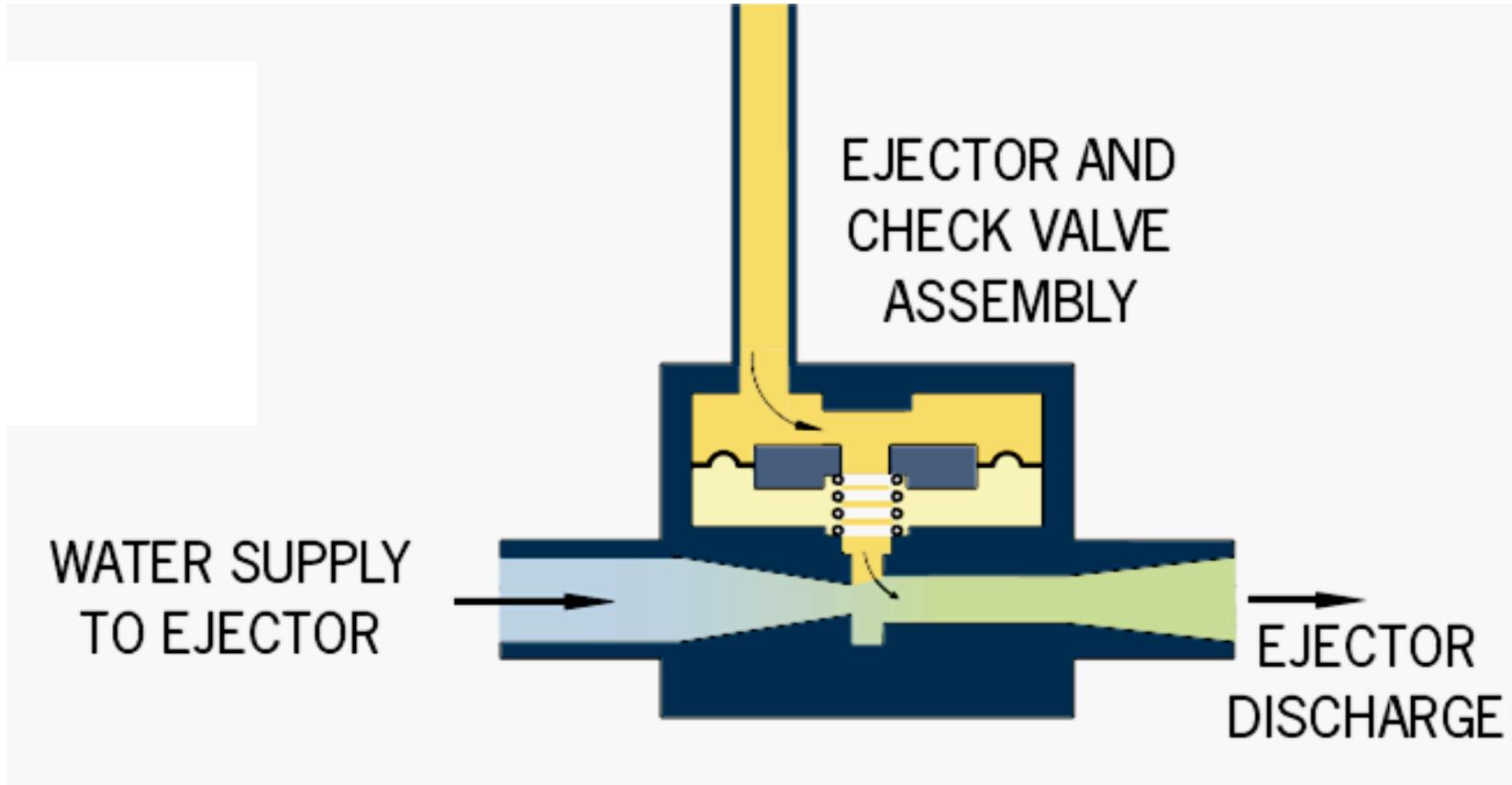
Inlet Valve Assembly



Inlet Valve Assembly



Ejector/Check Valve



Ejector/Check Valve



Ejector/Check Valve



Ejector/Check Valve



Ejector/Check Valve



Ejector/Check Valve



Ejector/Check Valve



Ejector/Check Valve



Ejector/Check Valve



Ejector/Check Valve

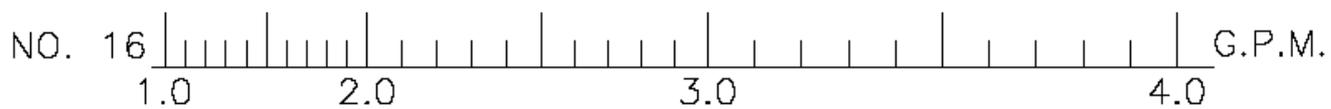
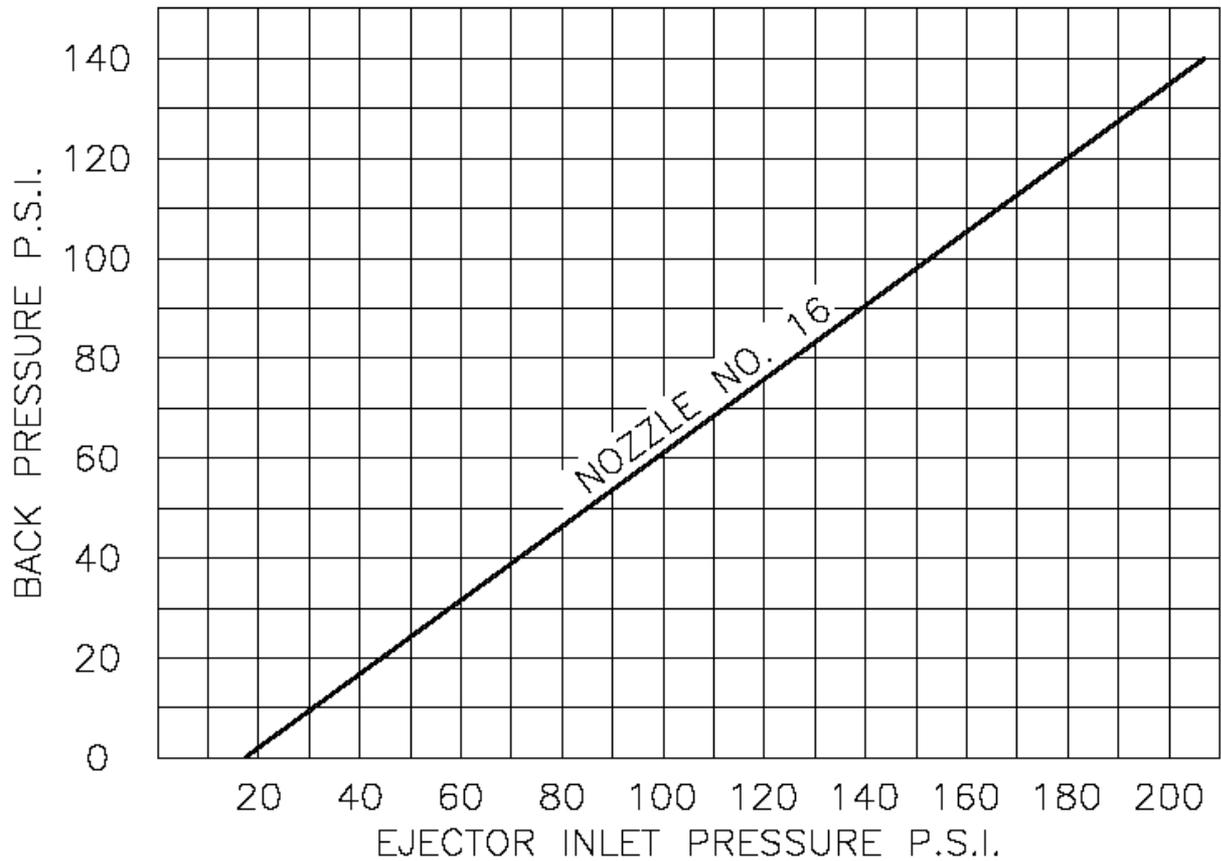


Ejector/Check Valve

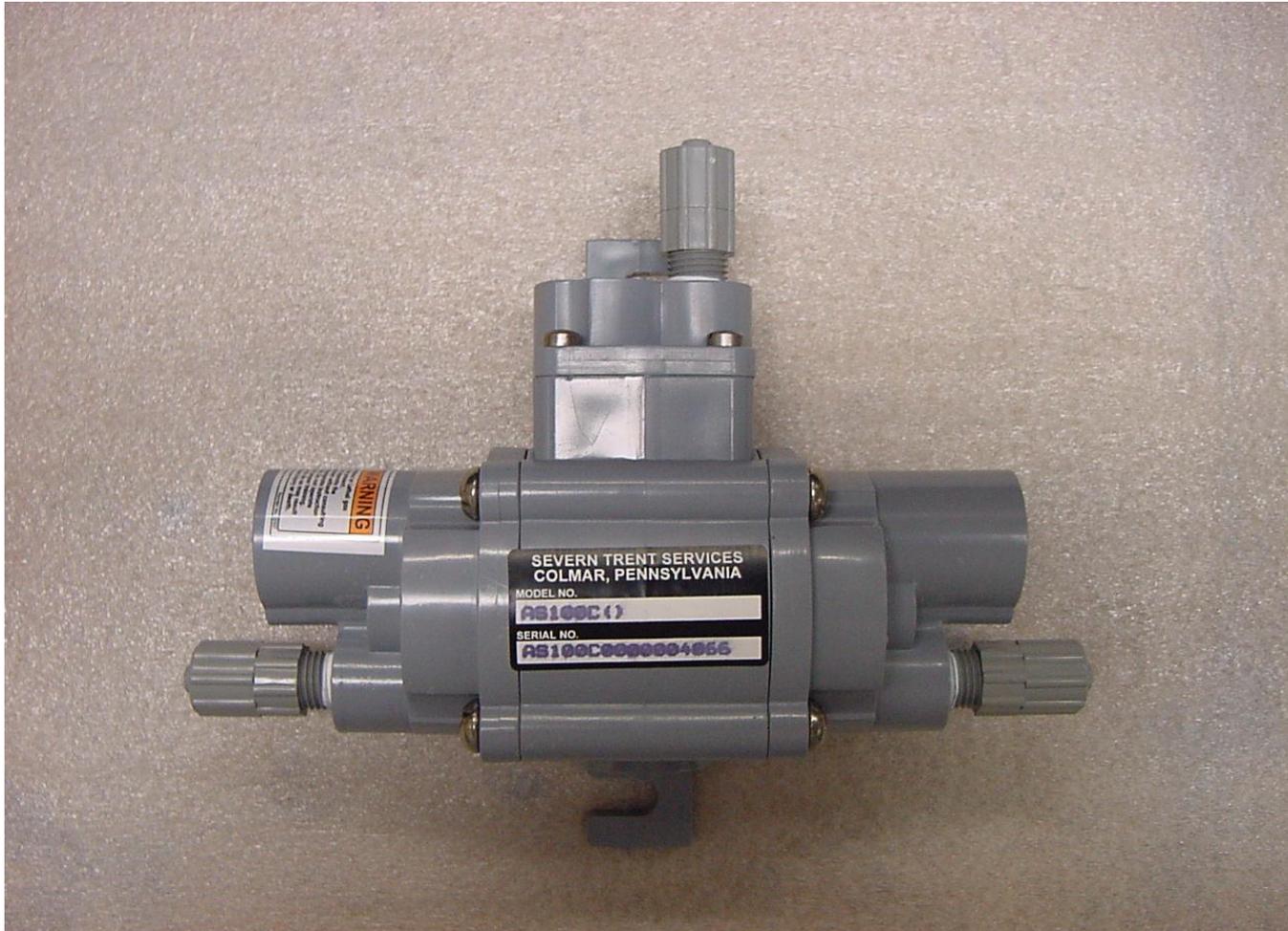


Nozzle Curve

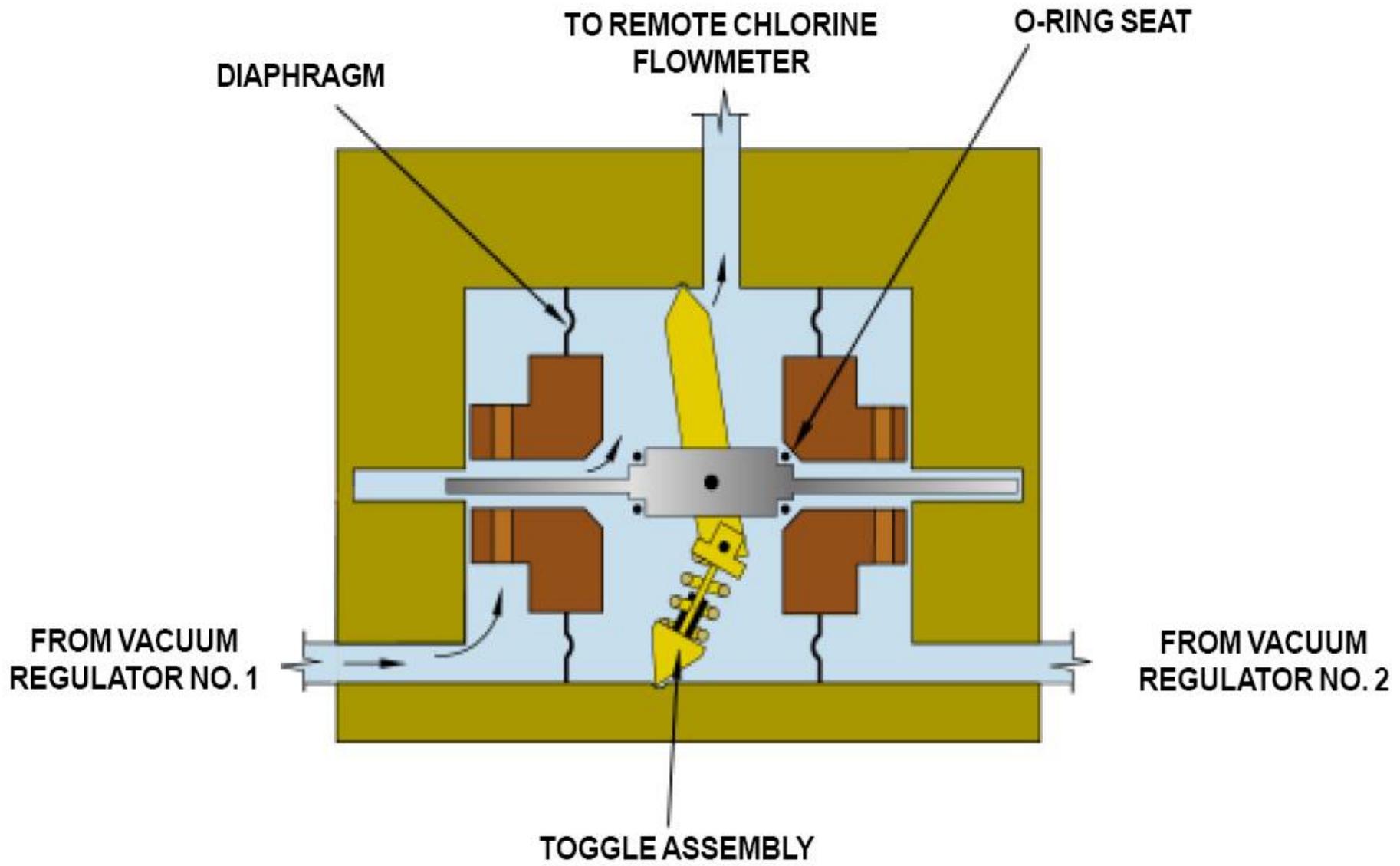
NOZZLE SIZING 10 PPD



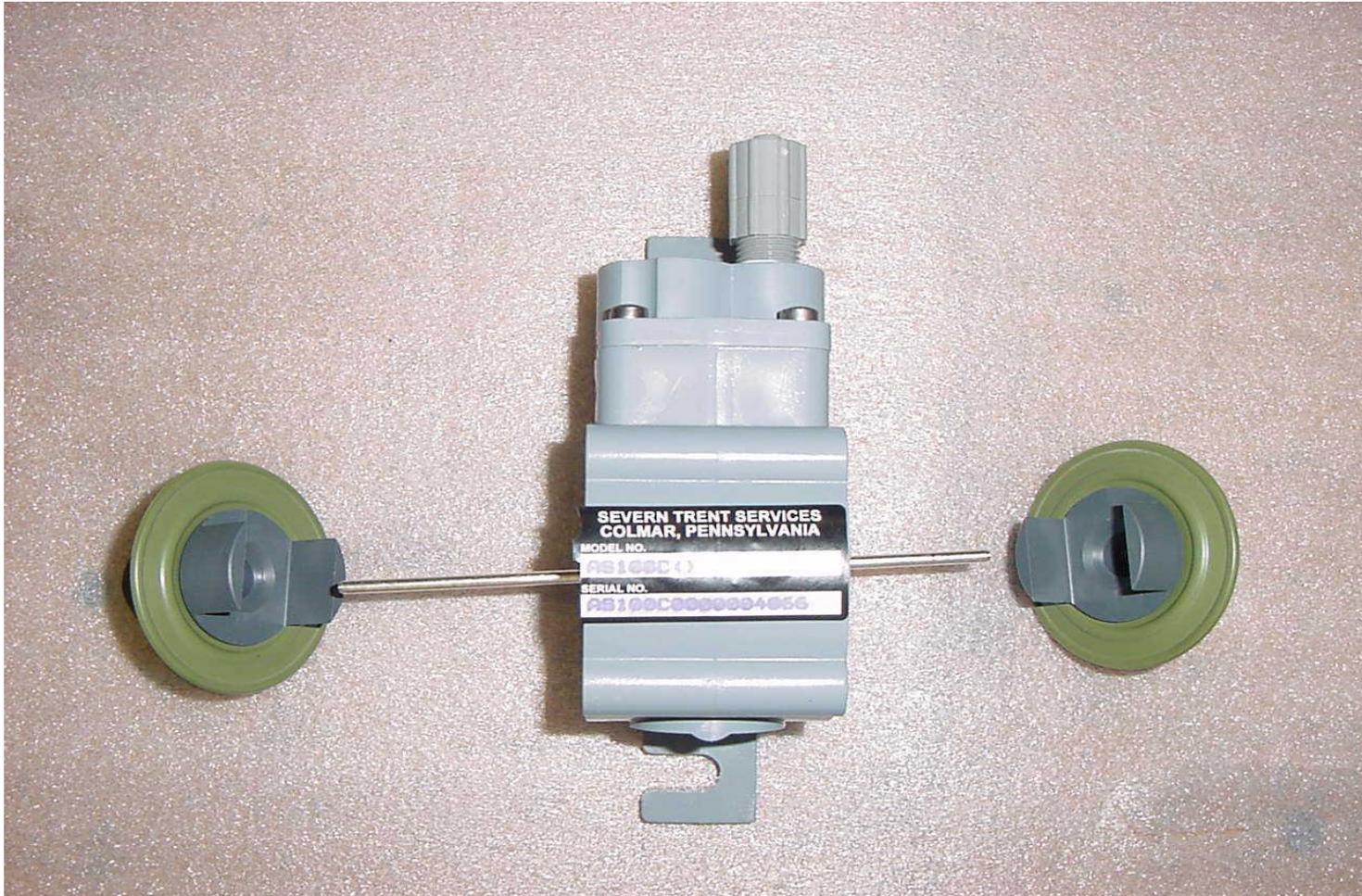
Automatic Switchover Module



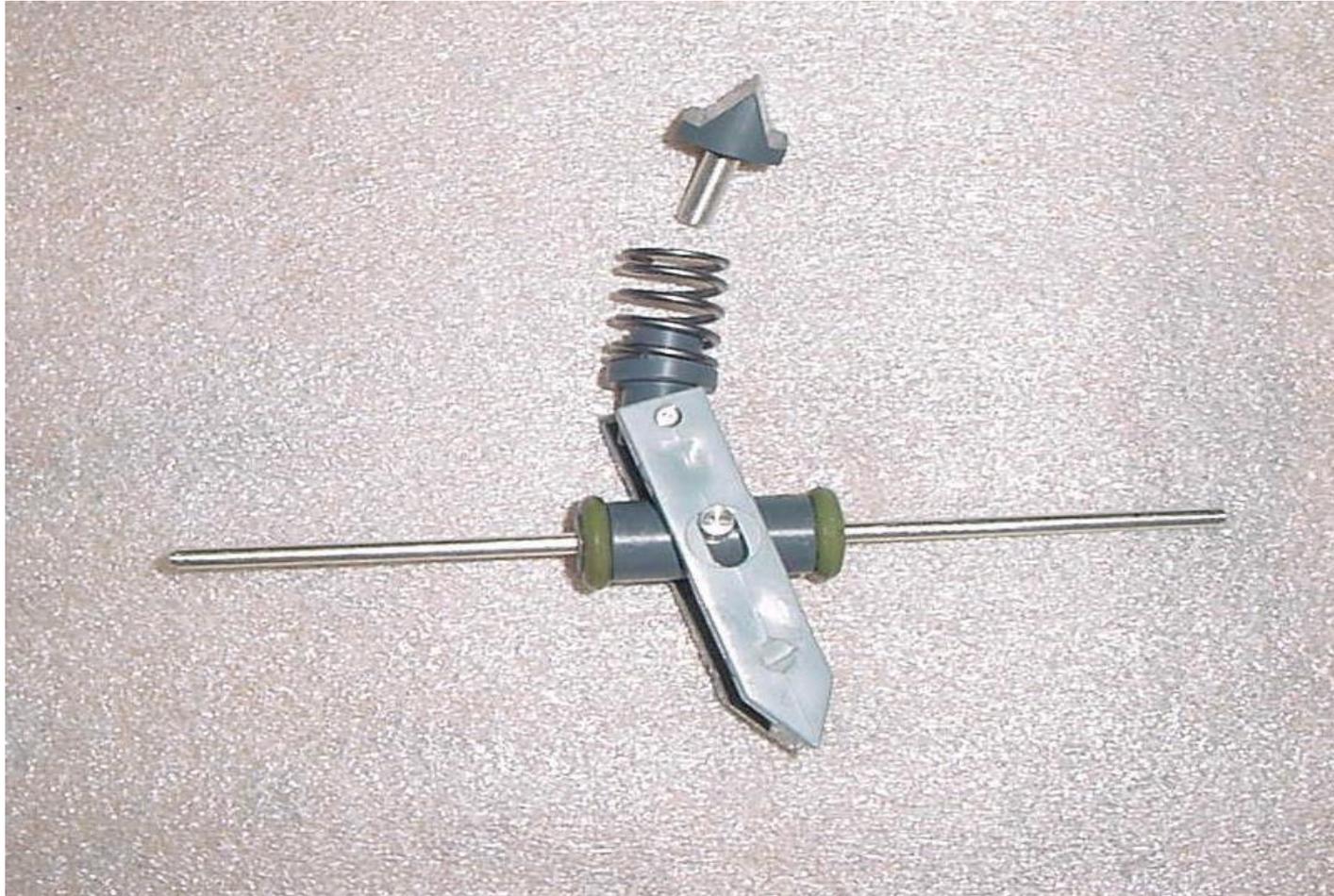
Automatic Switchover Module



Automatic Switchover Module



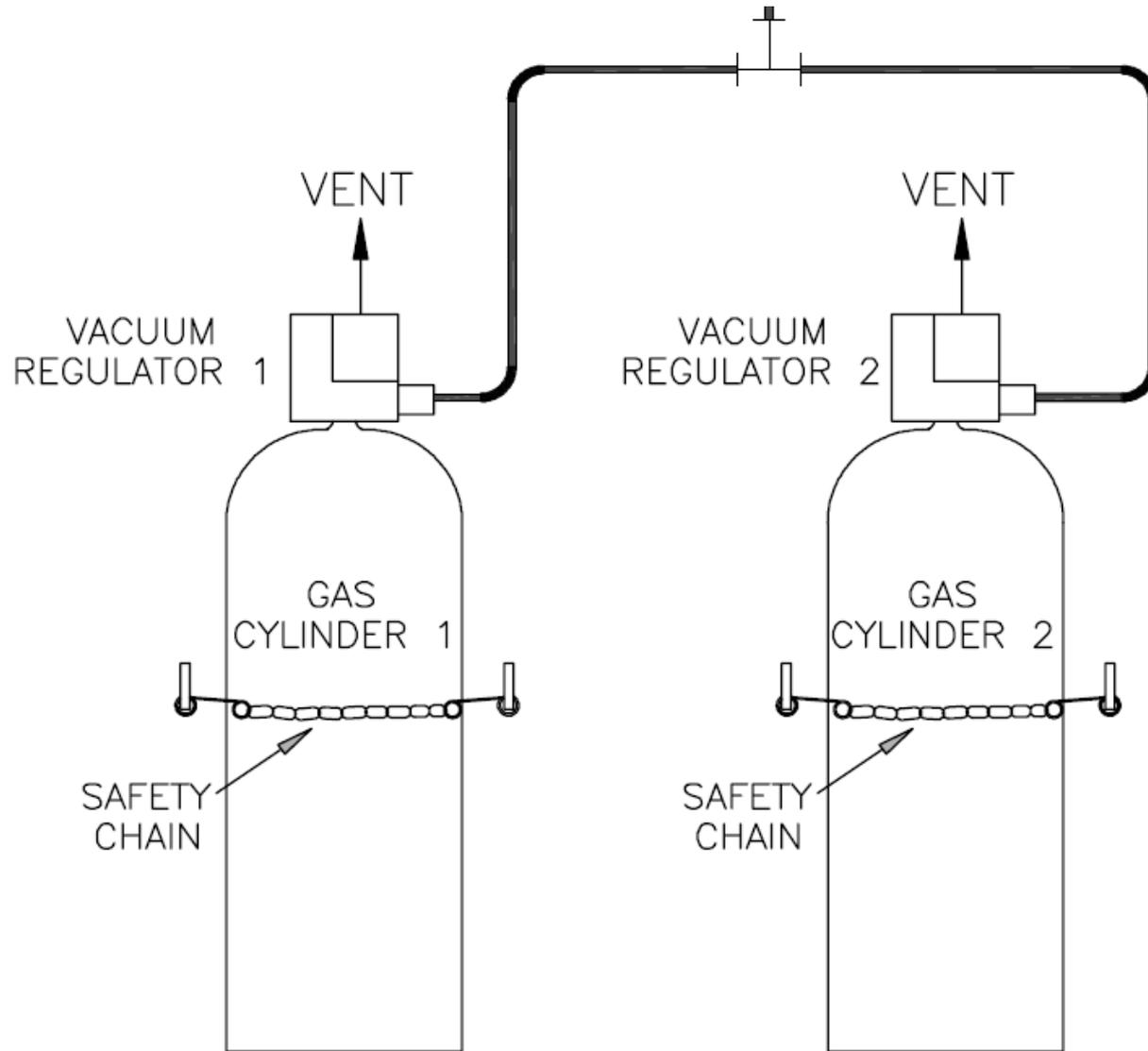
Automatic Switchover Module



Vacuum Regulator (switchover)



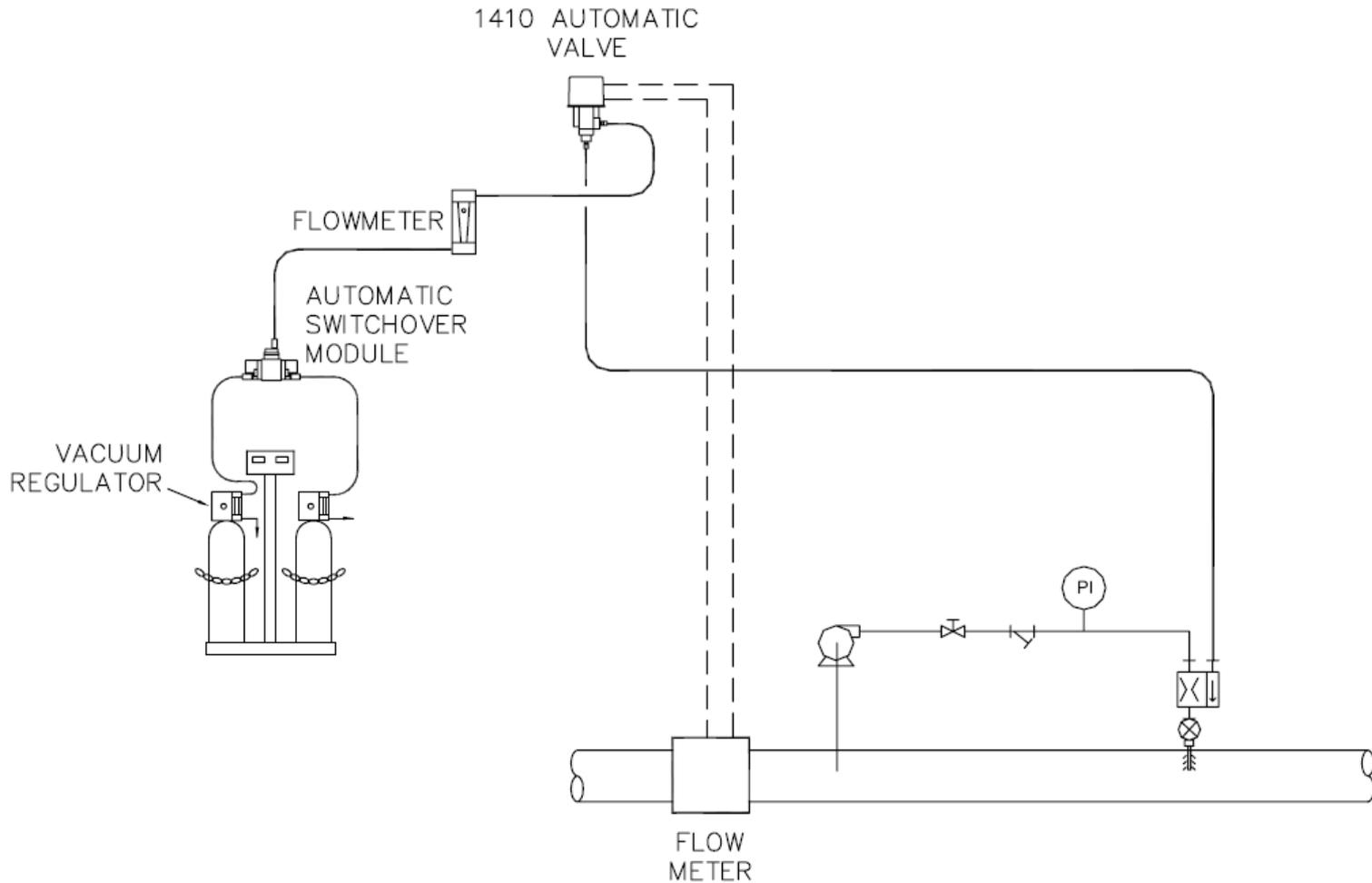
Vacuum Regulator (switchover)



Automatic Valve

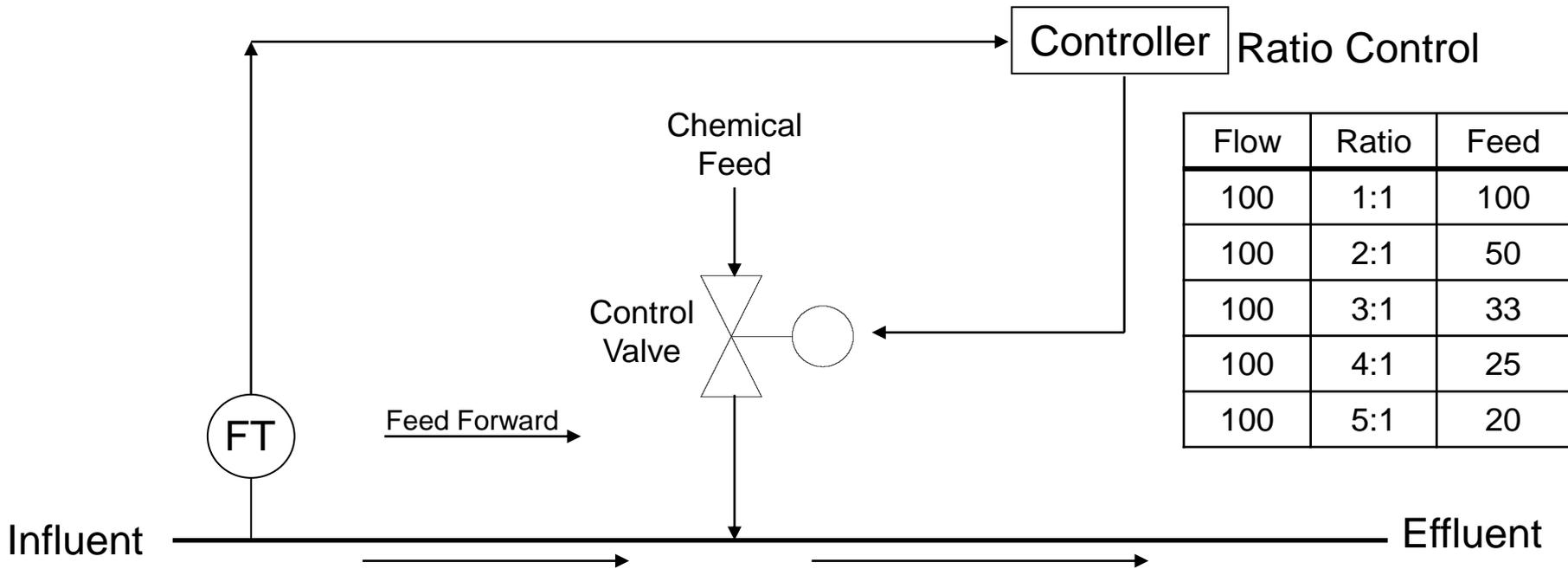


Flow Proportioning Control



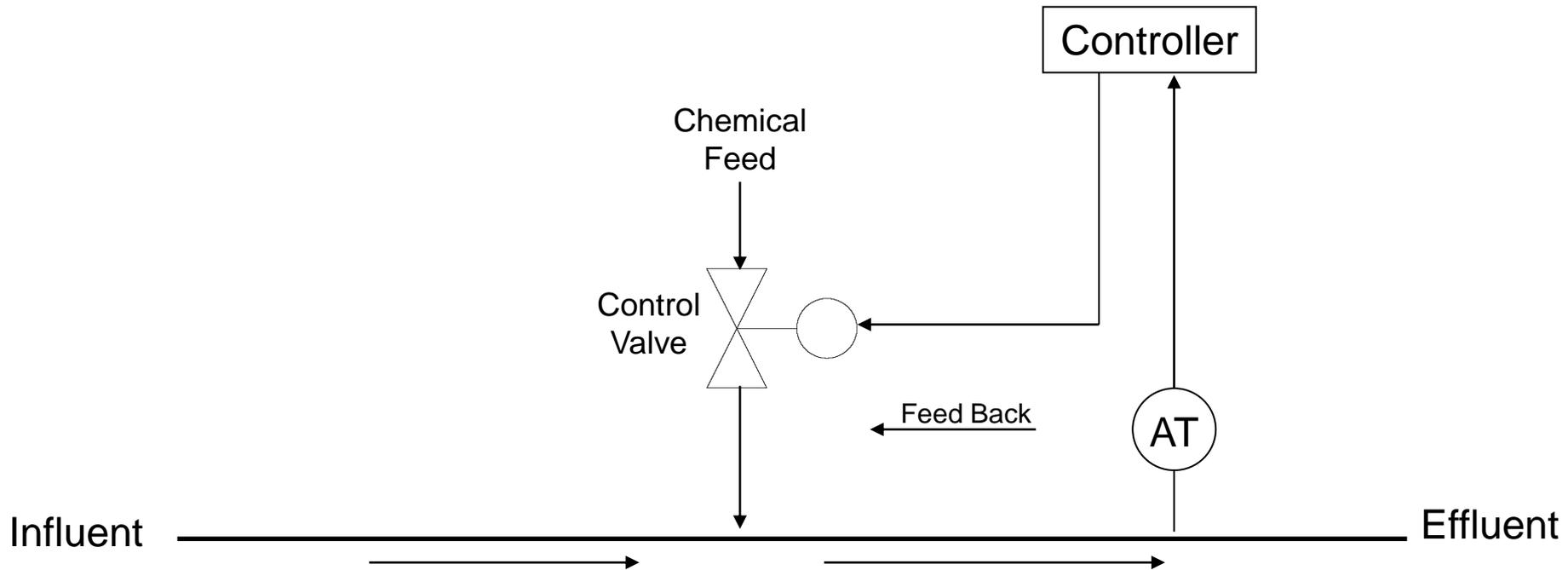
Process Control Loops

Feed Forward (ratio)



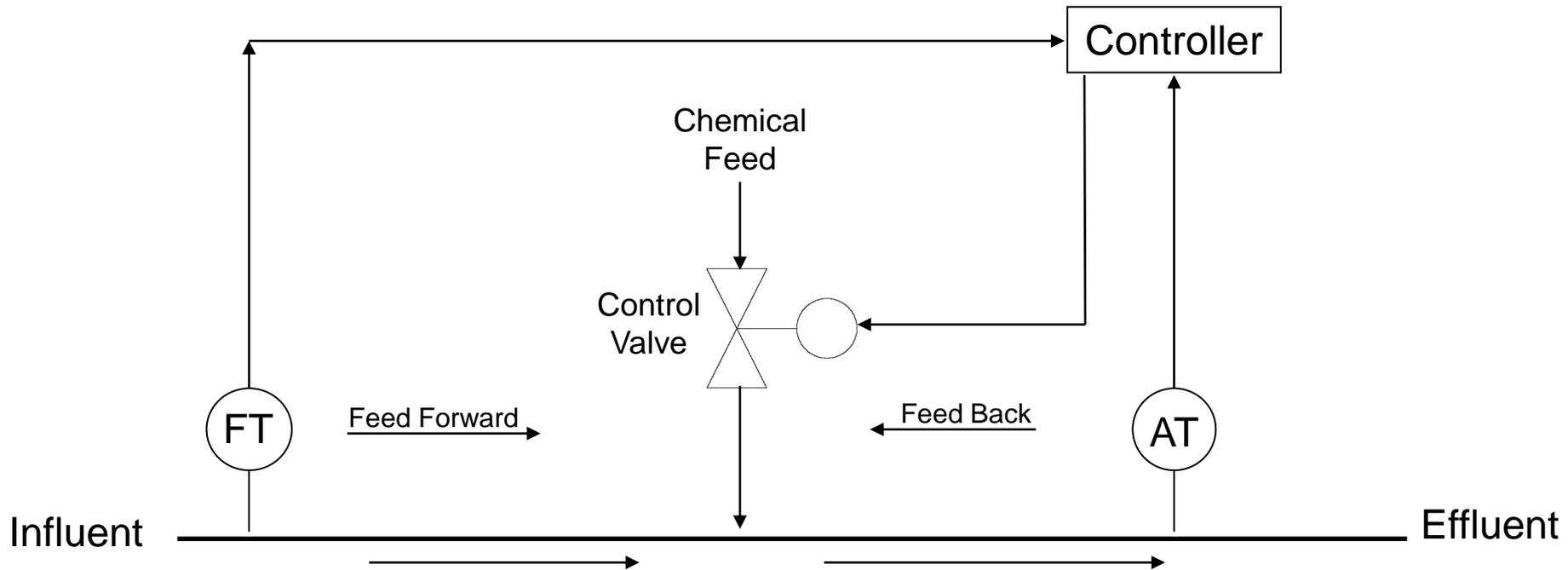
Process Control Loops

Feed Back (PID)



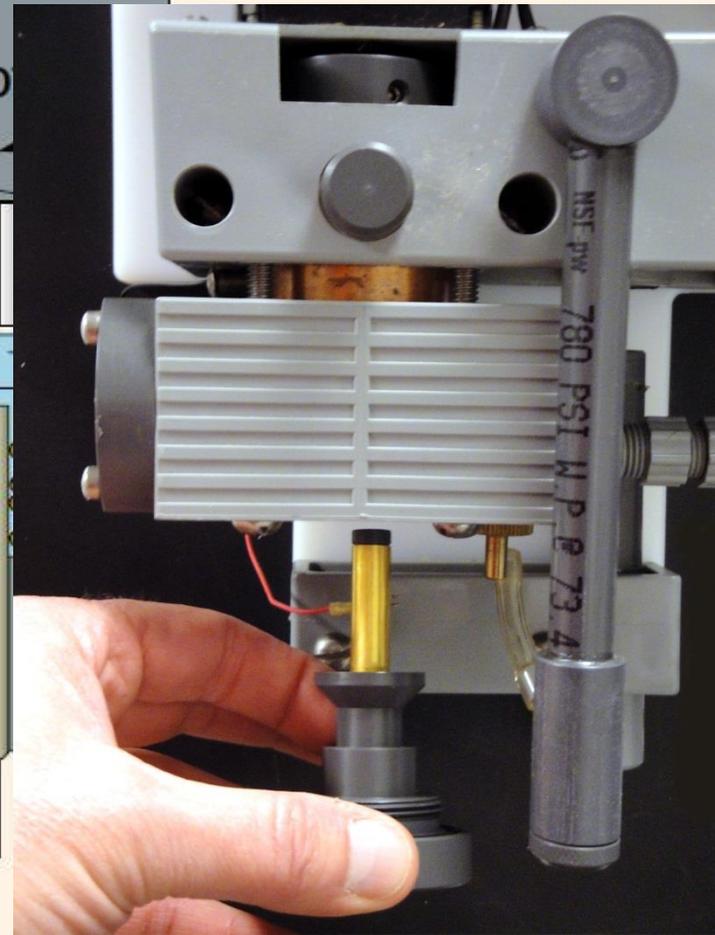
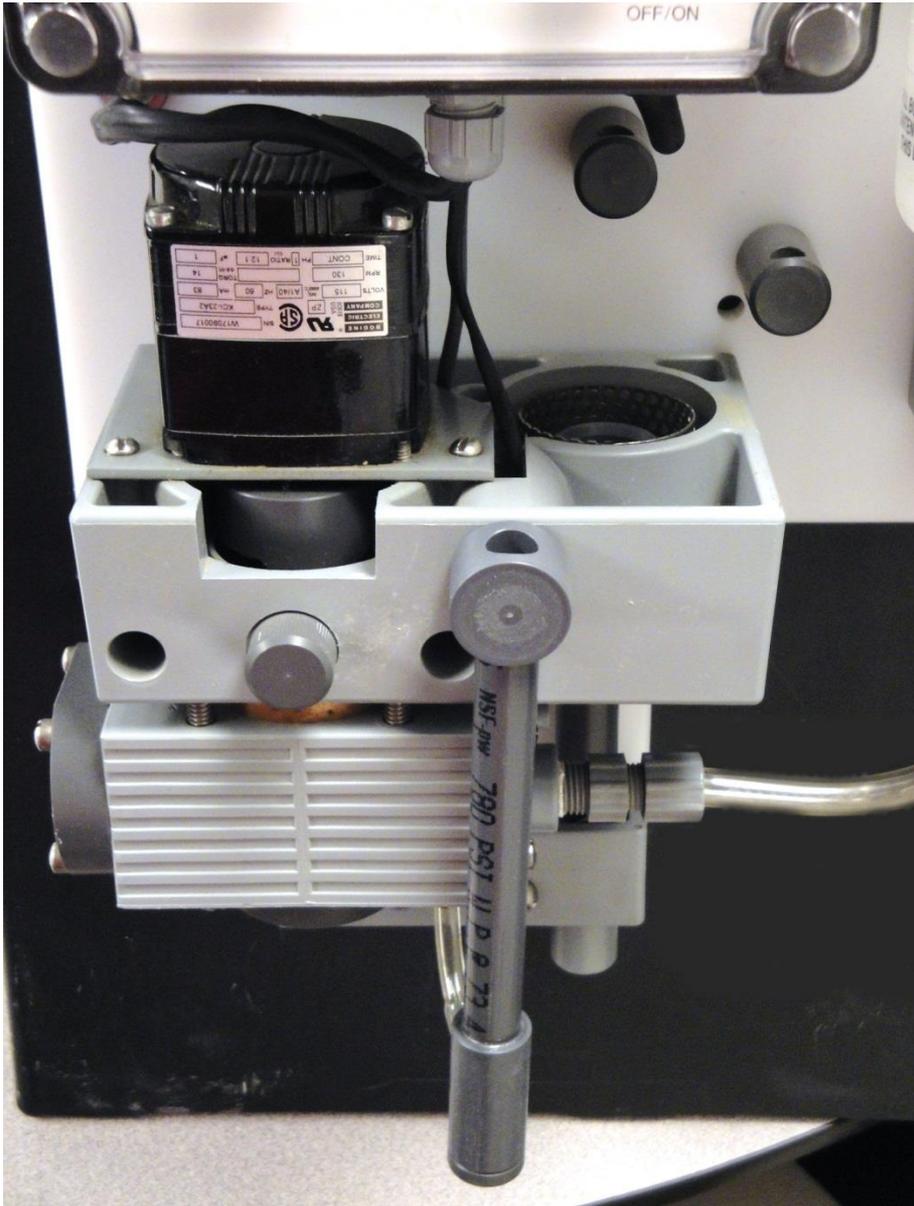
Process Control Loops

Compound Loop



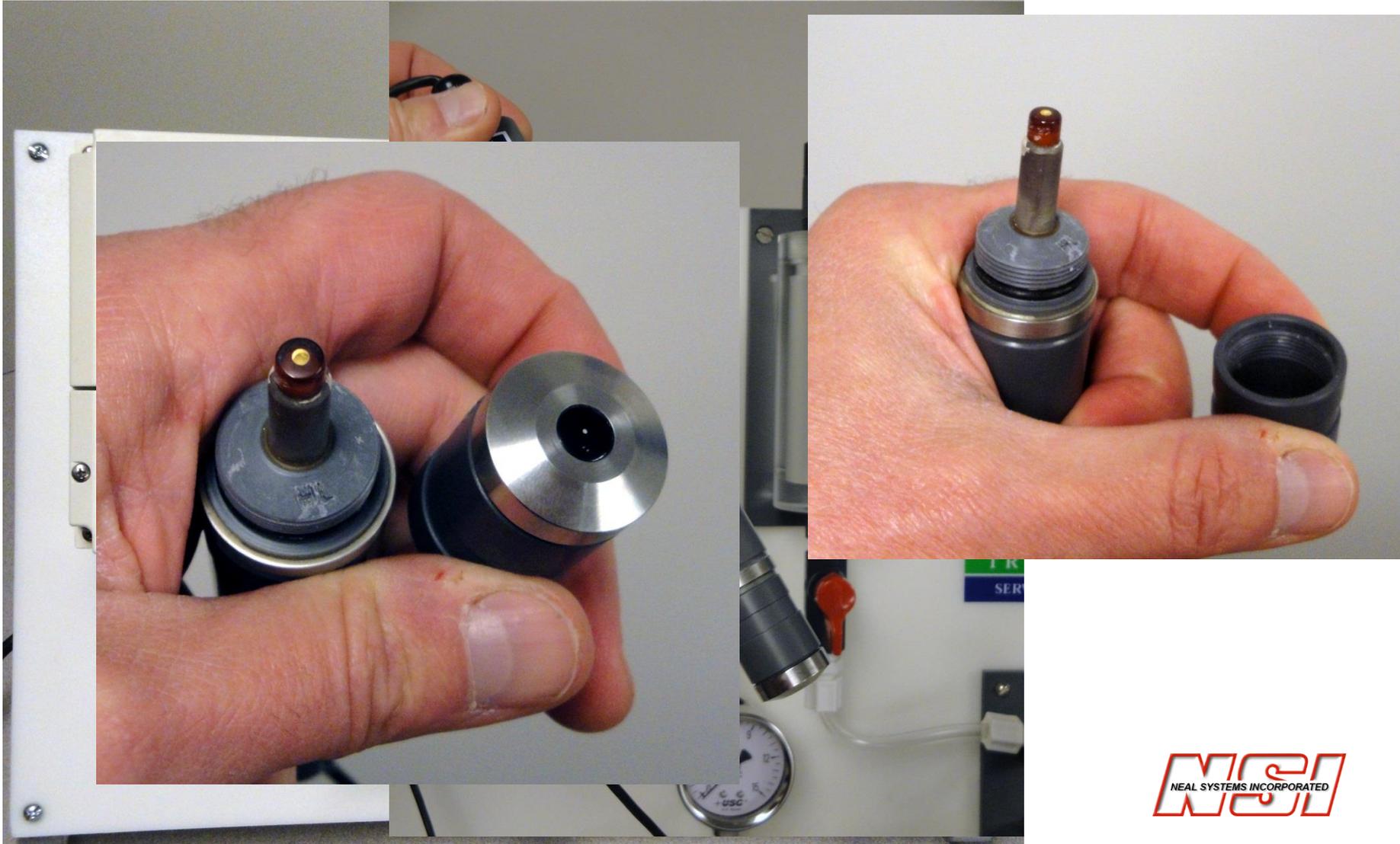
Chlorine Residual Analyzers

Amperometric



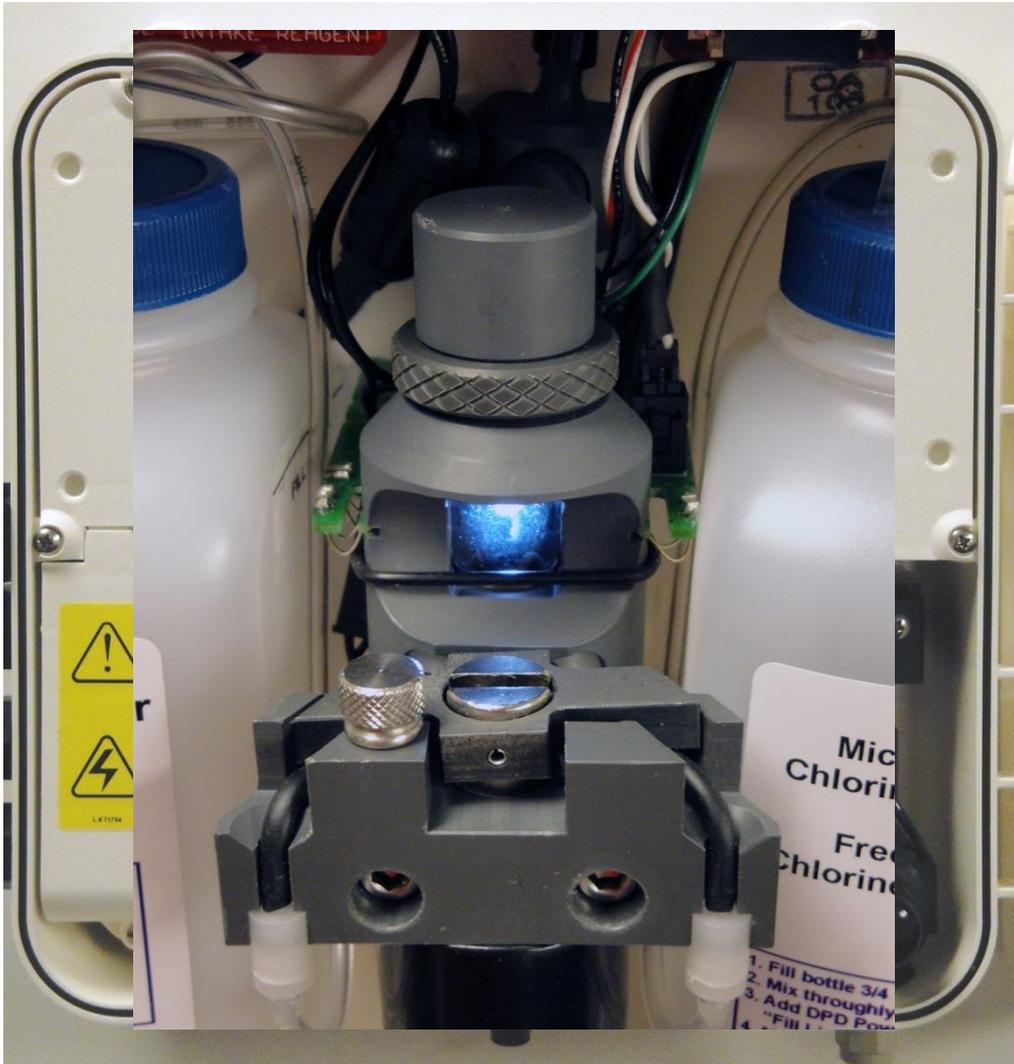
Chlorine Residual Analyzers

Amperometric Probe



Chlorine Residual Analyzers

Colorimetric



Chlorine Safety

- Transportation under USDOT regulation
- Classified as Poisonous Gas by DOT
- On-site storage should follow the Chlorine Institute recommendations
- Hoists & lifting slings must be properly rated and in good condition
- All containers must have valves protected during shipment & handling

Chlorine Safety

- Be sure that safety signs are posted, clean & legible



- Inspect cylinder valve before installing vacuum regulator

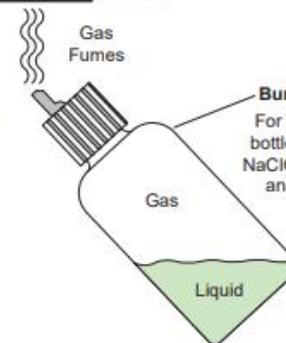


Chlorine Safety

- Install and test chlorine gas detectors



WARNING: Do NOT allow the liquid solution to directly contact the sensor membrane.



Bump Test Bottle
For Chlorine sensors bottle contains 2 parts NaClO solution (bleach) and 1 part vinegar

Chlorine Safety

- Install and test automatic cylinder shutoff valve actuators

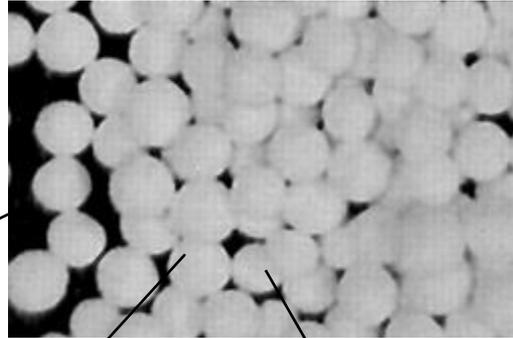


Chlorine Safety

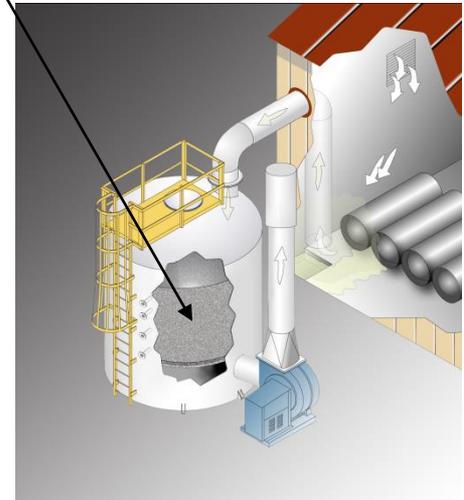
- Install and test automatic cylinder shutoff valve actuators



Dry Scrubbers



Type "STS"
4 mm
Impregnated
Activated
Alumina
Beads



Chlorine Safety

- Implement a procedure for regular inspection and maintenance of chlorination and safety equipment
- Call your friendly, local chlorinator service tech for help with maintenance and repairs



Chlorine Safety

- Develop a Process Safety Management (PSM) plan.
- Reference OSHA PSM standard 29 Code of Federal Regulations 1910.119
 - Required if storing greater than 1500lb
- Develop a Risk Management Plan (RMP)

Chlorine Safety

- Implement regular safety training including simulated emergencies using breathing apparatus and emergency kits
- For a major spill or release contact CHEMTREC (The North American emergency information system)

1-800-424-0300

Thank You