

**ENGINEERING STANDARD**

**FOR**

**PROCESS REQUIREMENTS**

**OF**

**CAUSTIC AND CHEMICAL SYSTEMS**

**FIRST EDITION**

**AUGUST 2006**

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**0. INTRODUCTION**

"Design of Major, Non-Patented Refining Processes" are broad and contains subject of paramount importance. Therefore a group of IPS Standards are prepared to cover the subject. The Process Engineering Standards of this group includes the following Standards:

**STANDARD CODE****STANDARD TITLE**[IPS-E-PR-491](#)

"Process Requirements of Crude Distillation and Hydrogen  
Production Units"

[IPS-E-PR-492](#)

"Process Requirements of Caustic and Chemical Systems"

[IPS-E-PR-500](#)

"Process Design of LPG Recovery & Splitter Units"

[IPS-E-PR-551](#)

"Process Design of Gas Treating Units"

This Engineering Standard Specification covers:

**"PROCESS REQUIREMENTS OF CAUSTIC AND CHEMICAL SYSTEMS"**

## 1. SCOPE

This Engineering Standard Specification set forth the content and the extent of the minimum process and control system requirements of "Fresh & Spent Caustic Units" and "Chemical Injection Systems".

For design of any equipment inside the subject Units / Systems, reference shall be made to the relevant IPS standards.

This Standard Specification consists of two parts as described below:

**Part I:** Process Requirements of Fresh & Spent Caustic Units.

**Part II:** Process Requirements of Chemical Injection Systems.

**Note:** This is a revised version of the standard No: IPS-E-PR-491(0) Parts III & IV Engineering Standard for process requirements of caustic and chemical systems, which is issued as revision (1) and will revise and issue as IPS-E-PR-492(1). Revision (0) of the said standard is withdrawn.

## 2. REFERENCES

Throughout this Standard the following dated and undated standards/codes are referred to. These referenced documents shall, to the extent specified herein, form a part of this standard. For dated references, the edition cited applies. The applicability of changes in dated references that occur after the cited date shall be mutually agreed upon by the Company and the Vendor. For undated references, the latest edition of the referenced documents (including any supplements and amendments) applies.

### IPS (IRANIAN PETROLEUM STANDARDS)

[IPS-E-GN-100](#) "Engineering Standard for Units"

### API (AMERICAN PETROLEUM INSTITUTE)

API Std. 650 "Welded Steel Tanks for Oil Storage",  
10<sup>th</sup> Ed., Nov. 1998

### NACE (NATIONAL ASSOCIATION OF CORROSION ENGINEERS)

TPC Publication 1, 1984 "Cooling Water Treatment Manual",  
3rd., Ed.,

### ANSI (AMERICAN NATIONAL STANDARD INSTITUTE)

ANSI B 16.5 "Pipe Flanges and Flanged Fittings, NPS 1/2 through NPS  
24",  
Ed. 2003

## 3. DEFINITIONS AND TERMINOLOGY

### 3.1 Back Pressure

a) The pressure on the outlet or downstream side of a flowing system.

b) In an engine, the pressure which acts adversely against the piston, causing loss of power.

### 3.2 Controlled-Volume Pump

A controlled-volume pump is a reciprocating pump in which precise volume control is provided by

varying effective stroke length. Such pumps also are known as proportioning, chemical injection, or metering pumps.

- 1) In a packed-plunger pump, the process fluid is in direct contact with the plunger.
- 2) In a diaphragm pump, the process fluid is isolated from the plunger by means of a hydraulically actuated flat or shaped diaphragm.

### 3.3 Inhibitor

A substance, the presence of which in small amounts, in a petroleum product prevents or retards undesirable chemical changes from taking place in the product, or in the condition of the equipment in which the product is used. In general, the essential function of inhibitors is to prevent or retard oxidation or corrosion.

### 3.4 Multiple Feed

Multiple feed is the combination of two or more pumping elements with a common driver.

### 3.5 Slurry

A free-flowing mixture of solids and liquid.

## 4. SYMBOLS AND ABBREVIATIONS

<b>DN</b>	Diameter Nominal, in (mm).
<b>DP</b>	Differential Pressure.
<b>F</b>	Flow.
<b>ID</b>	Inside Diameter, in (mm).
<b>KO</b>	Knock-Out.
<b>LP</b>	Low Pressure.
<b>LPG</b>	Liquefied Petroleum Gas.
<b>max.</b>	Maximum.
<b>min.</b>	Minimum.
<b>No.</b>	Number.
<b>NPSH</b>	Net Positive Suction Head, in (m).
<b>ppm</b>	parts per million.
<b>PC</b>	Pressure Controller.
<b>PIC</b>	Pressure Indicator Controller.
<b>TC</b>	Temperature Controller.
<b>TI</b>	Temperature Indicator.
<b>TIC</b>	Temperature Indicator Controller.
<b>TPC</b>	Technical Practices Committee.
<b>vol.</b>	Volume.

## 5. UNITS

This Standard is based on International System of Units (SI) in accordance with [IPS-E-GN-100](#), except where otherwise specified.

**PART I**  
**PROCESS REQUIREMENTS**  
**OF**  
**FRESH & SPENT CAUSTIC UNITS**

## 6. PROCESS REQUIREMENTS OF FRESH & SPENT CAUSTIC UNITS

### 6.1 Fresh Caustic Unit

#### 6.1.1 General

6.1.1.1 Fresh caustic Unit shall involve but not limited to the following:

- a) Preparation and storage of strong and dilute caustic solution, including storage facilities for the regenerated caustic from LPG Caustic Treating Section.
- b) Transferring the proper caustic solution strength to the plants or process Units where required with available pumps.
- c) Supplying strong caustic solution (typically 50% by mass) for the Unit by means of solid caustic or available strong caustic solution from existing petrochemical plants.

#### 6.1.2 Design requirements

6.1.2.1 The temperature of the solution to the suction of caustic transferring pump during transferring from caustic dissolving tank shall not exceed 98°C.

6.1.2.2 Connections of cold condensate or demineralized water addition shall be considered for diluting the contents of caustic dissolving tank and each of the dilute caustic tanks, to prepare desired concentration.

6.1.2.3 The capacity of dilute caustic tanks shall be enough to provide continuous make-up caustic, during catalyst regeneration of Catalytic Unit.

6.1.2.4 Provision of the tank heaters (typically by use of LP steam) shall be considered for caustic tanks to maintain the solutions above their freezing points.

6.1.2.5 Caustic tanks shall be provided with temperature and level indicators as well as air spargers for homogenizing the solutions and/or to maintain constant bulk temperature.

6.1.2.6 The regenerated caustic that is purged continuously from the regenerative caustic treating section in the LPG Unit should be stored in regenerative caustic tank in fresh caustic Unit area.

6.1.2.7 Pump(s) shall be provided to pump constantly fresh caustic from dilute caustic tanks, to regenerative caustic treating section to maintain the content of  $\text{Na}_2\text{S}$  and other impurities less than specified value (typically 2% by mass).

6.1.2.8 Regenerative caustic solution shall be used in non-regenerative batch caustic wash treating for  $\text{H}_2\text{S}$  removal throughout the refinery/plant.

6.1.2.9 Dilute caustic pumps shall be provided to pump the regenerative caustic where required. In addition these pumps shall be used to transfer fresh dilute caustic from appropriate tanks under the following circumstances:

- 1) To supply fresh caustic to the Catalytic Unit;
- 2) To supply fresh caustic in absence of regenerated caustic.

6.1.2.10 Pump(s) shall be provided to pump constantly fresh caustic from dilute caustic tanks into the line carrying sour water produced in regenerative caustic treating section, to the sour water plant.

6.1.2.11 The overflows and drains of all caustic tanks in fresh caustic Unit area and drains of non-regenerative caustic wash treaters shall be drained in a closed loop drainage system which is led to

caustic sump pit in Spent Caustic Treating Unit.

## **6.2 Spent Caustic Treating Unit**

### **6.2.1 General**

**6.2.1.1** The purpose of Spent Caustic Treating Unit shall be to improve the quality of spent caustic up to the point, that it is not harmful to the environment, before sending it to the water sewer.

**6.2.1.2** The Spent Caustic Unit as a typical may involve but not limited to the following equipment:

- a) Spent caustic drains sump.
- b) Spent caustic drains pump.
- c) Spent caustic surge tank.
- d) Spent caustic feed pump(s).
- e) Spent caustic oxidizer(s).
- f) Hydrochloric acid tank.
- g) Caustic oxidizer effluent separator.
- h) Spent caustic filter (s).
- i) Spent caustic cooler.
- j) Static HCl acid mixer.
- k) Spent caustic degassing vessel.

### **6.2.2 Design requirements**

**6.2.2.1** In case of existence of oil in spent caustic drains sump, an oil separator with internal baffle shall be installed to remove the oil from spent caustic before transferring to spent caustic surge tank.

**6.2.2.2** Automatic level control system shall be provided to transfer the entrained oil to API separator.

**6.2.2.3** Provision of cold condensate addition shall be made to dilute the spent caustic feed line to desired concentration of contaminants, before entering the spent caustic surge tank.

**6.2.2.4** Provision of tank heater (typically by use of LP steam) shall be considered for spent caustic surge tank to maintain the contents of tank above its freezing point.

**6.2.2.5** A series of stirred reactors shall be provided to convert the sulphide contained to thiosulphate/sulphate with atmospheric oxygen at proper temperature and pressure.

**6.2.2.6** The utility air injection shall be flow controlled to the bottom of each reactor, through convenient distributor.

**6.2.2.7** The temperature of the reactors could be logged and controlled (TIC) by the injection of live steam to the reactor through air distributor line to supplement the heat of reaction.

**6.2.2.8** Vent gases and effluents from the reactors shall be discharged to effluent separator, from where, the gas (essentially air) should be sent to atmosphere at safe location.



**6.2.2.9** The pressure in the reactors and effluent separator should be monitored and maintained by pressure indicator controller (PIC) for controlling the gas discharge to atmosphere.

**6.2.2.10** Dual filters and cooler shall be provided to filter and cool (typically up to 35°C) the treated liquid effluent from effluent separator.

**6.2.2.11** A mixer shall be provided for mixing the hydrochloric acid solution (typically 30% by mass) with effluent liquid from cooler.

**6.2.2.12** A storage tank for hydrochloric acid with appropriate transferring pumps shall be provided for neutralization system mentioned above.

**6.2.2.13** A degassing vessel shall be provided to enter the neutralized solution.

**6.2.2.14** Level indicator controller shall be provided to discharge the neutralized solution (treated spent caustic) to the water sewer.

**6.2.2.15** The size and numbers of series reactors shall be chosen to reduce the sulphide content of liquid effluent from the last reactor to acceptable standard figure.

**PART II**  
**CHEMICAL INJECTION SYSTEMS**

## 7. CHEMICAL INJECTION SYSTEMS

### 7.1 Definition of Terms

For definition of terms herein used, reference is made to Clause 3.

### 7.2 Chemical Feed Systems-General

**7.2.1** Chemical feed systems shall be designed to ensure high reliability and have flexibility enough to cover contingencies that might arise. The required volume of chemical as well as its physical and characteristics should also be considered in the feed system design.

#### 7.2.2 Feed concepts

The method by which a chemical is added shall be suited to both its intended use and the system into which the product is being added. Feeding mechanisms should be categorized to: intermittent feed, slug feed, continuous feed, and shock feed:

##### a) Intermittent feed

Intermittent feed is on/off feed, over an extended time span, with chemicals added at fixed intervals to a threshold level of treatment.

##### b) Slug feed

Slug feed involves the addition of chemical in excess of the amount required to produce a desired concentration after a specific time interval. As make-up is added to compensate for system losses over a period of time, the residual is gradually lowered to an unacceptable level, therefore requiring another slug.

##### c) Continuous feed

Continuous feed is the method most commonly encountered. It may be manual, providing a constant rate of chemical addition, or it might be automatic, the feed rate being automatically adjusted in response to some measured variable such a pH or flow rate. Feeders which cycle on and off over short time spans shall also be considered continuous.

##### d) Shock or shot feed

Shock feed is a specialized form of slug feed as applied to the introduction of micro-biocides to recirculating cooling system. Shock feed is utilized to provide maximum benefit from the "kill" effect on microbiological growths afforded by a high level of treatment.

#### 7.2.3 Chemical feeders

Chemicals used in chemical injection system are added by means of devices called chemical feeders. These feeders are classified as, wet feeders, dry feeders, and gas feeders:

a) Wet feeders are designed to feed solutions only, or solutions and suspensions.

b) Chemicals in solid form are fed with dry feeders and gases with gas feeders.

**7.2.3.1** Important design notes on some of chemical feeders are as bellow:

##### a) Water-jet eductor

Application of water jet eductors is limited by the amount of lift or suction necessary, by available motive pressure and by discharge pressure. Generally, a ratio of at least 3.5 : 1 for motive and discharge pressure is necessary.

**b) Positive displacement pump**

- 1) The pump shall be protected by a relief valve in the discharge piping or with an internal relief mechanism.
- 2) One pump or pumping head shall be used for each point of application, because it is impossible to throttle discharge from one pump so that several points will receive a controlled amount of treatment.

**c) Dry feeders**

Dry feeders shall be used in larger plants where quantities of chemicals to be added to a system exceed approximately 4.5 kg/h.

**7.2.4 Chemical feed equipment used in water treatment**

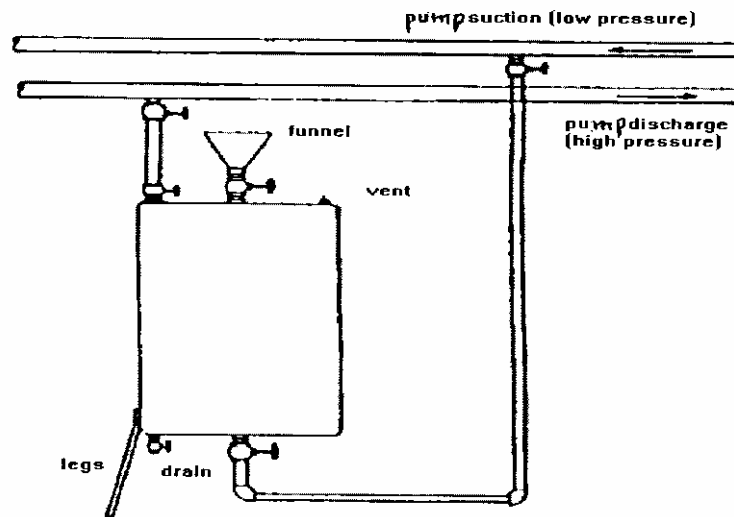
7.2.4.1 Most cooling water and boiler water treatment products are liquids or solutions prepared from powders. The pump is therefore the most frequently encountered feed device. Different feed equipment is briefly mentioned in the following:

**7.2.4.2 Metering pump**

See Clause 7.5 hereinafter.

**7.2.4.3 Shot feeders**

The shot feeder typically shown in Fig. 1 consist of a pressure-rated chemical tank installed across a pressure differential such as the feedwater or circulation pump.

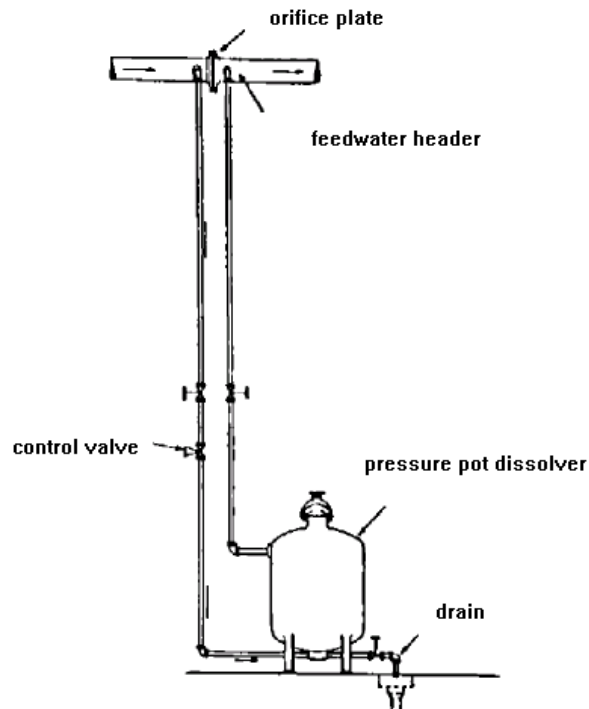


**TYPICAL SHOT FEEDER INSTALLATION**  
Fig. 1

**7.2.4.4 Miscellaneous feeders**

**a) By-pass feeders**

Treatment chemicals which dissolve slowly, or are made in special briquette form can be added, using the bypass feeder, typically shown in Fig. 2.



**TYPICAL BY-PASS FEEDER**  
Fig. 2

### b) Chlorine feeders (chlorinator)

The water jet eductor uses the kinetic energy of water under pressure to entrain chlorine gas, mix the two and discharge mixture to water in flow line or in a treating basin. Chlorine shall not flow if a vacuum is not produced. If hypochlorite solutions are to be used, pumps and shot feeders can be used.

### c) Acid/Alkali feeding

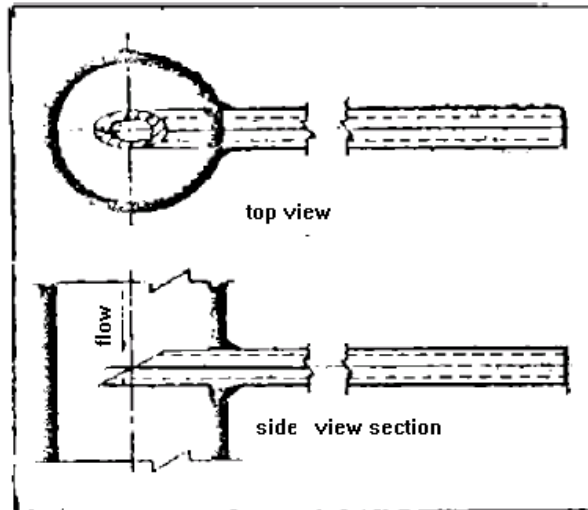
Acids and alkalis require suitable feed mechanisms and control. Acid feed is recommended to regulate automatically by a pH controller. The following safeguards shall commonly be considered:

- 1) Day tanks-feeding from a day tank in lieu of a bulk tank limits the total volume which might enter the system in the event of an accident.
- 2) Dilution-acid is frequently diluted to improve mixing and pH control. Alarms indicating loss of dilution flow should be considered to stop further acid flow, if necessary.
- 3) Safeguard-the pH sensing element should be provided with a no-flow switch in the sample line to indicate if sample flow is lost. Duration timers should also be used to provide the alarm if acid is fed for an unusually long period of time.

## 7.2.5 Accessories

### 7.2.5.1 Injection nozzles

Specialized nozzles should often be needed when injecting chemicals into the pipeline. Fig. 3 shows typically a nozzle for adding liquid chemicals into a steam line or other gaseous stream. This nozzle mechanically atomizes the liquid by force of the gas.



**TYPICAL NOZZLE FOR INJECTING LIQUID CHEMICALS INTO A GASEOUS STREAM**

**Fig. 3**

#### **7.2.5.2 Mixers**

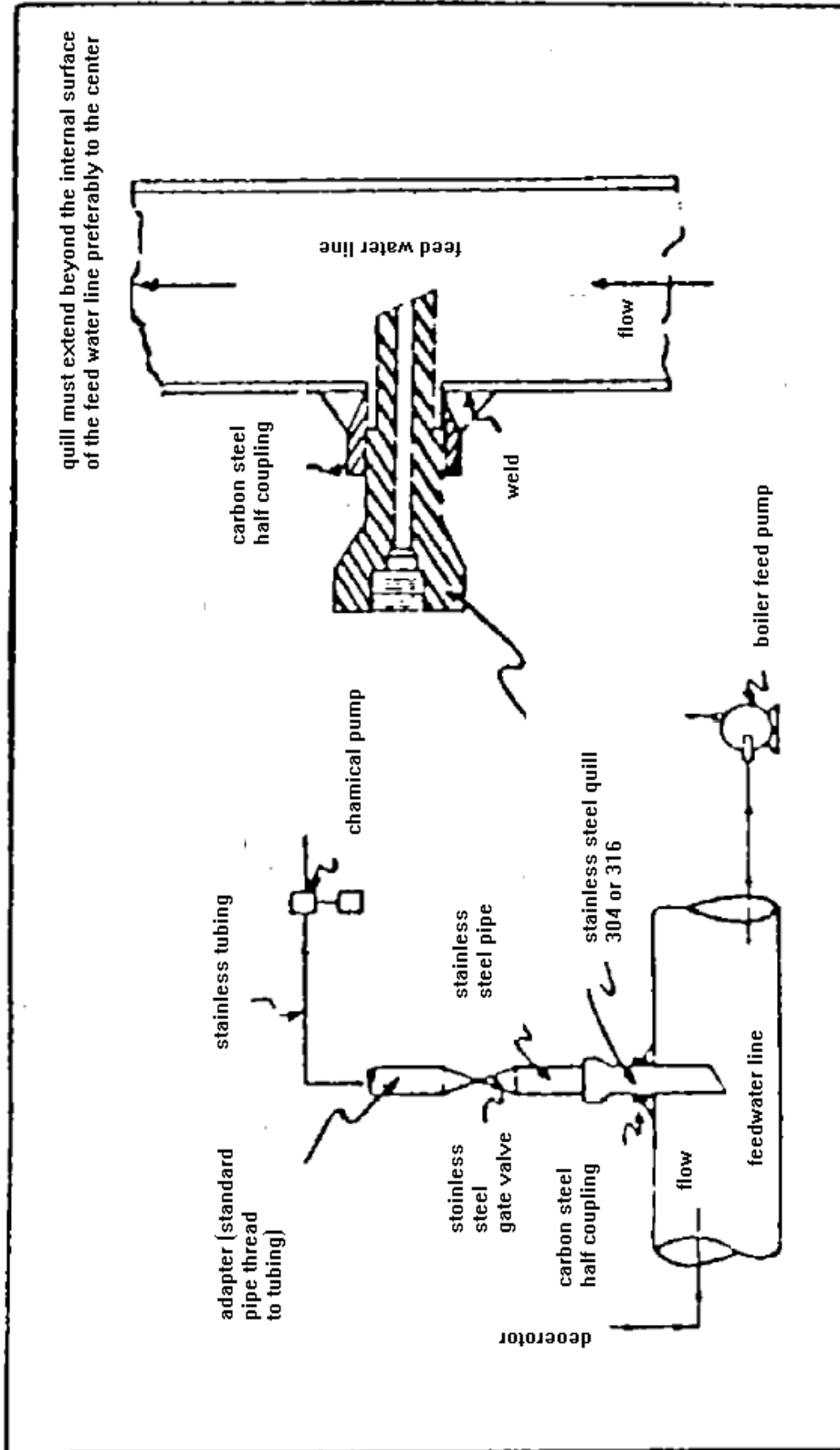
- a)** An agitator or mixer should be used whenever a powdered chemical shall be dissolved or if a heavy or viscous liquid product is to be diluted.
- b)** The mixer should not be run continuously except for slurries.
- c)** Dissolving polymers and other viscous materials requires a larger propeller and slower speed.
- d)** Direct injection of air or steam is satisfactory for dissolving chemicals.

#### **7.2.5.3 Level alarm**

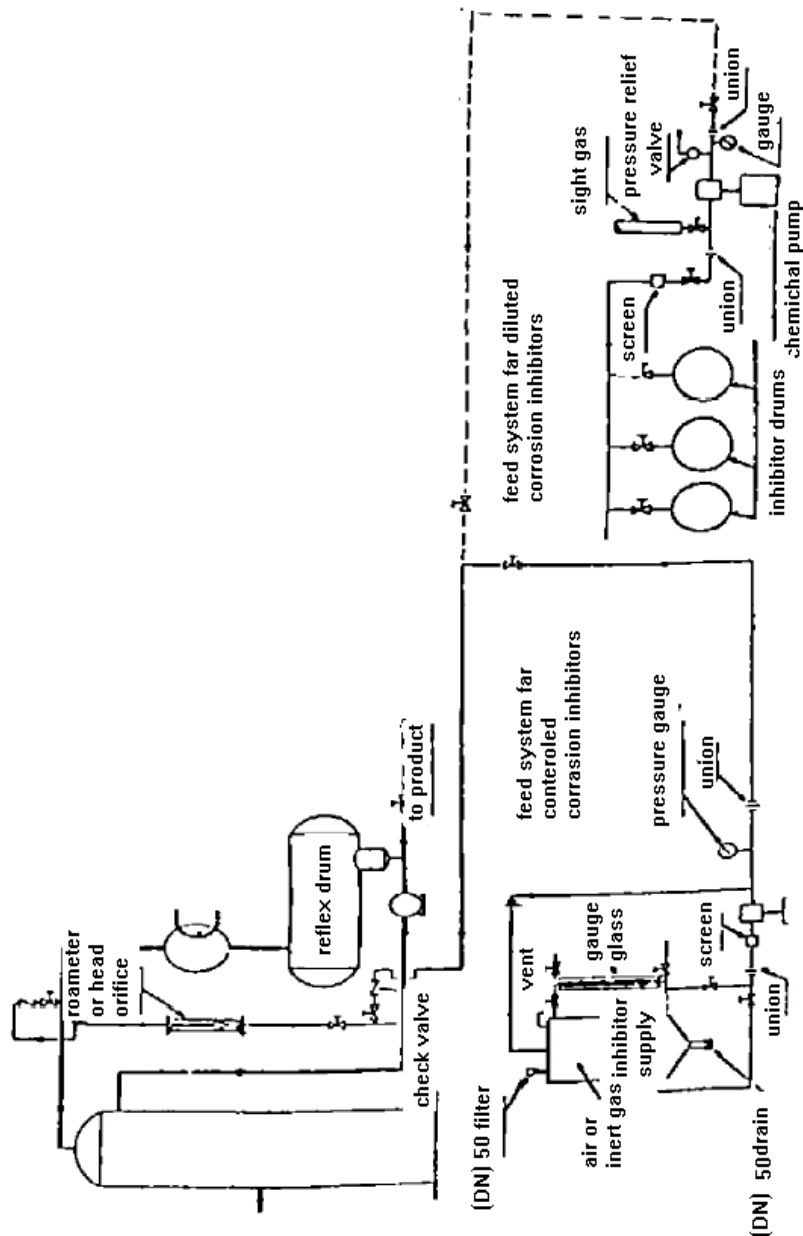
- a)** A level alarm should be installed on a feed tank when chemical feed shall not be interrupted or when the pump will be damaged if it runs dry.
- b)** Chemical feed tanks usually use an electrode-type level control operating on the conductivity of the chemical solution.
- c)** Level control package will automatically perform a variety of functions, such as shutdown of a chemical feed pump and alarm at low level, energizing a pump or opening a valve at low level to fill the tank and alarm at high level.

#### **7.2.6 Chemical additive feeding systems**

Figs. 4 & 5 are presented to show typical feeding system in boiler water treatment & corrosion inhibitor, respectively.



TYPICAL BOILER WATER TREATMENT FEEDING SYSTEMS  
Fig. 4



TYPICAL FEED SYSTEM FOR CONCENTRATED AND/OR DILUTED CORROSION INHIBITORS

Fig. 5

Notes:

Important Factors for slipstream inhibitor feeding:

- 1) Slipstream line must be large enough for structural strength, yet not so large as to keep fluid from filling it and entering overhead vapor line under pressure. Recommended size is DN 20 to DN 25.
- 2) A Rotameter is important so that being sure that the inhibitor is flowing through the line and is thoroughly mixed.

7.2.7 System design and operation of chemical feeders for cooling towers

7.2.7.1 Fig. 6 shows the equipment, piping and auxiliaries to be included in the Vendor's scope of supply.

7.2.7.2 Wet chemical feed systems shall be designed to hold a minimum of 72 hours supply of chemicals based on design flow and design raw water analysis, or on peak treatment dosages. For



metaphosphate inhibitors use 24 hours hold up.

**7.2.7.3** Solution strengths for phosphates shall not exceed 3% (by mass).

**7.2.7.4** All equipment shall be suitable for unsheltered out-door installation for the climatic zone specified.

**7.2.7.5** Units shall be designed for continuous service and an uninterrupted operation for a period of 2 years.

**7.2.7.6** Controlled volume pumps shall have a capacity of two times specified design feed rate to allow flexibility (increase or decrease) in dosing. A minimum of two pumps (one spare) shall be included.

**7.2.7.7 Equipment design and selection**

**7.2.7.7.1** Mechanical agitators shall be designed to operate continuously.

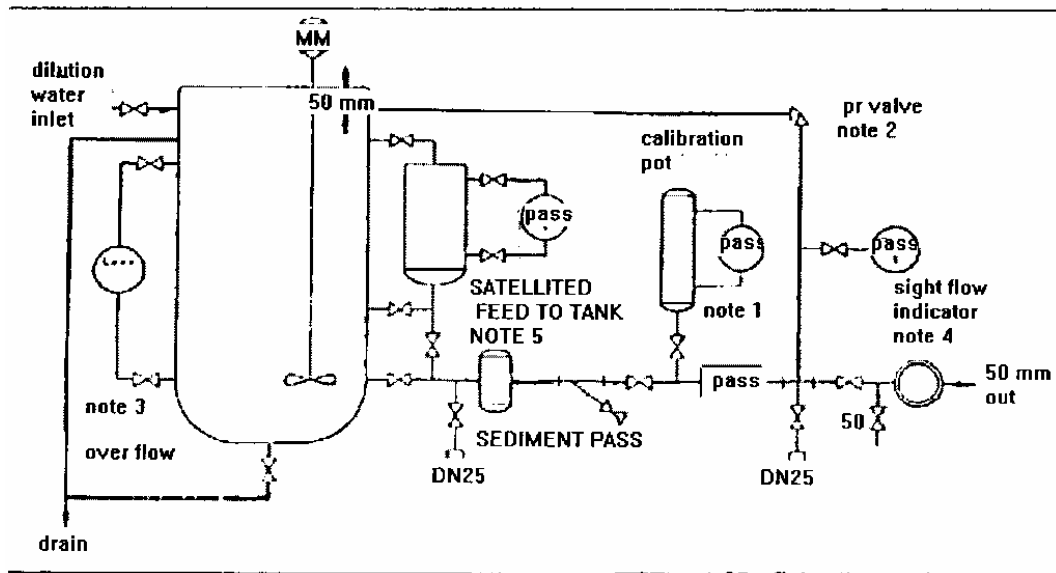
**7.2.7.7.2** Each positive displacement pump shall be furnished with a calibration pot. A gage glass shall be furnished with a gage board calibrated in cm.

**7.2.7.7.3** Tanks and small vessels used for storage and handling of water and solutions not subject to pressure or vacuum shall be designed and fabricated to the requirements of API 650.

**7.2.7.7.4** Dispersion equipment for dispersing concentrated chemicals shall be furnished to assure complete solution of soluble chemicals or a complete dispersion of suspended solids.

**7.2.7.7.5** Enclosures for electrical equipment shall be appropriate for the specified area classification and environmental exposure.

**7.2.7.7.6** The chemical feeding and automatic control shall be as per TPC publication 1, "Cooling Water Treatment Manual", 3rd. Ed., by NACE.



**CONTROLLED VOLUME PUMP FEEDER  
(DIAGRAMMATIC LAYOUT OF EQUIPMENT AND PIPING)**

**Fig. 6**

**Notes:**

- 1) Gage glass with calibrated gage board.

- 2) PR Valve to be furnished even when built-in relief valves are provided with pumps. Set pressure to be provided by the pump manufacturer.
- 3) Gage glass not required if tank is constructed of transparent plastic.
- 4) Sight flow indicator with flapper.
- 5) Satellite feed tank required when chemical mixing and storage are done in the same tank. The satellite tank is used when the main tank is being used for preparing new batch.

### **7.3 General Requirements for Design and Construction of Chemical Dosing Units in Water Treating System**

#### **7.3.1 Performance**

- a) The chemical dosing Unit shall be capable of withstanding continuous operation.
- b) The accuracy of the chemical feeds shall be  $\pm 5\%$  through the range of 20 to 100% of the design maximum feed rate of the Unit.
- c) Adjustment for changing the feed rate from 0 to 100% of design shall be possible.

#### **7.3.2 Construction**

- a) The chemical dosing Unit shall consist of a chemical tank (and measuring tank, if necessary), feed pump (or eductor) and mixer.
- b) The equipment containing chemicals shall be fabricated of suitable materials for each respective chemical service.
- c) All equipment shall be installed on the common base plate at the shop so as to constitute a packaged Unit.
- d) All equipment shall be suitable for unsheltered outdoor installation.

#### **7.3.3 Materials**

- a) Each item of equipment of the chemical dosing Unit shall be of materials which are sufficiently resistant to corrosion and erosion by the chemicals.
- b) Table 7-1 "Material Selection Guide for Dosing Unit" is applicable to typical chemicals used in the water treatment Unit.

#### **7.3.4 Instrumentation and control**

##### **a) Control system**

- 1) The control system shall be integrated into the control and instrumentation system of the water treating system, unless the equipment is isolated.
- 2) Flow control shall be automatic except in the case of systems in which fluctuations in the chemical dosing rates can be disregarded.

##### **b) Instruments**

The instrumentation shall include, but not be limited to the following:

- 1) Local level indicators on all tanks.
- 2) Low-level sensor that will initiate an alarm on the control panel.

- 3) Measurement of charge (as required).

### **7.3.5 Mechanical**

#### **a) Chemical tanks**

- 1) Chemical tanks shall have sufficient capacity on the basis of the maximum operating rate.
- 2) Where the chemical solution is to be prepared by dissolving powder chemicals or by diluting concentrate chemicals, the chemical tanks shall be provided with motor driven mixers which shall be capable of performing continuous operation. The mixers shall be magnetic type where the content of the tanks are toxic or hazardous materials.
- 3) Where the chemicals handled are physically non-hazardous and non-toxic, and for tanks smaller than 200 L in capacity, hand-operated mixers may be used.
- 4) Chemical tanks shall be provided with instruments capable of measuring the quantities in the tanks.
- 5) The powder chemicals are to be dissolved. For this purpose, dissolving baskets shall be provided in the tank.

#### **b) Pumps**

- 1) Safety valve discharge lines shall be connected to the chemical tanks.
- 2) Proportioning pump stroke shall be capable of being changed manually even during operation.
- 3) Pumps other than proportioning pumps shall be provided with flow indicators and control valves.
- 4) Chemical pumps into which slurry may pass, shall be of an open impeller centrifugal type and shall be provided with flow indicators and control valves in accordance with item (3) above.
- 5) Provisions shall be made to isolate the pump during maintenance period.
- 6) All types of pumps shall be furnished with spare.

### **7.3.6 Other items**

- a) For dosing of acid and caustic soda for regeneration in the ion exchange system, eductors may be used instead of pumps. In this case, flow indicators and control valves shall be provided.
- b) Ladders and platforms required for operation, inspection and maintenance shall be provided.
- c) Enclosures for electrical equipment shall be appropriate for the specified area classification and environmental exposure.

### **7.3.7 Inspection and testing**

#### **a) Shop inspection and testing**

The following inspections and tests shall be performed on each respective part or

equipment:

- 1) Visual and dimensional check.
- 2) Material check against the mill test certificate.
- 3) Mechanical running test on each respective equipment in the Unit.

**b) Field inspection and testing**

- 1) A running and performance test shall be performed.

**TABLE 7-1 MATERIAL SELECTION GUIDE FOR DOSING UNIT**

Chemical	Solution Concentration (mass %) Max. Temp.	Material
Aluminum Sulphate $Al_2(SO_4)_3 \cdot 14H_2O$	20% Ambient	Plastic or natural rubber lined carbon steel or Alloy 20
Ammonia $NH_4OH$	40% Ambient	Carbon steel (copper alloys not to be used)
Calcium Hypochlorite $Ca(OC_{12})_2$	10% Ambient	Plastic or natural rubber lined carbon steel or Alloy 20
Copper Sulfate $CuSO_4 \cdot 5H_2O$	10% Ambient	Natural rubber lined carbon steel or type 316 stainless steel or Alloy 20
Cyclohexy-Amine $C_6H_{11}NH_2$	40% Ambient	Carbon steel
Disodium Phosphate $Na_2HPO_4 \cdot 12H_2O$	3% Ambient	Carbon steel
Hydrazine $N_2H_4 \cdot H_2O$	50% Ambient	Type 304 or type 316 stainless steel
Hydrochloric Acid HCl	40% Ambient	Natural rubber lined carbon steel or FRP or Hastelloy B
Monosodium Phosphate $NaH_2PO_4 \cdot H_2O$	3% Ambient	Type 304 stainless steel or rubber lined carbon steel
Potassium Permanganate $KmnO_4$	20% Ambient	Carbon steel
Sodium Chloride NaCl	25% Ambient	Fiber-glass reinforced plastic (FRP) or FRP lined carbon steel or natural rubber lined carbon steel or bronze
Sodium Hydroxide NaOH	50% Ambient	Carbon steel
Sodium Hypochlorite NaOCl	10% Ambient	Natural rubber lined carbon steel or plastic
Sodium Metaphosphate $(NaPO_3)_x$	3% Ambient	Type 304 stainless steel or natural rubber lined carbon steel
Sodium Sulfite $Na_2SO_3$	30% Ambient	Type 304 stainless steel
Sulfuric Acid $H_2SO_4$	80-100% Ambient	Type 316 stainless steel or Alloy 20 for pump and mixer, carbon steel for tank and piping (Velocity less than 1.0 m/sec.)
Trisodium Phosphate $Na_3PO_4 \cdot 12H_2O$	3% Ambient	Carbon steel

**7.4 General Design Requirements of Chemical Feed Equipment**

**7.4.1 Cooling tower warm lime softener**

**7.4.1.1** The equipment shall be designed to feed the chemicals in direct proportion to the amount of water entering the softener.

**7.4.1.2** The equipment shall accurately proportion the chemicals at all rates and ranges of flow within the specified capacity of the softener.

**7.4.1.3** The equipment shall also include means of adjusting the dosage of chemicals without increasing or decreasing the strength of solution.

**7.4.1.4** The equipment shall include wet or dry chemical feeders with level indicators, tank agitators, proportion devices and chemical feed pumps.

**7.4.1.5** Two chemical pumps (one as spare) shall be furnished for each chemical feed system.

**7.4.1.6** The Vendor shall guarantee that; the chemical proportioning and feeding equipment shall deliver automatically the respective chemicals in proportion to the rate of water flow.

**7.4.1.7** An acid feed system shall also be provided in the inlet line to the pressure filters for pH control to prevent clogging of filters. The feed system shall include a solution tank with support stand, two acid feed pumps and all necessary accessories.

#### **7.4.2 Clarifier**

**7.4.2.1** The equipment shall be designed to feed the chemical in direct proportion to the amount of raw water entering the reactivator.

**7.4.2.2** The equipment shall accurately proportion the chemical at all rates and ranges of flow within the specified capacity of the clarifier.

**7.4.2.3** The equipment shall also include means of adjusting the dosage of chemicals without increasing or decreasing the strength of solution.

**7.4.2.4** The equipment shall include dry chemical handling facilities for storage and conveyance of chemical to the central chemical dissolving tank.

**7.4.2.5** One central chemical dissolving tank with air agitation, dry chemical handling facilities and its own chemical transfer pumps to pump the chemical solution to the clarifiers chemical feed tanks, level indicator and all interconnecting piping shall be provided.

**7.4.2.6** The Vendor shall guarantee that; the chemical proportioning and feeding equipment shall deliver automatically the respective chemicals in proportion to the rate of water flow.

### **7.5 General Design Requirements of Metering Pump in Chemical Injection Systems**

#### **7.5.1 Introduction**

The following requirements should be considered in the design of metering pumps that are used in chemical injection systems.

#### **7.5.2 Installation**

**7.5.2.1** All factors and considerations of sound hydraulic practice, including freedom from air and foreign matter, accurate and reliable seating of valves, proper size and length of piping, liquid vapor pressure, viscosity, and temperature shall be considered for successful metering pump installation.

**7.5.2.2** The application of basic hydraulic principles during planning, installation (as shown in Fig. 7) and operation is essential.

**7.5.2.3** The installation should be made with careful attention to all instructions regarding handling of corrosive, toxic or hazardous chemicals to assure personnel safety.

#### **7.5.2.4 Location**

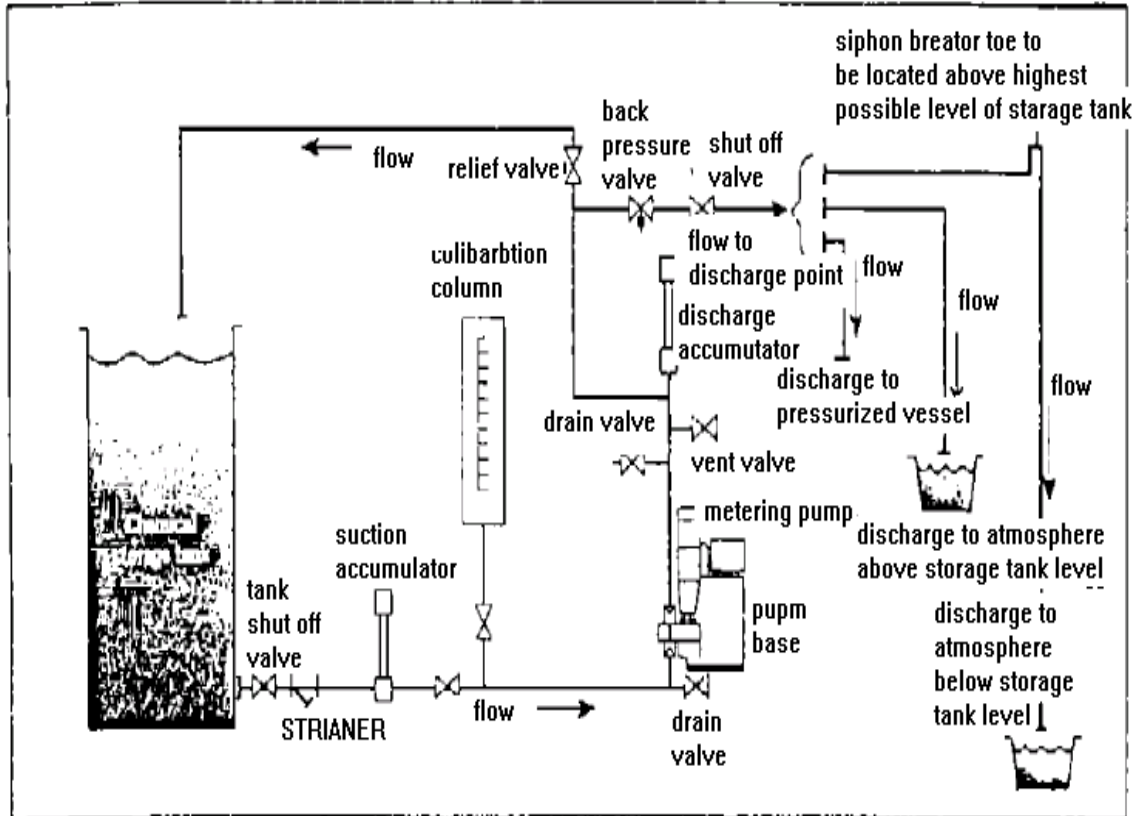
The preferred location of metering pump is indoors, although pumps can be installed outdoors. Manufacturer's recommendations for ambient operating temperatures shall be followed.

**7.5.2.5** All pumps used outdoors where temperature can fall below 0°C should be provided with a means of heating the pump, as well as being sheltered for protection from precipitation, blowing

sand, dust or other possible contamination.

**7.5.2.6** All pump installations should allow sufficient room all around for operator access for adjustments or servicing.

- The pump should not be installed under tanks or other equipment where possible overflow would damage the pump.
- The pump foundation shall have sufficient height to accommodate system piping.



**TYPICAL PUMP, TANK, AND PIPING ARRANGEMENT**

**Fig. 7**

**7.5.2.7 Installation tips**

- a) A strainer should be employed to prevent foreign matter or undissolved lumps of chemicals from entering the pump that may interfere with check valve operation.
- b) Strategically located shutoff and check valves should be incorporated to permit servicing the pump without draining the entire system.
- c) Drain valves should be installed at the lowest point in the discharge line.
- d) If the pump is not provided with check valves that are removable without disconnecting the piping, unions shall be installed near the pump suction and discharge valves to facilitate removal of the pump head.
- e) Suction and discharge piping runs should be as straight and short as possible.

- f) Piping should be sloped, if necessary, to eliminate vapor pockets.
- g) A manual vent on the pump discharge line is desirable to facilitate removal of entrapped air particularly during pump start-up.
- h) Shutoff valve shall not be placed between the pump discharge and the system relief valve; to do so would make the relief valve ineffective.
- i) A nipple or pipe shall not be welded to valve bodies without first removing from pump head. If pipe is welded, be sure to use flanges near valve bodies for easy disassembly.

### 7.5.3 Suction line

The suction line is a critical part of the system. To assure proper operation of the metering pump, the following recommendations should be followed:

- 7.5.3.1 Keep suction lines short; locate the pump as close to the chemical supply tank as possible.
- 7.5.3.2 Locate both pump and tank as close to the application point as possible, long lines may require large-diameter pipe.
- 7.5.3.3 If possible, locate the pump and chemical supply tank so that high-positive suction does not coexist with low discharge pressure, as liquid will siphon through the pump.
- 7.5.3.4 Long lines may result in poor performance, notably under feeding, non-linearity, noisy operation, and vibration of the piping.
- 7.5.3.5 When a number of individual pumps are connected to a common supply, the suction line and/or header shall be sized to accommodate the total flow required by all pumps running simultaneously.
- 7.5.3.6 A pump calibration column should be installed in the suction line, suitably valved to shut off flow from the supply tank. The calibration column should provide sufficient volume for at least a 30-second test run.
- 7.5.3.7 To minimize problems inherent in long suction lines, a day tank or an accumulator may be located close to the pump. Installation of an accumulator at the pump suction can act as a day tank. Essentially, the flow will be continuous in the long line between the supply tank and the accumulator and discontinuous between the accumulator and the pump.

In installations where a suction line of over 10 m in length is needed, and use of a day tank is impractical, a suction accumulator shall be installed. The accumulator should be installed close to the suction connection, within 0.3 m if possible.

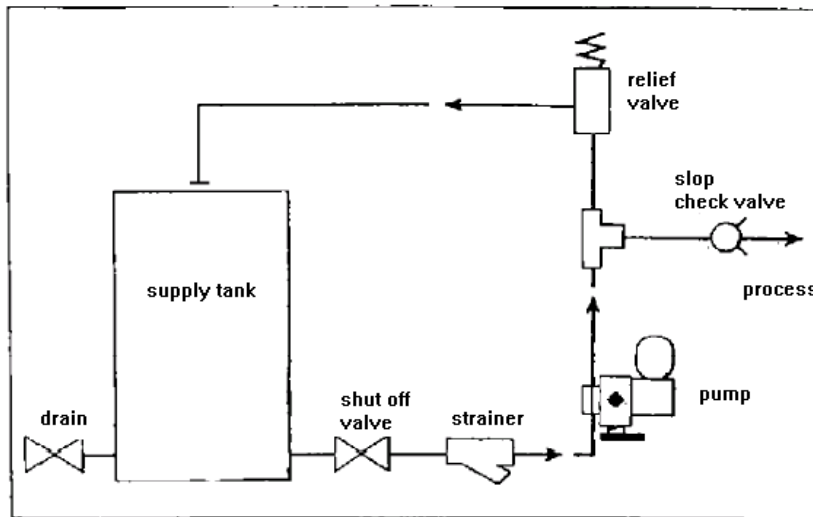
### 7.5.3.8 Suction pressure

The pump selected shall be capable of operating against a specified pressure, and it shall supply the pump with liquid at a certain minimum suction pressure (NPSH).

### 7.5.4 Relief valve

7.5.4.1 A process line relief valve is required for chemical injection system protection and should always be installed in the discharge line close to the pump. This valve will protect the line from damage due to plugging or accidental valve closure.

7.5.4.2 It is recommended to pipe relief valve discharge back to the supply tank above the fill level (refer to Fig. 8).



**TYPICAL SYSTEM RELIEVING TO SUPPLY TANK DUE TO EXCESS LINE PRESSURE**

**Fig. 8**

**7.5.4.3** If the distance and/or cost of the relief valve return line preclude its being piped to the tank, this line may be piped into the pump suction.

**7.5.4.4** The relief valve, whether in the hydraulic fluid line or process line, should be set for a pressure 10-20% higher than the operating pressure of the system.

### **7.5.5 Back pressure**

**7.5.5.1** All reciprocating metering pumps require some amount of positive system pressure or back pressure to assure accurate metering. This required pressure prevents overfeed from the internal force of the suction line liquid due to the hydraulic characteristic of the pump design.

**7.5.5.2** Adjustable in-line or non-adjustable internal pump-mounted back pressure valves shall be provided for this supplementary pressure.

**7.5.5.3** A back pressure valve should not be used to prevent a positive liquid level from draining or siphoning through the pump to an atmospheric discharge.

**7.5.5.4** A back-pressure valve shall not be used to prevent the siphoning of fluid into a below-grade normally pressurized main that has been depressurized. The sole purpose of the back-pressure valve should be to assure accuracy of pump delivery.

**7.5.5.5** Most back-pressure valves cannot be used in a line handling slurry. The pump manufacturer shall be consulted for appropriate back-pressure valves.

**7.5.5.6** Pressure loss created by long discharge lines shall not be considered as required back pressure. Similarly, a throttling valve or other fixed orifice will not be usable.

**7.5.5.7** In order to overcome inertial pressure in the lines to and from the pump, a minimum of 207 kPa (ga), and/or [2.07 bar (ga)] back pressure shall be required.

### **7.5.6 Siphoning**

**7.5.6.1** Static siphoning may occur in situations where suction pressure is high relative to discharge pressure (typically when pumping into open tanks).

**7.5.6.2** An antisiphon device is required in any chemical injection system that has a positive suction



head in excess of the pressure at the discharge of the system. Without such a device, flow will pass from the tank through the pump to the end of the pipe.

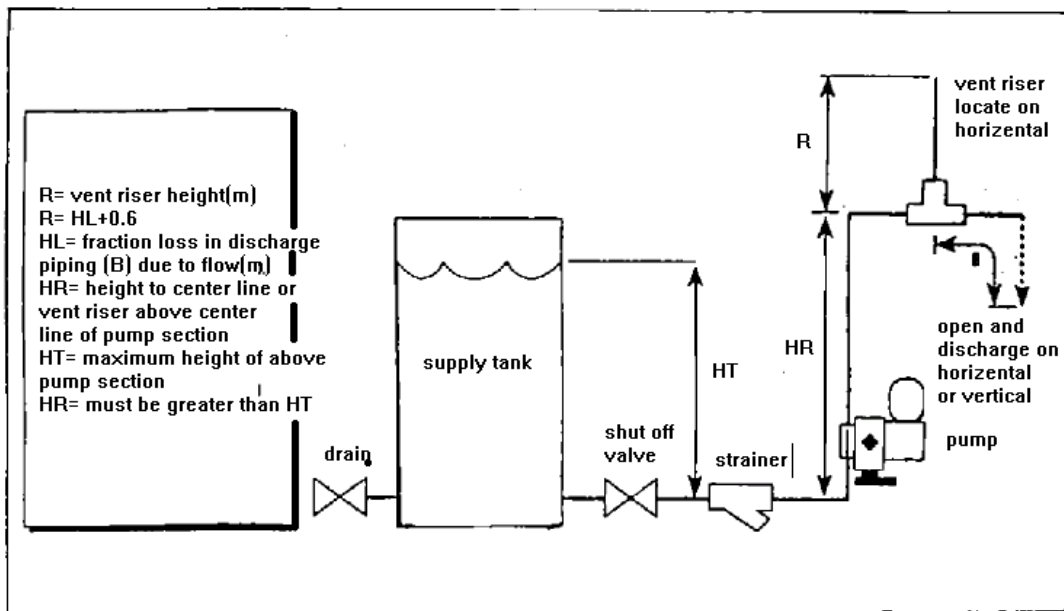
**7.5.6.3** Antisiphon valves are usually spring-loaded valves whose long term reliability depends upon frequency of operation. In failure of an antisiphon valve, the system may be subject to overfeed or uncontrolled flow.

**7.5.6.4** The pump back-pressure valve shall not be used as an antisiphon valve. A separate antisiphon device shall be installed and shall provide a greater capability than the system differential between supply tank and discharge point.

**7.5.6.5** Drainage shall be prevented by locating the antisiphon device at the end of discharge line.

**7.5.6.6** Antisiphon set pressure value shall be equal with the static pressure in the discharge system as "seen" by the pump.

**7.5.6.7** It is strongly recommended that in place of a mechanical valve, a vented riser be used in a manner as shown in Fig. 9.



**GUIDELINES FOR PROPER VENTING**  
Fig. 9

**7.5.7 Slurries**

**7.5.7.1 Pump selection**

- a) High speed pump shall be selected for slurries. The higher liquid velocities aid in maintaining a slurry suspension.
- b) For fast settling materials, such as slaked lime, speeds less than 2.4 strokes per second should be avoided. For slurries such as hydrated lime, speeds down to 1.6 strokes per second may be used.

**7.5.7.2 Piping system layout**

- a) Consideration should be given to the piping layout of slurry materials in chemical injection system, to avoid slurry settling out.

- b) Vertical runs shall be minimized in slurry systems.
- c) Any 90-degree direction changes should be accomplished by using plugged tees or crosses. These fittings permit prodding out deposits and also provide temporary flushing connections.
- d) If deposits are likely (that is, calcium carbonate scaling from lime slurries), flexible plastic tubing or rubber hose should be used rather than rigid pipe. Normal flexing from pump pulsations will dislodge scale. A flexible discharge line also allows long radius bends and direction changes with few fittings.
- e) If the water used for slaking the lime is softened, flanged steel pipe may be used.

#### 7.5.7.3 Valves

- a) A relief valve shall be used to protect the pump against dead ending or from severe plugs in long, vertical runs.
- b) To prevent siphoning, the slurry shall be pumped to an elevated atmospheric break, from which it flows to the application point by gravity.

#### 7.5.7.4 Flushing

- a) As settling during shutdowns is unavoidable, a flushing connection should be provided between the chemical feed tank and the suction check valve.
- b) The flushing systems can be manual or automatic. If automatic a timed sequence flushing cycle will be established and consequent plugging will be materially reduced.

#### 7.5.7.5 Data sheet

Typical data sheet of controlled volume pump is shown in Appendix A, A.2 - Data Sheet 2.

### 7.6 General Design Requirements of Package Type Chemical Injection Systems

#### 7.6.1 Scope of supply

A packaged type chemical injection system shall typically consist of, but not be limited to the following composite items:

**7.6.1.1** Each system shall be shop assembled as much as possible and skid-mounted complete with chemical solution tank, tank level gage, mixer, diaphragm and plunger chemical feed pump, piping dosing device, complete necessary accessories and instruments for proper operation.

**7.6.1.2** Each system shall be painted, lined, skid-mounted and pretested at Vendor's shop so that it shall be shipped to site ready to operate

#### Special Note:

**Vendor shall select lining materials upon taking into account that this system suffer cold temperature as specified by Company, in transportation and site storage during construction stage.**

#### 7.6.2 Design requirements

##### 7.6.2.1 Mixing tanks

- a) Mixing tanks shall be cone bottom and mounted on legs of sufficient length to insure satisfactory pump operation, and allow clearance for drain connection.

b) Tanks shall be complete with gage glass, hinged cover, connections for drain, pump suction and discharge.

c) All tanks shall have mixer supports:

- Polymer phosphate mixing tanks shall have a dissolving basket.

#### 7.6.2.2 Mixers

a) A portable mixer shall be provided for each tank.

b) Mixers shall be stable while agitating contents of tank from 1/3 to full.

#### 7.6.2.3 Pumps

a) Chemical feed pumps shall be piston type (diaphragm and plunger, as required by the service), and shall have facilities to permit adjustment of capacity from 0 to 100% of maximum specified.

b) Accessories shall include coupling guard, floor stand, back pressure valve, relief valve and strainer.

#### 7.6.2.4 Relief valves

A relief valve shall be provided for each pump for the purpose of protecting the pump and piping from excessive pressure. The relief valves shall have internal construction adequate for the pressure, temperature and material being pumped and shall be sized to pass the maximum output of which the pump is capable at the relieving pressure.

#### 7.6.2.5 Strainers

Each pump shall be provided with a suction strainer adequate to protect the pump against damage from insoluble materials which may enter the suction line. Materials of construction shall be suitable for the material being pumped.

#### 7.6.2.6 Data sheet

Typical data sheet of package Unit chemical injection system is shown in Appendix A, A.1- Data Sheet 1.

#### 7.6.2.7 Piping

All flanged connections to package boundaries shall be consistent with ANSI B 16.5 Standard.

#### 7.6.3 Guarantee

a) Equipment size and capacity under conditions given in data sheet.

b) Equipment is free from fault in design, workmanship and material to fulfill satisfactorily the operating conditions specified.

APPENDIX A

TYPICAL DATA SHEETS OF CHEMICAL INJECTION SYSTEM

A.1 - DATA SHEET 1

TYPICAL DATA SHEET OF PACKAGE UNIT CHEMICAL INJECTION SYSTEM

Item No.:	No. Req'd.	Service
1	Pump-Item No.	
2 No. of pumps per unit	Mfg'r.*	Mfg. Model No.*
3 Type:	Plunger	Diaphragm
4 Metering heads: Simplex	Duplex	Triplex
5 Liquid handled	Stroke adjustment: Manual	Automatic
6 Maximum capacity, m <sup>3</sup> /hr	While running	Stopped
7 Pressure, discharge, bar(ga)	Local	Remote
8 Suction, bar(ga)	Signal: Pneu.	Elec.
9 Temperature °C	Capacity adjust:	
10 Plunger/diaphragm-diameter*/	Materials of construction:	
11 Stroke, length*	Liquid end	
12 Pump speed, SPM*	Valves/seats	* Types
13 Connections, suction*	Plunger/diaphragm*	
14 Discharge*	Packing/seal*	
15 Pump relief valve set, bar (ga)	Paint:	
16 Valves replaceable: Yes	No	(with/without) Piping removed
17 Motor drive: AC	DC	Exp. proof
18 400 Volts 3 Phase 50 Cycle*	TEFC	TENV
19	HP*(kW)	r/min (RPM)
20		
21	Tank-Item No.	
22 Liquid handled	Design press, @ Temp.	bar(ga)
23 Capacity, m <sup>3</sup>	Freeboard %	Operating press, @ Temp.
24 Connections, size: Drain	Tank size:	mID x mH
25 Gage glass	Materials:	
26 Fill	Side	Bottom
27 Suction	Tank legs	
28 Relief valves	Pump platform	
29 Bottom: Flat	Cone	Dished
30 Top cover:	Basket	
31 Corrosion allowance	mm.	Lining
32 Thickness: Side*	Bottom	Paint
33 Basket size, m <sup>3</sup>	PERF.	Seismic zone No.
34		
35	Mixer-Item No.	
36 Mfg'r.*	Model No.*	
37 Motor drive: AC	DC	Exp. Proof
38	Volts	Phase
39 Type mounting bracket	Cycle*	HP* (kW)
40 Materials of construction wetted parts	r/min.(RPM.)	Paint:
41 Chemical mixed	Liquid	Solid
42		
43	Piping and instruments	
44 Piping included: Suction	Discharge	Drain
45 Line class spec. req'd or state materials	Other	
46 Instruments included: Relief valve	Level gage	Pressure gage
47 Mfg. and type req'd.*	Other	
48 Remarks:* All blanks to be proposed by Vendor		
49		
50		

(to be continued)

APPENDIX A (continued)

A.2 - DATA SHEET 2

TYPICAL CONTROLLED-VOLUME PUMP DATA SHEET

CONTROLLED VOLUME PUMP DATA SHEET

SI UNITS

JOB No. .... ITEM No.....  
 PURCHASE ORDER No. ....  
 REQUISITION No. ....  
 INQUIRY No. ....  
 PAGE ..... OF ..... BY .....

APPLICABLE TO: c PROPOSALS c PURCHASE c AS BUILT DATE _____ REVISION _____ FOR _____ UNIT _____ SITE _____ SERIAL No. _____ SERVICE _____ No. PUMPS REQUIRED _____ ITEM No. _____ No. MOTORS REQUIRED _____ MANUFACTURER _____ SIZE AND TYPE _____ PROVIDED BY _____ MODEL _____ NOTE: INFORMATION TO BE COMPLETED: c BY PURCHASER b BY MANUFACTURER	
<b>OPERATING CONDITIONS</b>	
c LIQUID _____ c PT (C) NORMAL _____ MAXIMUM _____ c SPECIFIC GRAVITY AT PT _____ c VAPOR PRESSURE AT PT (kPa abs) _____ c VISCOSITY AT PT (mPa. s) _____ c CORROSION/EROSION CAUSED BY _____ c ACCEL HEAD (m) _____ c ELECTRICAL AREA HAZARD: CLASS _____ GROUP _____ DIVISION _____ <b>LOCATION:</b> c INDOOR c HEATED c OUTDOOR c UNHEATED	c CAPACITY AT PT (L/h): MAXIMUM _____ MINIMUM _____ RATED _____ c DISCHARGE PRESSURE (kPa gage): MAXIMUM _____ MINIMUM _____ RATED _____ c SUCTION PRESSURE (kPa gage): MAXIMUM _____ MINIMUM _____ RATED _____ c DIFFERENTIAL PRESSURE (kPa): MAXIMUM _____ MINIMUM _____ RATED _____ NPSH AVAILABLE (m) WITHOUT ACCEL HEAD _____ ACTUAL _____ <b>SITE DATA:</b> c TEMPERATURE (°C) MAXIMUM _____ MINIMUM _____
<b>CONSTRUCTION FEATURES</b>	
NOZZLES _____ SIZE _____ RATING _____ FACING _____ LOCATION _____ SUCTION _____ DISCHARGE _____ FLUSH _____	
<b>LIQUID END</b>	
TYPE: c DIAPHRAGM c PLUNGER b DIAPHRAGM DIAMETER (mm) _____ No. REQUIRED _____ <b>REMARKS:</b> _____	VALVES PER FEED _____ SUCTION _____ DISCHARGE _____ TYPE _____ NUMBER _____
<b>MATERIALS</b>	
LIQUID END _____ CONTOUR PLATE _____ HYDRAULIC DIAPHRAGM _____ PROCESS DIAPHRAGM _____ PLUNGER _____ LANTERN RING _____ PACKING GLAND _____ REMARKS: _____	PACKING _____ VALVE _____ VALVE SEAT _____ VALVE GUIDE _____ VALVE BODY _____ VALVE GASKET _____ FRAME _____
<b>MANUFACTURER'S DATA</b>	
<b>PERFORMANCE:</b> b NUMBER OF FEEDS _____ b RATED CAPACITY _____ b NPSH REQUIRED (m) _____ b kW. RATED _____ AT RELIEF SETTING _____ <b>REMARKS:</b> _____	b PLUNGER SPEED (strokes/min) _____ DIAMETER (mm) _____ LENGTH OF STROKE (mm) _____ b PUMP HEAD: _____ MAXIMUM PRESSURE (kPa gage) _____ HYDRO TEST PRESSURE (kPa gage) _____