ENGINEERING STANDARD

FOR

PROCESS REQUIREMENTS

OF

REFINERY NON-LICENSED UNITS

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APPENDICES:

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 Refinery Non-Licensed Units"
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 REFINERY NON-LICENSED UNITS"

1. SCOPE

This Engineering Standard Specification set forth the content and the extent of the minimum process requirements of Refinery Non-Licensed Units, including, "Crude Distillation Units", "Hydrogen Production Unit", "Fresh & Spent Caustic Units" and "Chemical Injection Systems". This Standard Specification is further intended to cover the minimum process requirements and guidelines for process engineers to define control systems of process plants.

The requirements outlined herein are supplementary to those on the individual job specification/duty specification.

In the event of a conflict among the various documents, the order of precedence shall be as follows:

1) Individual Job Specification.
2) This Engineering Standard Specification.

This Standard Specification consist of four parts as described below:

Part I: Process Requirements of Distillation Units.
Part II: Process Requirements of Hydrogen Production Units.
Part III: Process Requirements of Fresh & Spent Caustic Units.
Part IV: Process Requirements of Chemical Injection Systems.

2. REFERENCES

Throughout this Standard the following standards and codes are referred to. The editions of these standards and codes that are in effect at the time of publication of this Standard shall, to the extent specified herein, form a part of this Standard. The applicability of changes in standards and codes that occur after the date of this Standard shall be mutually agreed upon by the Company and the Vendor/Consultant.

NIOC (NATIONAL IRANIAN OIL COMPANY)

"Arak Refinery Engineering and Construction Contract, Scope of Work, Arak Refinery Project"

IPS (IRANIAN PETROLEUM STANDARDS)

IPS-E-PR-200 "Basic Engineering Design Data"

NACE (NATIONAL ASSOCIATION OF CORROSION ENGINEERS)

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

API (AMERICAN PETROLEUM INSTITUTE)

API Std. 650 "Welded Steel Tanks for Oil Storage", 9th. Ed., May 1993

(ANSI/API STD. 650-1992)

API RP 533, 1st. Ed., Jan. 1986 "Air Preheat Systems for Fired Process Heaters"

BSI (BRITISH STANDARDS INSTITUTION)

BS 1523, Part 1, 1967 "Glossary of Terms Used in Automatic Controlling and Regulating Systems, Part 1. Process and Kinetic Control"

DALE R. PATRICK, STEPHEN W. FARDO

"Industrial Process Control Systems", 1979, Prentice Hall Inc., Englewood Cliffs, N.J.

THOMAS A. HUGHES

"Measurement and Control Basics", 1988, Instrument Society of America, North Carolina

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 Cascade Control System

A control system in which one controller provides the command signal to one or more other controllers.

3.3 Company/Employer/Owner

Refers to one of the related affiliated companies of the petroleum industries of Iran such as National Iranian Oil Company (NIOC), National Iranian Gas Company (NIGC), National Petrochemical Company (NPC), etc., as parts of the Ministry of Petroleum.

3.4 Contractor

The persons, firm or company whose tender has been accepted by the Company and includes the Contractor's personnel representative, successors and permitted assigns.

3.5 Control Element

A control element is a part of the process control system that exerts direct influence on the controlled variable that brings it to the set point position. This element accepts output from the controller and performs some type of operation on the process. The term "final control element" is also used interchangeably with control element.

3.6 Controlled Variable

Controlled variables are the basic process values being manipulated by a system. These values may vary with respect to time or as a function of other system variables, or both.

3.7 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.

3.8 Dead Time

The time interval between a change in a signal and the initiation of a perceptible response to that change.

3.9 Deviation

The difference between the measured value of the controlled condition and command signal.

3.10 Disturbance

A physical quantity other than the system command signal, generated independently of the closed loop itself, which affects the control system. Disturbance may be of two kinds, direct and indirect.

3.11 Feedback

The transmission of a signal from a later to an earlier stage.

3.12 Feed Forward

The transmission of a supplementary signal along a secondary path, parallel to the main forward path, from an early to a later stage.

3.13 Hunting

Prolonged self-sustained oscillation of undesirable amplitude.

3.14 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.

3.15 Multiple Feed

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

3.16 Slurry

A free-flowing mixture of solids and liquid.

3.17 Process Control System

A control system, the purpose of which is to control some physical quantity or condition of a process.

3.18 Process Time Lags

Most of the processes used in manufacturing operations perform quite well when variables are held within certain limits. When a process variable is subjected to some type of change, it obviously takes a certain amount of time for the process to correct itself. The term process time lag is commonly used to describe this condition."Process time lag" refers to the time it takes a system to correct itself and seek a condition of balance after a variable has changed. Inertia, capacitance, resistance and dead time are typical causes of process time lag.

3.19 Programmed Controller

A controller incorporating a programmed controlling element.

3.20 Set Value, Set Point

The command signal to a process control system.

3.21 System Response

The main purpose of a control loop is to maintain some dynamic process variable (flow, temperature, level, etc.) at a prescribed operating point or set point. System response is the ability of a control loop to recover from a disturbance that causes a change in the controlled process variable.

4. SYMBOLS AND ABBREVIATIONS

AC	Analysis Controller.
API	American Petroleum Institute.
ASTM	American Standards for Testing Materials.
AWWA	American Water Works Association.
BTM	Bottom.
CCR	Continuous Catalyst Regeneration.
DN	Diameter Nominal, in (mm).
DP	Differential Pressure.
F	Flow.
FC	Flow Controller.
FDF	Forced Draft Fans.
FF	Flooding Factor.
FR	Flow Recorder.
FRC	Flow Recorder Controller.
HLA	High Liquid Alarm.
HLL	High Liquid Level, in (mm).
HP	High Pressure.
HT	High Temperature.
ID	Inside Diameter, in (mm).
IDF	Induced Draft Fans.
IPS	Iranian Petroleum Standards.
KO	Knock-Out.
LC	Level Controller.
LLL	Low Liquid Level, in (mm).
LP	Low Pressure.
LPG	Liquefied Petroleum Gas.
LRC	Level Recorder Controller.
LSS	Low Signal Selector.
LT	Low Temperature.
max.	Maximum.
min.	Minimum.
NACE	National Association of Corrosion Engineers.
No.	Number.
NPC	National Petrochemical Company.
NPSH	Net Positive Suction Head, in (m).

OVHD	Overhead Product.
ppm	parts per million.
PC	Pressure Controller.
PDC	Pressure Differential Controller.
PIC	Pressure Indicator Controller.
PRC	Pressure Recorder Controller.
PSA	Pressure Swing Adsorption.
PTB	Pounds per thousand barrels.
SFC	Spill-back Flow Controller.
SR	Straight Run and also Split Range (see Appendix A).
TC	Temperature Controller.
TDC	Temperature Differential Controller.
TDDCR	Temperature Differential Differential Controller Recorder.
TDR	Temperature Differential Recorder.
TE	Temperature Element.
TI	Temperature Indicator.
TIC	Temperature Indicator Controller.
TPC	Technical Practices Committee.
TRC	Temperature Recorder Controller.
vol.	Volume.
YC	Blind Controller.

5. UNITS

This Standard is based on International System of Units (SI), except where otherwise specified.

PART I
PROCESS REQUIREMENTS
OF
DISTILLATION UNITS

6. PROCESS REQUIREMENTS OF ATMOSPHERIC AND VACUUM DISTILLATION UNITS

6.1 General

6.1.1 The purpose of the crude distillation Unit shall be to make the initial separation of crude oil into desired fractions.

6.1.2 The Units typically shall produce the following products:

Butane and lighter material (Light Ends), light straight run naphtha, heavy straight run naphtha, (blending) naphtha, kerosene, light diesel, heavy diesel, waxy distillate (Hydrocracker Unit Feed), lubricating oils if any, slop vacuum gas oil, and vacuum bottoms. A part of vacuum bottoms is used for paving and roofing asphalts.

6.1.3 The production rates of waxy distillate (Hydrocracker Unit Feed), lubricating oils, slop vacuum gas oil and vacuum bottoms will be depended upon the specific mode of operation in the lube Unit.

6.1.4 Provision shall be made for incremental increases in the withdrawal rate of waxy distillate (Hydrocracker Unit Feed), slop vacuum gas oil, and vacuum bottoms when the lube Unit is shutdown.

6.1.5 The Unit shall typically be consisted but not be limited to the following sections:

- **a)** Atmospheric Distillation Section.
- **b)** Vacuum Distillation Section.
- **c)** Straight Run Naphtha Fractionation Section.
- **d)** Off Gas Compressor Section.
- **e)** Lube Distillation Section, if required.

6.1.6 The purpose of lube distillation Unit shall be to charge light and heavy gas oil cuts made in vacuum distillation section and to produce in blocked operation the required quantities and specifications of required lube cut distillates.

6.1.7 Lube Distillation Section typically shall consist but not be limited to the following facilities:

- **a)** charge heater;
- **b)** lube distillation column;
- **c)** vacuum jets and all related equipment;
- **d)** instrumentation and piping.

6.1.8 Tank heaters shall be provided in crude tanks to maintain 10-32°C Crude temperature before pumping to the Unit to prevent the crude wax sedimentation in the tanks.

6.1.9 Crude shall receive adequate preheat from hot process streams in Crude Distillation Unit. The heat exchanger configuration and temperatures shall be optimized using appropriate computer softwares (e.g., Pinch Method, etc.).

6.1.10 The crude outlet temperature of preheat exchangers shall be specified such that to avoid vaporization in the last exchanger(s).

6.1.11 Typically, streams of naphtha, vacuum tower top side cut, kerosene, light diesel, waxy distillate (Hydrocracker Unit Feed), SAE 10/20 lube cut, slop vacuum gas oil and vacuum tower mid side cut should be considered as heat source of crude preheat exchangers.

6.2 General Design Criteria

6.2.1 Where tray material is specified to be stainless steel, then the valves shall be of the same material as the tray.

6.2.2 Manways shall be provided as follows:

a) Horizontal vessels

900 to 1300 mm ID	Manway, on the head, 460 mm (18") ID.
Larger than 1300 mm ID	Manway, on the side or on the top 510 mm (20") ID.*

b) Vertical vessels

Under 900 mm ID	Top head flanged.
900 to 1300 mm ID	Manway, in shell, 460 mm (18") ID.
Larger than 1300 mm ID	Manway, in shell, 510 mm (20") ID.*

c) Packed vessels

Each packed bed shall have a manway at top and a manway at bottom.

d) Trayed columns

Manways shall be provided above the top tray, below the bottom tray, at any feed and side cut draw off tray and at intermediate points. The maximum number of trays between manways in the trayed section shall not exceed 10 trays.

*** Note:**

Higher size manway shall be provided if required to accommodate internals.

6.2.3 Recommended minimum tray spacing shall be as follows:

1300 mm ID or less	460 mm (18").
1300 to 3000 mm ID	560 mm (22").
3000 mm ID and larger	610 mm (24").

6.2.4 Tray spacing shall be greater than the minimum where required for access to column internals, manway location, vapor disengaging, nozzle interference or other reasons.

6.2.5 Minimum distance from the top tray to top tangent line shall be 750 mm or as required to accommodate manway, internals or nozzles.

6.2.6 Minimum trayed column size shall be 800 mm internal diameter.

6.2.7 Leak tight trays shall not be required except for the following services:

a) once-through reboiler draw off boxes;
b) side draw off tray draw pan;
c) chimney trays.

6.2.8 Minimum hole diameter for perforated trays should be 13 mm (½"). However the lower range of 3-13 mm ($^1/_8$"-½") from case to case can be applied if it is approved by the Company.

6.2.9 Vessels shall be provided with vent, drain and steam-out nozzles, in accordance with the IPS-E-PR-200, "Basic Engineering Design Data".

6.2.10 Drain nozzles on horizontal vessels shall be located at the opposite side of the liquid outlet line.

6.2.11 A blanked off ventilation nozzle shall be provided on top of the vessel (and at the opposite side of the manway in horizontal vessels).

The size will be in accordance with the following Table 1.

TABLE 1

VESSEL DIAMETER	NOZZLE SIZE
4500 mm ID or less	DN 100
4500 to 7500 mm ID	DN 150
7500 mm ID and larger	DN 200

6.2.12 Water draw-off boots, if any, will be welded to the vessels, regardless of boot diameter. If the vessel is lined, the boot will be lined and welded to the vessel, any exceptions shall be approved by the Company.

6.2.13 A blanked-off facility shall be provided on all connections to the flare headers.

6.3 Design Requirements

6.3.1 Design temperature

6.3.1.1 Columns with fired feed heater with/without side-cut strippers:

a) In the zone between the draw-off trays of two adjacent side cuts, the design temperature shall be the draw - off temperature of the heavier side cut plus 30°C.

b) In the zone between the heaviest sidecut draw-off tray and the bottom of the column, the design temperature shall be the flash zone temperature plus 30°C, or the reboiler outlet (whichever is greater) plus 30°C.

c) Sidecut strippers with stripping steam

The design temperature shall be the operating inlet temperature of the process stream plus 30°C.

d) Fractionators with reboiler

The design temperature shall be the reboiler return line temperature plus 30°C.

e) For vessels having a design pressure not higher than 350 kPa (ga), the minimum design temperature shall be 120°C.

6.3.2 Design pressure

a) Vessels

Vessels design pressure should be as indicated in Table 2.

TABLE 2

OPERATING PRESSURE	DESIGN PRESSURE
Under vacuum	min. value: full vacuum max. value : 350 kPa (ga)
0 up to 1800 kPa (ga)	350 kPa (ga) or operating pressure plus 180 kPa (ga) whichever is the highest value.
1800 kPa (ga) to 6900 kPa (ga)	Operating pressure plus 10%

b) Heat Exchangers

If a control or block valve is installed downstream the heat exchanger, the design pressure shall be the same of the upstream equipment or the actual shut-off pressure of the upstream pump.

If a control or block valve is installed upstream the heat exchanger, the design pressure shall be calculated as the design pressure of the downstream equipment at the inlet point plus 1.20 times the pressure drop of the circuit between the heat exchanger inlet and the inlet point of the downstream equipment plus static head (if any).

c) OVHD receiver

The overhead receivers shall be designed considering the same design pressure as the upstream columns.

6.4 Design Oversizing Factors

The philosophy of design oversizing factors to be used for sizing of equipment and machinery of the project shall be approved by the Company. The recommended oversizing factors are as follows:

6.4.1 Fired heaters

Heaters design duty (excluding Licensed Units heaters), shall be at least 110% of max. normal duty. Normal duty shall be based on lower inlet temperature.

6.4.2 Columns and drums

6.4.2.1 Tray design

Maximum normal load of the trays shall be considered for the design purpose.

6.4.2.2 Generally valve type trays should be used. Sieve trays may be applied, upon Company's approval, taking also into account the requirements of specified turndown ratio, for instance in pump-around if technically feasible.

6.4.2.3 Flooding factor for fractionating trays: 78% maximum.

6.4.2.4 Flooding factor for pumparound trays: 85% maximum.

6.4.2.5 Flooding factor for steam stripping trays and side cuts strippers regardless of strip ping medium: 75% maximum.

6.4.2.6 Downcomer back-up: 50% maximum of the tray spacing.

6.4.2.7 Type of internals:

Structured packing may be applied provided that they are compatible with coke formation tendency of the service.

6.4.2.8 Random packings can be used in columns less than: 800 mm in diameter.

6.4.3 Hold-up time

Water settling requirements take priority over these times where applicable.

6.4.3.1 Columns feeding other Units: 900 seconds (HLL-LLL) on net liquid product. (Except when surge drum is provided for downstream Unit).

6.4.3.2 Columns discharging to storage only: 300 seconds (HLL-LLL) on net liquid product.

6.4.3.3 Columns feeding heat exchangers trains:	300 seconds (HLL-LLL) on net liquid product.
6.4.3.4 Columns feeding fired heater:	600 seconds with respect to the equivalent flowrate of the vapor generated in the fired heater plus 300 seconds on net bottom product full (HLL-LLL).
6.4.3.5 Vacuum column bottom :	240 seconds (HLL-LLL) with quench.
6.4.3.6 Feed surge drums:	1200 - 1800 seconds (HLL-LLL).
6.4.3.7 Columns feeding multistage charge pumps (5 or more stages):	1500 seconds (HLL-LLL).
6.4.3.8 Drums feeding other equipment for further processing:	600 seconds (HLL-LLL).
6.4.3.9 OVHD receivers:	300 seconds on reflux plus net product (HLL-LLL).
6.4.3.10 Drums feeding fired heaters:	600 seconds (HLL-LLL) on total liquid.
6.4.3.11 Gas and water separators:	300 seconds (HLL-LLL) on water flowrate.
6.4.3.12 Water boots:	300 seconds below normal interface level or 600 seconds on water (HLL-LLL), whichever is greater.

6.4.3.13 Compressor suction KO drums

14400 seconds (240 minutes) on maximum entrained liquid in the inlet line (HLL-LLL if level control is provided otherwise HLA-BTM tangent line).

Compressor suction drums will consider this time or the use of a 3.6 m (14") level range, whichever is greater, taking also into account the requirements of specified turndown ratio, for instance in pumparound services, if technically feasible.

6.4.3.14 Other types of KO drums:

A volume corresponding to 15 m of liquid slug in the inlet line (HLL-LLL if level control is provided otherwise HLA-BTM tangent line) or a 3.6 m (14") level range, whichever is greater.

6.4.4 Shell and tube heat exchangers

6.4.4.1 Cooled water condensers:	10% on maximum duty and flowrate.
6.4.4.2 Cooled water cooler:	10% on maximum duty and flowrate.
6.4.4.3 Pumparounds exchangers:	15% on rated surface.
6.4.4.4 Reboilers:	10% on maximum duty and flowrate.
6.4.4.5 Steam generators:	10% on maximum duty and flowrate.
6.4.4.6 Air cooler and air condensers:	10% on maximum duty and flowrate.

6.4.5 Pumps

6.4.5.1 Unit feed:	10% on maximum normal flowrate.
6.4.5.2 Feed booster:	10% on maximum normal flowrate.
6.4.5.3 Unit product:	10% on maximum normal flowrate.
6.4.5.4 OVHD reflux:	20% on maximum normal flowrate.
6.4.5.5 Pumparound:	20% on maximum normal flowrate.
6.4.5.6 Reboiler feed:	15% on maximum normal flowrate.
6.4.5.7 Boiler feed water:	10% on maximum normal flowrate.
6.4.5.8 Surface condensers condensate:	10% on maximum normal flowrate.
6.4.5.9 Chemical injection:	20% on maximum normal flowrate.
6.4.5.10 Metering pumps:	30% on maximum normal flowrate.
6.4.5.11 Reciprocating and rotary pumps:	15% on maximum normal flowrate.
6.4.5.12 All other pumps:	10% on maximum normal flowrate.
6.4.5.13 Pump shut-off pressure:	Maximum suction pressure plus 120% of differential pressure at design capacity.
6.4.6 Compressors and blowers:	10% on maximum normal flowrate as minimum (not Licensed Units).
6.4.7 Turbines:	Steam turbines: 10% on design brake horse power in kW of the driven pump or compressor.

6.4.8 Heaters and waste heat boiler fans

6.4.8.1 Induced draft fans:	15% on design (100 percent) flowrate (including any defined leakage from the preheater and the other system losses) at design excess air. (see API-RP-533).
6.4.8.2 Forced draft fans:	15% on design (100 percent) flowrate (including any defined leakage from the preheater and other system losses) at design excess air.

6.5 Process Requirements for Distillation Unit

6.5.1 Product fractionation

6.5.1.1 Fractionation between two adjacent products is defined the difference, positive (gap) or negative (overlap), between the temperatures of the 5% point on ASTM distillation of the heavier product and the 95% point on ASTM distillation of the lighter product. The fractionation between adjacent products, as defined below, shall be as follows, however, the actual figures will depend on project requirements:

1)	Light SR Naphtha-Heavy SR Naphtha	+ 15°C
2)	Heavy SR Naphtha-Blending Naphtha	+ 10°C
3)	Blending Naphtha-Kerosene	+ 8°C
4)	Kerosene-Atmospheric Gasoil	+ 14°C

6.5.1.2 The pentanes and heavier components contained in the unstabilized LPG shall be 1 vol. % max. referred to butanes content.

6.5.1.3 The butanes and lighter components contained in the light SR Naphtha shall be 1 vol. % max.

6.5.2 Other design requirements

6.5.2.1 The Unit turndown shall be 60% of design throughput, without loss of efficiency in fractionation while meeting the product specifications.

6.5.2.2 By-passing of Vacuum Distillation Section shall be feasible. The Unit (Light End Section included) should be able to operate at a minimum rate of 75% of design capacity, while the Vacuum Distillation Section is out of service.

6.5.2.3 Compression facilities shall be provided for crude Unit overhead gases. Spare compressor is not required.

6.5.2.4 The Atmospheric Distillation Section and Vacuum Distillation Section can be integrated for maximum recovery within their own battery limit (Light End Section excluded).

6.5.2.5 System of Light Ends shall be designed to allow continued operation of Distillation Unit while the Light End Section is out of service.

6.5.2.6 Heat exchanger network optimization should be considered for distillation units (e.g., pinch method).

6.5.2.7 The Unit shall be equipped with desalter and relevant chemical injection facilities. The desalted crude shall have a total salt content of 2.85 kg/1000 m^3 (1 PTB) maximum.

6.5.2.8 The stripped water from the Sour Water Stripper Unit shall normally be used as desalter feed water. Demineralized water supply to the desalter shall be considered as an alternative source.

6.5.2.9 The Unit heaters shall be designed for 10 percent excess capacity for flow and duty.

6.5.2.10 All the heaters shall be capable to utilize either of fuel gas and fuel oil or combination of them.

6.5.2.11 All heaters shall be designed for maximum energy conservation. Minimum efficiency of 90 percent should be considered for the charge heaters.

6.5.2.12 Crude and vacuum heaters shall have forced draft fans and air preheat system. Heater forced draft fans shall have a spare. FDF and IDF and Air Preheater Systems shall be designed in accordance with API-RP-533.

6.5.2.13 The fuel gas knock-out drum shall be provided in the Unit.

6.5.2.14 Atmospheric Crude Tower shall have kerosene and gasoil circulation refluxes.

6.5.2.15 Coalescers shall be provided for the Atmospheric and Vacuum diesels.

6.5.2.16 Vacuum column ejectors shall have 50% spare capacity for each set.

6.5.2.17 All pumps shall have individual spares. Spare pumps shall be provided as follows:

No. OF OPERATING PUMPS	No. OF SPARE PUMPS
1	1
2	1

6.5.2.18 All the machineries shall be electrically driven with exception of the following spare pumps which shall be steam driven:

a) Flashed crude pump.
b) Atmospheric residue pump.
c) Atmospheric column top reflux pump.
d) Vacuum residue pump.

6.5.2.19 Where the fin fan coolers are utilized, spare for additional one bay for future expansion shall be provided.

6.5.2.20 Inhibitor injection facilities to the overhead streams shall be provided.

6.5.2.21 Local level gages, and control room level indicators are required on all draw off trays of vacuum column.

6.5.2.22 Tempered water system shall be provided where required.

6.5.2.23 Transfer lines

Transfer lines between furnace and tower shall be designed for proper fluid velocity such that to avoid coke deposition and vibration.

6.5.2.24 In general the pressure drop through the vacuum tower should not exceed one-half the absolute pressure in the flash zone.

6.5.2.25 Control of vacuum tower flash zone entrainment

The entrainment should be controlled by proper design of tower loadings and by keeping the first section above the flash zone (wash section) irrigated with a minimum flow of gas oil reflux. This reflux commonly referred to as "overflash" shall be set at no less than 2 vol.% of the vacuum charge. This flow rate shall be designed to yield at least 2 vol.% overflash leaving the bottom. Liquid flow to the wash section shall be uniformly distributed for optimum performance.

6.5.2.26 Vacuum tower leak proof draw trays

For maximum thermal efficiency and gas oil yield, all product draw trays shall be essentially leak proof.

6.5.2.27 Stability of vacuum residuum

If downstream processing requires a substantial holding time in vacuum tower, a recirculating quench system shall be provided to reduce holding temperatures to 315°C or less. In designing such a quench system, care shall be taken to avoid possible reabsorption effect due to improper introduction of the cooled residuum recycle.

6.5.2.28 Vacuum tower furnace temperature

Pressure drop between the furnace outlet and the tower flash zone shall be kept low enough so that heater outlet temperatures are below the accelerated cracking region.

6.5.2.29 Control Scheme Design

Control scheme design of Crude Distillation Units shall be as per Appendix A, "Control Scheme Design".

PART II
PROCESS REQUIREMENTS
OF
HYDROGEN PRODUCTION UNIT

7. PROCESS REQUIREMENTS OF HYDROGEN PRODUCTION UNIT

7.1 General

7.1.1 The process shall involve the conversion of light hydrocarbon gases, primarily methane to hydrogen.

It shall consist of the following main processing sequence:

a) Steam hydrocarbon reforming.
b) Shift conversion.
c) Pressure Swing Adsorption (PSA) System.

7.1.2 Feedstock to the Unit may consist of one or a mixture of the followings:

a) Natural gas.
b) Platformer Unit off-gases.
c) HP Amine contactor gas.
d) Propane gas.
e) Naphtha fraction (if gas feed is not available).

7.1.3 Steam is a reactant for the reforming and shift conversion reactions and is consumed. This steam shall normally be supplied as 2070 kPa (ga) steam.

7.1.4 The quantity of steam needed shall be generated within the Unit by utilizing the waste process heat available.

7.1.5 The plant shall be designed with proper steam to carbon ratio, considering the following purposes:

a) to maximize the conversion of hydrocarbons in the reforming operation;
b) to suppress coke formation on the catalyst;
c) to use later in the shift conversion reaction.

7.1.6 Performance

The minimum and guaranteed hydrogen purity in the product shall be 99.9 mol.% based on PSA System performance at design conditions.

7.1.6.1 The Unit is to be designed for maximum on - stream efficiency.

7.1.6.2 The Unit shall be capable of reaching normal operating conditions within 24 hours after feed gas is introduced.

7.1.6.3 The supplier has:

- to determine and specify the governing case in each section of the Unit, sections being:

a) feed treating (dechlorination and H_2S removal);
b) reforming (steam-hydrocarbon reforming);
c) high temperature shift converter;
d) PSA section; and

- to design each section to be capable to handle each case of feedstocks.

7.1.7 Feed

7.1.7.1 The supplier shall state the product purity if one of the Units providing the feed is down, and also the turndown ratio of the hydrogen Unit shall be stated at which the product purity 99.9 mol.% can still be achieved.

7.1.7.2 Feed gas coming from the platforming separator contains chlorine ion (max. 2 mg/kg). This should be removed entirely in the hydrogen Unit by dechlorination catalyst in a separate vessel at the required temperature.

7.1.7.3 Zinc oxide beds in two separate vessels sufficient for two years operating without renewal shall be provided for reducing sulfur to 0.1 mg/kg in feed stream. Piping arrangement shall be such that the vessels can be put in parallel service or in series when required.

7.1.7.4 Feed gas to ZnO vessels shall be preheated with appropriate device for carrying out the reaction, this temperature shall be selected as high as possible to maximize the reformer inlet temperature and hence reduce reformer heater duty. Typical temperature range for this purpose is 300-350°C.

7.1.8 Product specifications

The hydrogen product gas shall have the following composition:

H_2	:	min. 99.9 vol.% (dry basis)
$CO + CO_2$	:	max. 15 mg/kg
HCl	:	Nil.

7.1.9 Steam generation and boiler feed water

7.1.9.1 During normal operation, the Unit shall generate all steam required for its process requirements.

7.1.9.2 Maximum recovery of condensate for use as boiler feed water shall be provided in hydrogen Unit. Utility condensate shall be available only as make-up.

7.1.9.3 Steam pressure produced in the waste heat boiler should be just enough to meet process requirements.

7.1.9.4 External temperature control should be considered for the waste heat boiler.

7.1.9.5 A separate transmitter shall be provided for the level control on the steam drum. The steam drum shall also have high and low level alarms.

7.1.9.6 Steam generated in the Unit should have necessary control and safety valves.

7.1.9.7 Suitable stainless steel, for impellers of boiler feed water pumps and lining of deaerator(s) shall be considered.

7.1.9.8 Condensate shall be used for any processing purpose and the use of treated water should be avoided.

7.1.9.9 Chemical injection facilities for waste heat boiler shall be provided.

7.1.9.10 Provisions shall be made for automatic running of stand-by pump of steam generating pumps in boiler.

7.1.10 Reformer heater shall be tubular type, typically terrace wall furnace, equipped with natural-draft burners.

7.1.10.1 Burners shall be capable of accepting gaseous and liquid fuel.

7.1.10.2 Various services shall be considered for heat recovery from the flue gas.

7.1.10.3 Heating steam/hydrocarbon blend in convection section shall be below the cracking temperature (typical temp. range is 450 to 570°C).

7.1.10.4 The thermal efficiency shall be approached to 90 percent with flue gas sent to the stack at 180 to 200°C.

7.1.10.5 Suspended from countermass or spring devices shall be designed for vertical tubes in radiation section, to prevent creep due to expansion (typically 250 mm for a length of 15 m), connected at the top and bottom to inlet and outlet distributors and collectors.

7.1.10.6 Catalyst filling in tubes shall be carefully performed, so that the pressure drop from one tube to the next, which may be as high as 500 kPa (ga) shall not undergo variations of more than 5 per cent about the average value. Otherwise, the resulting changes in flow rates may cause substantial local overheating.

7.1.10.7 The tubes shall be alloyed steel capable of withstanding skin temperatures of about 900 to 950°C and a maximum of 1000°C.

7.1.10.8 The outlet collectors of tubes shall be followed by expansion loops (pigtails) to offset the mechanical forces due to rapid temperature variations.

7.1.10.9 Heater outlet temperature shall be controlled by TRC-PRC. Additionally a start-up fuel gas pressure regulator shall be provided on bypass.

7.1.10.10 Air purged thermocouples to be provided for at least 15% of reforming tubes and be connected to TI console in the process control room.

7.1.11 Instrumentation

7.1.11.1 A total sulfur analyzer should be considered for monitoring the sulfur content on feed gas at ZnO bed inlet, inter-bed and outlet.

7.1.11.2 A feed gas density meter and ratio controller for the feed shall be provided.

7.1.11.3 A suitable recording analyzer shall be provided for CO and CO_2 in the product gas.

7.1.11.4 Continuous hydrogen analyzer for the product gas shall be furnished.

7.2 Pressure Swing Adsorption (PSA) System

7.2.1 General

7.2.1.1 Facilities to be supplied by the Vendor

a) Each PSA system shall be consisted of adsorbers, off gas surge drum, prefabricated piping, fully assembled and pretested valve skids, instrumentation and prefabricated pipe supports, control panels including control units, sequential chart boards and alarm annunciators, etc.

b) Provisions shall be considered to avoid water condensation and to prevent wet CO_2 corrosion.

c) The PSA facilities shall be fully automatic-operated.

7.2.1.2 Facilities arrangement

a) Vendor shall propose the layout drawing including plan and elevation showing pipe ways, valve skids, and walkways.

b) All valves, instruments, pressure relief valves etc. shall be installed so as to access easily from ground level.

7.2.2 System definition

7.2.2.1 The PSA system shall be used to recover hydrogen gas from hydrogen rich gases.

7.2.2.2 In refineries with CCR platformer Unit, the platformer off-gases can be purified directly in the PSA Section.

7.2.3 Vendor shall guarantee the following items:

a) Hydrogen recovery efficiency.

b) Fluctuation of pressure/flow rate for PSA product gas, and pressure/flow rate/heating value for PSA product off gas.

c) Throughput.

d) Hydrogen product specification.

e) Hydrogen product flow rate.

7.2.4 Vendor's proposal

7.2.4.1 Vendor shall fill all blanks of PSA process data sheet, process data sheet-pressure vessel and also specified adsorbent type and quantity, attached to his submitted proposal.

7.2.4.2 Appendix B represents typically PSA process data sheet and process Data sheet-pressure vessel.

PART III
PROCESS REQUIREMENTS
OF
FRESH & SPENT CAUSTIC UNITS

8. PROCESS REQUIREMENTS OF FRESH & SPENT CAUSTIC UNITS

8.1 Fresh Caustic Unit

8.1.1 General

8.1.1.1 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.

8.1.2 Design requirements

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

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

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

8.1.2.4 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.

8.1.2.5 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.

8.1.2.6 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.

8.1.2.7 Pump(s) shall be provided to pump constantly fresh caustic from dilute caustic tanks, to regenerative caustic treating section to maintain the content of Na_2S and other impurities less than specified value (typically 2% by mass).

8.1.2.8 Regenerative caustic solution shall be used in non-regenerative batch caustic wash treating for H_2S removal throughout the refinery.

8.1.2.9 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 Hydrocracker Unit;
2) to supply fresh caustic in absence of regenerated caustic.

8.1.2.10 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.

8.1.2.11 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.

8.2 Spent Caustic Treating Unit

8.2.1 General

8.2.1.1 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.

8.2.1.2 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.

8.2.2 Design requirements

8.2.2.1 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.

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

8.2.2.3 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.

8.2.2.4 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.

8.2.2.5 A series of stirred reactors shall be provided to convert the sulphide contained to thiosulphate/sulphate with atmospheric oxygen at 105-108°C and at pressure of about 5.3 bars (abs).

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

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

8.2.2.8 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.

8.2.2.9 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.

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

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

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

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

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

8.2.2.15 The size and numbers of series reactors shall be chosen to reduce the sulphide content of liquid effluent from the last reactor to less than 10 mg/kg.

PART IV

CHEMICAL INJECTION SYSTEMS

9. CHEMICAL INJECTION SYSTEMS

9.1 Definition of Terms

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

9.2 Chemical Feed Systems-General

9.2.1 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.

9.2.2 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 microbiocides 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.

9.2.3 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.

9.2.3.1 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.

9.2.4 Chemical feed equipment used in water treatment

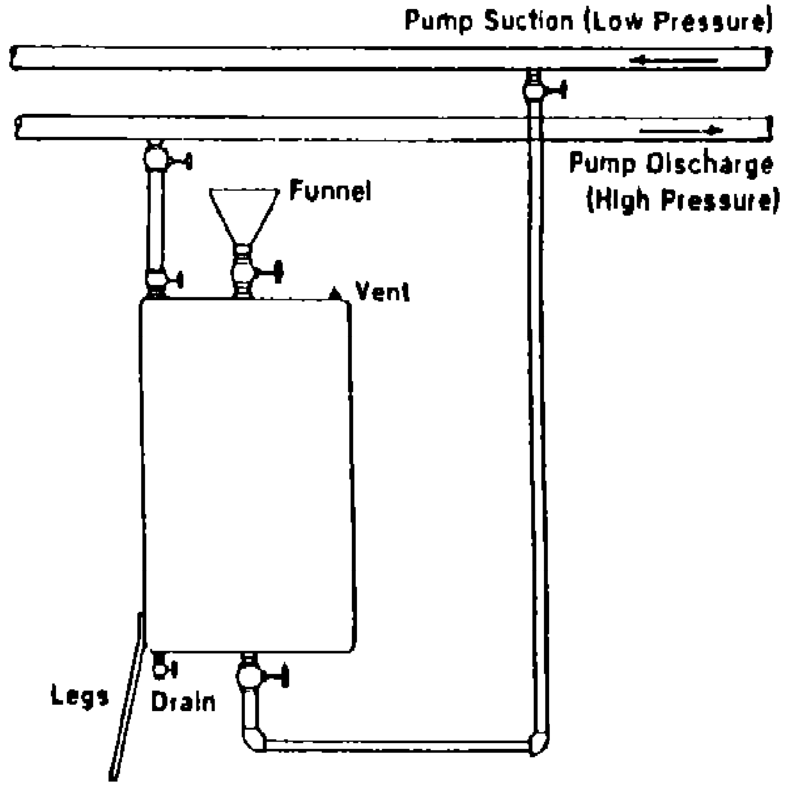
9.2.4.1 Most cooling water and boiler water treatment products are liquids or solutions prepared from powders. The pump is therefore the most frequently encountered feed device. Different feed equipment are briefly mentioned in the following:

9.2.4.2 Metering pump

See Clause 9.5 hereinafter.

9.2.4.3 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.

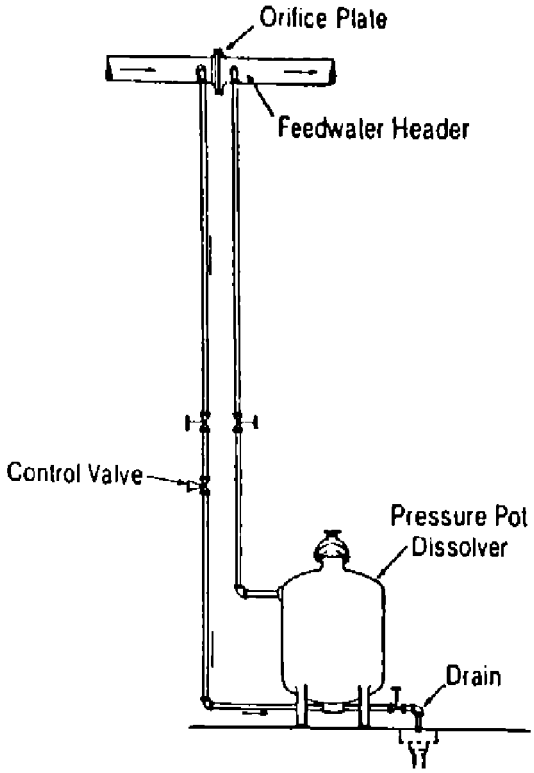


TYPICAL SHOT FEEDER INSTALLATION
Fig. 1

9.2.4.4 Miscellaneous feeders

a) By-pass feeders

Treatment chemicals which dissolve slowly, or are made in special briquette form can be added, using the by-pass 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 a 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.

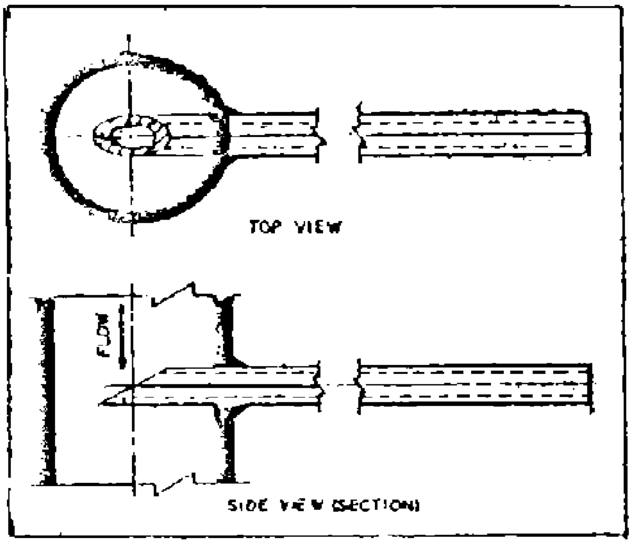
2) Dilution-acid is frequently diluted to improve mixing and pH control. Alarms indicating loss of dilution flow should be considered to stop further acid flow, if necessary.

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.

9.2.5 Accessories

9.2.5.1 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

9.2.5.2 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.

9.2.5.3 Level alarm

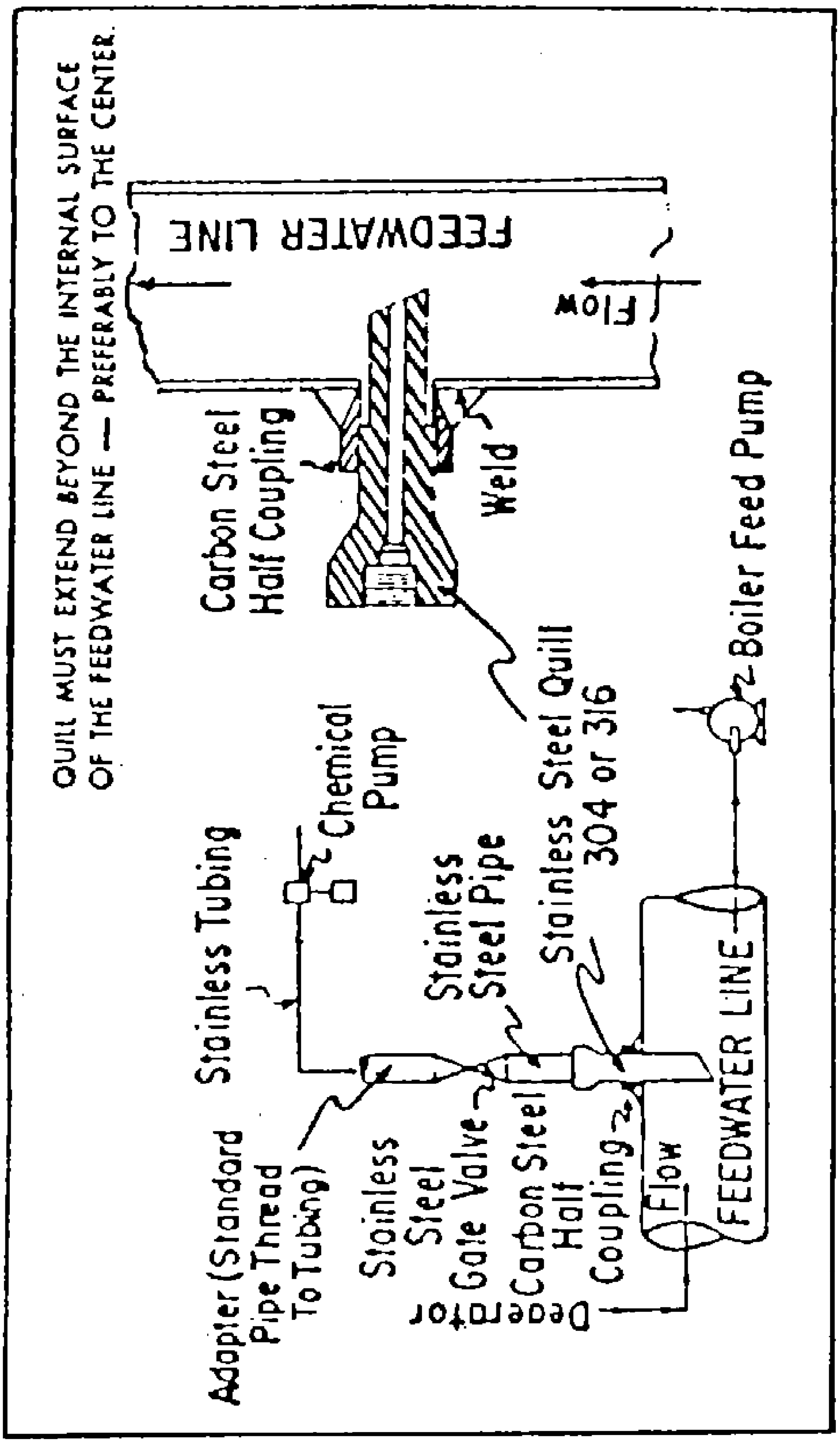
a) A level alarm should be installed on a feed tank when chemical feed shall not be interrupted or when the pump will be damaged if it runs dry.

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.

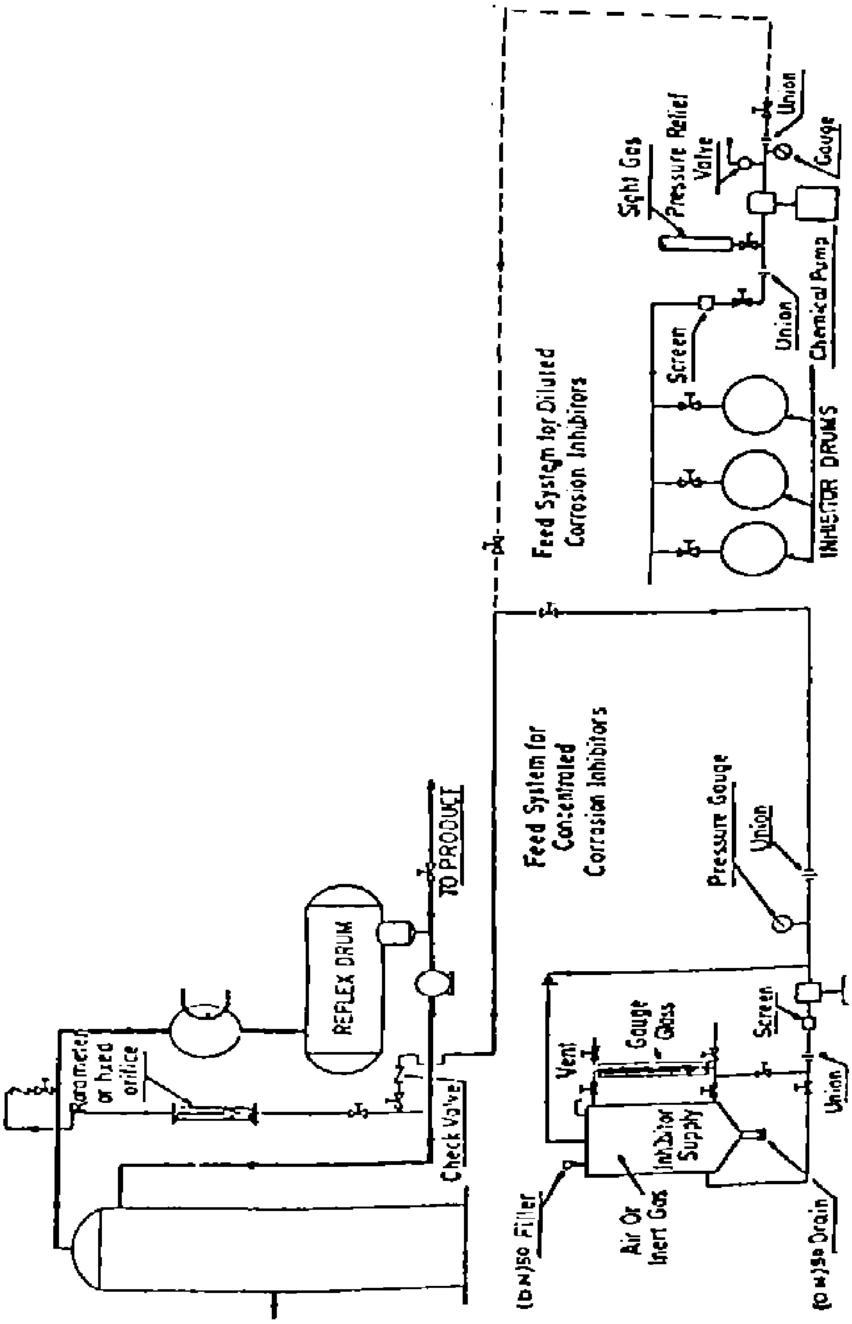
9.2.6 Chemical additive feeding systems

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.

9.2.7 System design and operation of chemical feeders for cooling towers

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

9.2.7.2 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.

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

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

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

9.2.7.6 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.

9.2.7.7 Equipment design and selection

9.2.7.7.1 Mechanical agitators shall be designed to operate continuously.

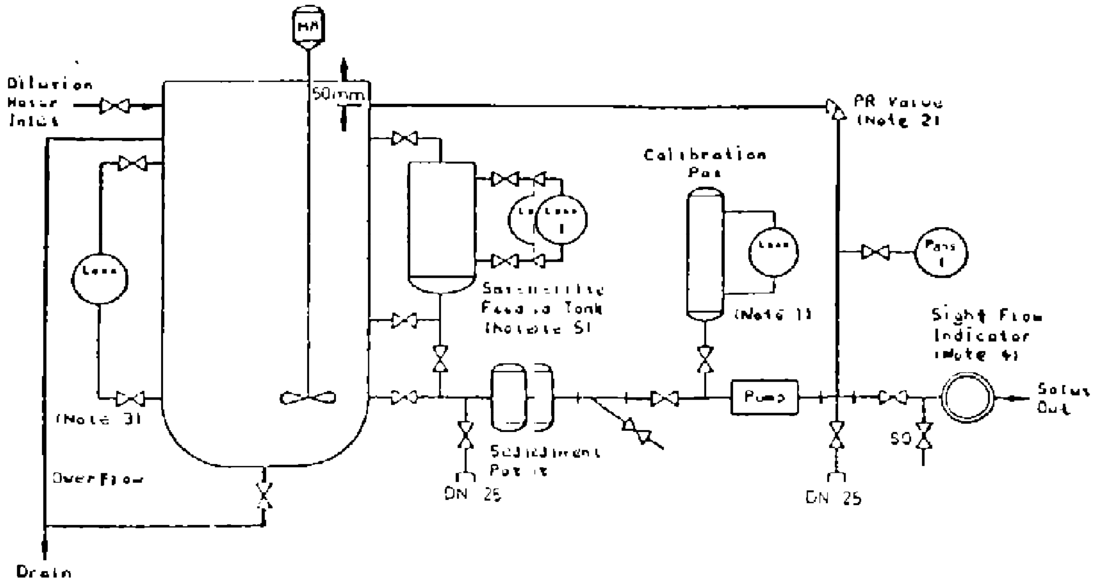
9.2.7.7.2 Each positive displacement pump shall be furnished with a calibration pot. A gage glass shall be furnished with a gage board calibrated in cm.

9.2.7.7.3 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.

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

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

9.2.7.7.6 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 3.5 bar (ga) above pump pressure.

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.

9.3 General Requirements for Design and Construction of Chemical Dosing Units in Water Treating System

9.3.1 Performance

a) The chemical dosing Unit shall be capable of withstanding continuous operation.

b) The accuracy of the chemical feeds shall be ±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.

9.3.2 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.

9.3.3 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 3 "Material Selection Guide for Dosing Unit" is applicable to typical chemicals used in the water treatment Unit.

9.3.4 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).

9.3.5 Mechanical

a) Chemical tanks

1) Chemical tanks shall have a seven-day storage 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.

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.

9.3.6 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.

9.3.7 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 3 - MATERIAL SELECTION GUIDE FOR DOSING UNIT

Chemical	Solution Concentration (mass %) Max. Temp.	Material
Aluminum Sulphate $Al_2(SO_4)_3 . 14H_2O$	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 $Ca(OC1_2)_2$	10% Ambient	Plastic or natural rubber lined carbon steel or Alloy 20
Copper Sulfate $CuSO_4 . 5H_2O$	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 $Na_2HPO_4 . 12H_2O$	3% Ambient	Carbon steel
Hydrazine $N_2H_4 . H_2O$	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 $NaH_2PO_4 . H_2O$	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 $(NaPO_3)\times$	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 $Na_3PO_4 . 12H_2O$	3% Ambient	Carbon steel

9.4 General Design Requirements of Chemical Feed Equipment

9.4.1 Cooling tower warm lime softener

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

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

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

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

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

9.4.1.6 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.

9.4.1.7 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.

9.4.2 Clarifier

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

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

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

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

9.4.2.5 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 pipings shall be provided.

9.4.2.6 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.

9.5 General Design Requirements of Metering Pump in Chemical Injection Systems

9.5.1 Introduction

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

9.5.2 Installation

9.5.2.1 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.

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

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

9.5.2.4 Location

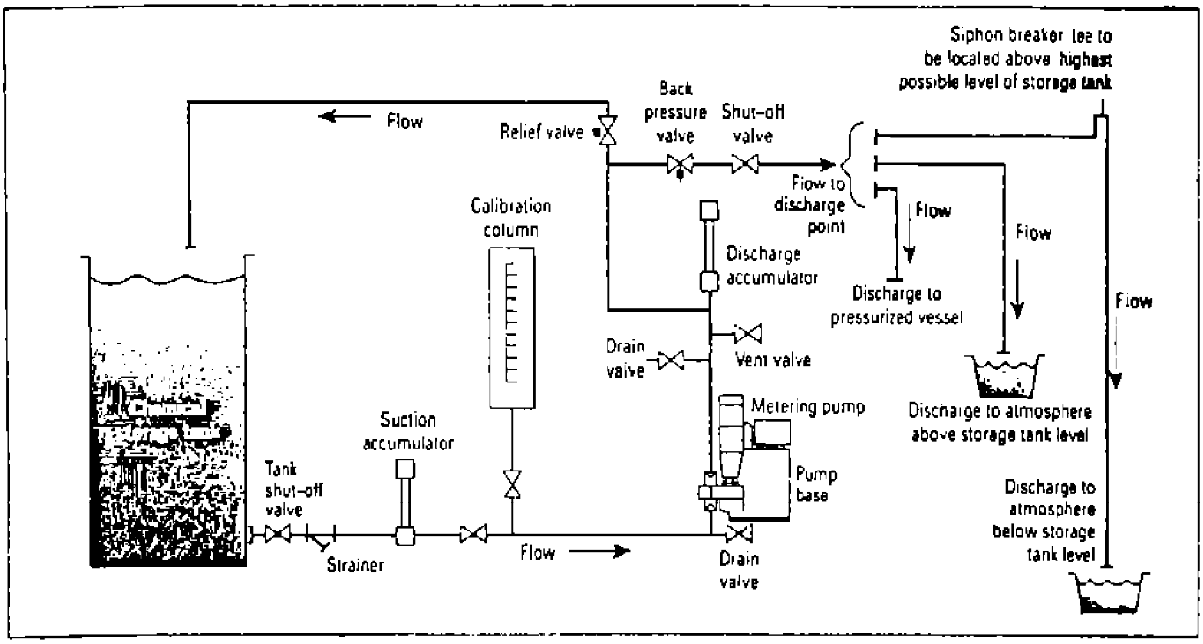
The preferred location of metering pump is indoors. Although pumps can be installed outdoors. Manufacturer's recommendations for ambient operating temperatures shall be followed.

9.5.2.5 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.

9.5.2.6 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

9.5.2.7 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.

9.5.3 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:

9.5.3.1 Keep suction lines short; locate the pump as close to the chemical supply tank as possible.

9.5.3.2 Locate both pump and tank as close to the application point as possible, long lines may require large-diameter pipe.

9.5.3.3 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.

9.5.3.4 Long lines may result in poor performance, notably under feeding, non-linearity, noisy operation, and vibration of the piping.

9.5.3.5 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.

9.5.3.6 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.

9.5.3.7 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.

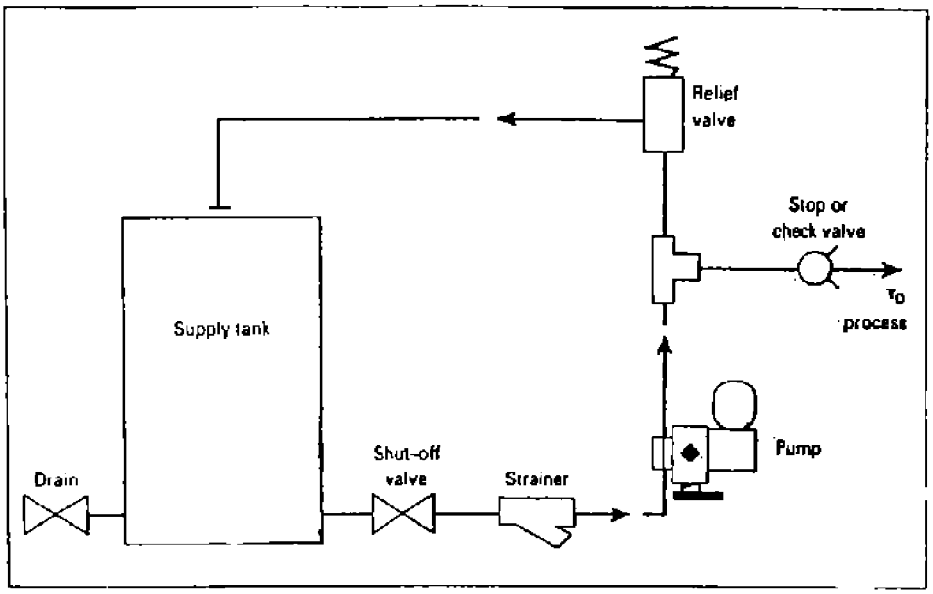
9.5.3.8 Suction pressure

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).

9.5.4 Relief valve

9.5.4.1 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.

9.5.4.2 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

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

9.5.4.4 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.

9.5.5 Back pressure

9.5.5.1 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.

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

9.5.5.3 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.

9.5.5.4 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.

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

9.5.5.6 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.

9.5.5.7 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.

9.5.6 Siphoning

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

9.5.6.2 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.

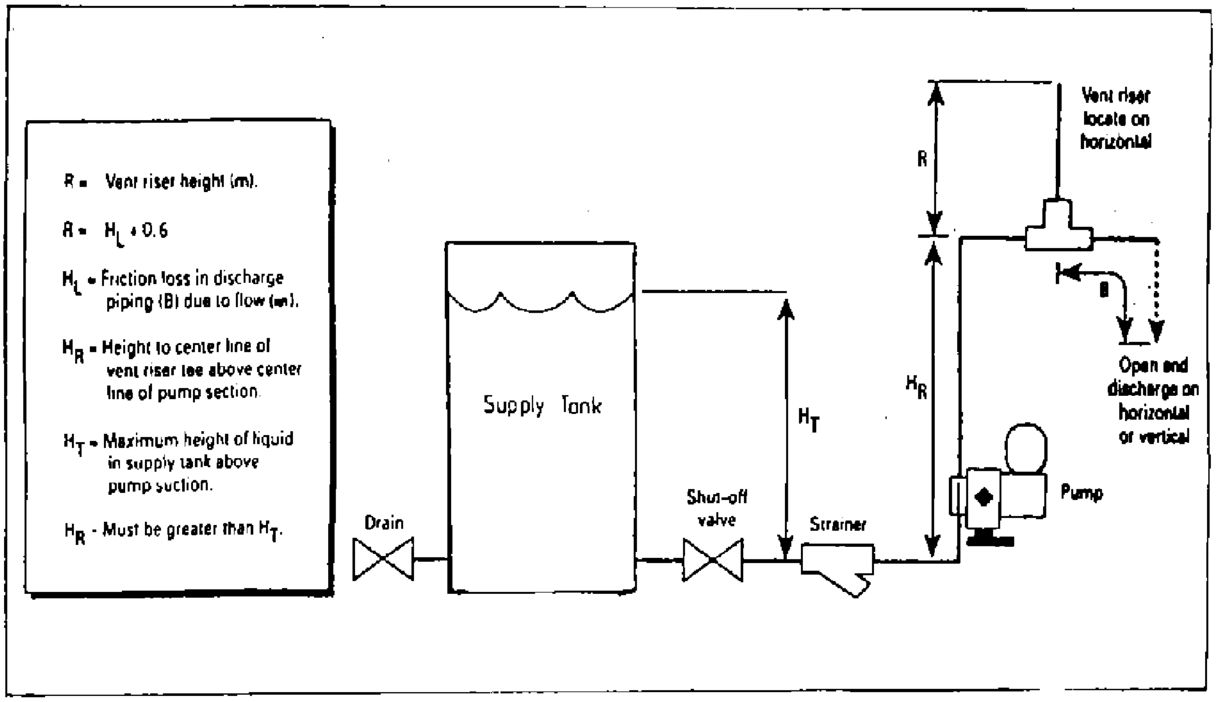
9.5.6.3 Antisiphon valves are usually spring-loaded valves whose long term reliability depends upon frequency of operation. In failure of an antisiphon valve, the system may be subject to overfeed or uncontrolled flow.

9.5.6.4 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.

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

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

9.5.6.7 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

9.5.7 Slurries

9.5.7.1 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.

9.5.7.2 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 rodding 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.

9.5.7.3 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.

9.5.7.4 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.

9.5.7.5 Data sheet

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

9.6 General Design Requirements of Package Type Chemical Injection Systems

9.6.1 Scope of supply

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

9.6.1.2 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.

9.6.1.3 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.

9.6.2 Design conditions

9.6.2.1 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.

9.6.2.2 Mixers

a) A portable mixer shall be provided for each tanks.
b) Mixers shall be stable while agitating contents of tank from $^1/_3$ to full.

9.6.2.3 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.

9.6.2.4 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.

9.6.2.5 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.

9.6.2.6 Data sheet

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

9.6.3 Guarantee

a) Vendor shall guarantee the following when the equipment is operated in accordance with the written operating instructions:

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

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

APPENDICES

APPENDIX A
CONTROL SCHEME DESIGN

A.1 General

A.1.1 At least the following controllers shall be used:

1) Fixed program controllers (for single loops including cascade control).
2) Programmable controllers for complicated strategies like feed-forward, furnace control, distillation column control, etc.

A.1.2 The entire system shall be suitable for future upgrading and expansion requiring no major modification.

A.1.3 The Contractor shall furnish typical instrumentation drawings for simple control loops and detailed drawing for complex control loops.

A.1.4 Selection of control objects, measuring points and controlling points shall be based on a thorough study of process type/nature, equipment types/sizes and their allowances.

A.1.5 The following points must be considered in the planning of control systems and the execution of the engineering:

1) Owner's philosophy of process control;
2) grade, operability and safety of control systems.

A.2 Selection of Controlled Variables and Manipulated Variables

For selection of controlled variables and manipulated variables among many process variables, the following points shall be followed (as a general criteria).

A.2.1 Selection of controlled variables

A.2.1.1 Process variables which are representative of the process objectives shall be distinguished.

A.2.1.2 Other process variables which can affect the above variables considerably shall also be distinguished (for cases of difficulty of measurement and large time lags for direct control).

A.2.1.3 Controlled variables shall then be selected based on the review of the fluctuation ranges and degree of importance of product quality and yield with consideration given to ease of their measurement, their dynamic characteristics, the effects of external disturbances and other relevant matters.

A.2.2 Selection of manipulated variables

Manipulated variables shall be selected as those process variables which can vary the selected controlled variables primarily, namely variables which can change the intended variables considerably without affecting other conditions (variables). The controllable ranges of the variables must be sufficiently large for the correction control, namely, their allowances must be sufficient for changes in the set point and for external disturbances, while having small time lag.

A.3 Basic Control Loops

A.3.1 Single feedback control

Single feedback controls shall be only used in cases where the effects of external disturbances on the process operation are sufficiently small, compared with the required control range and the cycles of the external disturbances are long, compared with the response in the process operation.

A.3.2 Multi-variable control

Depending on the conditions of process disturbances, there are cases for which single feedback controls may not serve the purpose, in such cases the following alternatives shall be studied:

1) Disturbances can be removed by using minor loops before they affect the controlled variables (e.g., cascade control).

2) External disturbances can be measured/predicted in order to adjust the manipulated variables to offset the disturbances before their effects appear (e.g., feed-forward control).

3) The control loop can be switched to another which is suitable for the type and/or size of the disturbance (e.g., selective control and split range control).

A.3.2.1 Cascade control

The general concept of cascade control is to place one feedback loop inside another feedback loop. In effect, one takes the process being controlled and finds some intermediate variable within the process to use as the set point for the main loop.

Cascade control (set point of secondary controller adjusted by the primary controller output) is intended to improve the response, reducing the effects of time lag and/or several other disturbances.

If the response of the secondary controller is not sufficiently prompt, compared with that of the primary controller, interference may occur between the two controllers. In order to determine the best cascade control arrangement, it is necessary to make a specific determination of the most likely disturbances to the system. It is helpful to make a list of these in order of increasing importance. Once this has been done, the designer must review the various cascade control options available and determine which best meets the overall strategy, i.e., to have the inner loop as fast as possible while at the same time receiving the bulk of the important disturbance.

A.3.2.2 Selective control

In cases where two or more variables are to be controlled by the same manipulated variable, the most important variable must be selected for control (selection of measurement signals/selection of manipulated signals).

A.3.2.3 Split range control

Depending on the control range, split range may be used for control of a variable in a broad range [split range control (similar to selective control) uses different manipulated variables for the same controlled variable].

A.3.2.4 Ratio control

Ratio control may be used in cases where the direct measurement of final controlled variable is difficult or the response is very slow, so as to improve the controllability against quick disturbances, such as flow rate fluctuations, typical applications of which are:

- calorie control for gas blending;
- fuel-air ratio control for boilers (including waste heat boilers) and heaters;
- feed ratio control for reactors.

It is also possible to implement a ratio control system if the primary instrument is not a controller but rather a transmitter. In such a situation, the set point of the controller is set in direct relation to the magnitude of the primary controlled variable.

A.3.3 Feed-forward control

There are some significant problems with feed-forward control. The configuration of feed-forward control assumes that the disturbances are known in advance, that the disturbances will have sensors associated with them and that there will be no important undetected disturbances.

A.4 Control Scheme Patterns

A.4.1 Control schemes for distillation tower

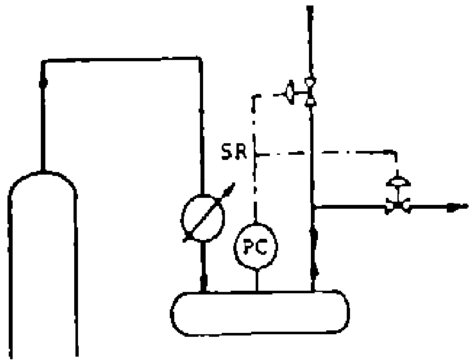
Unless otherwise specified, in distillation towers product composition shall be substantially maintained by temperature control with the pressure kept at the set point as follows:

A.4.1.1 Pressure control

1) Pressure is atmospheric or slightly positive and non-condensible gas is not existing: pressure control can be carried out by introducing inert gas in case of general distillation towers as shown in Fig. A.1-(a) or fuel gas (in case of petroleum distillation towers) into the receiver and by releasing gas from the receiver through a vent or to flare. In this case, as pressure hunting will occur if the size of the piping from the receiver nozzle to the flare header is excessively small, the piping must have a size sufficient for the purpose. The possibility of hunting may be reduced by using the control shown in Fig. A.1-(b). In this control the gas to be introduced must be insoluble in tower’s liquid.

Inert Gas or Fuel Gas

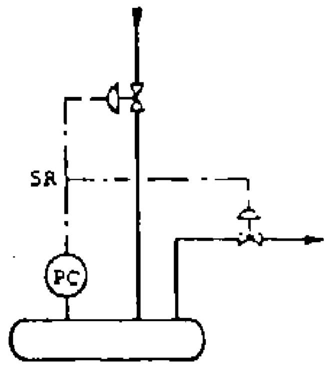
(a)



Off Gas to Vent or Flare

Inert Gas or Fuel Gas

(b)

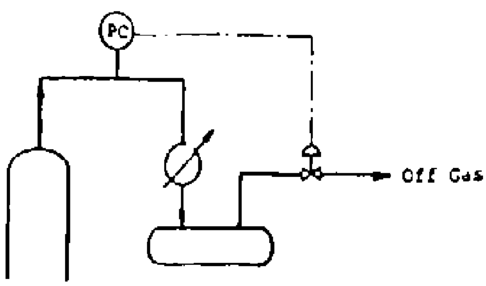


Off Gas to Vent or Flare

SR: Split Range

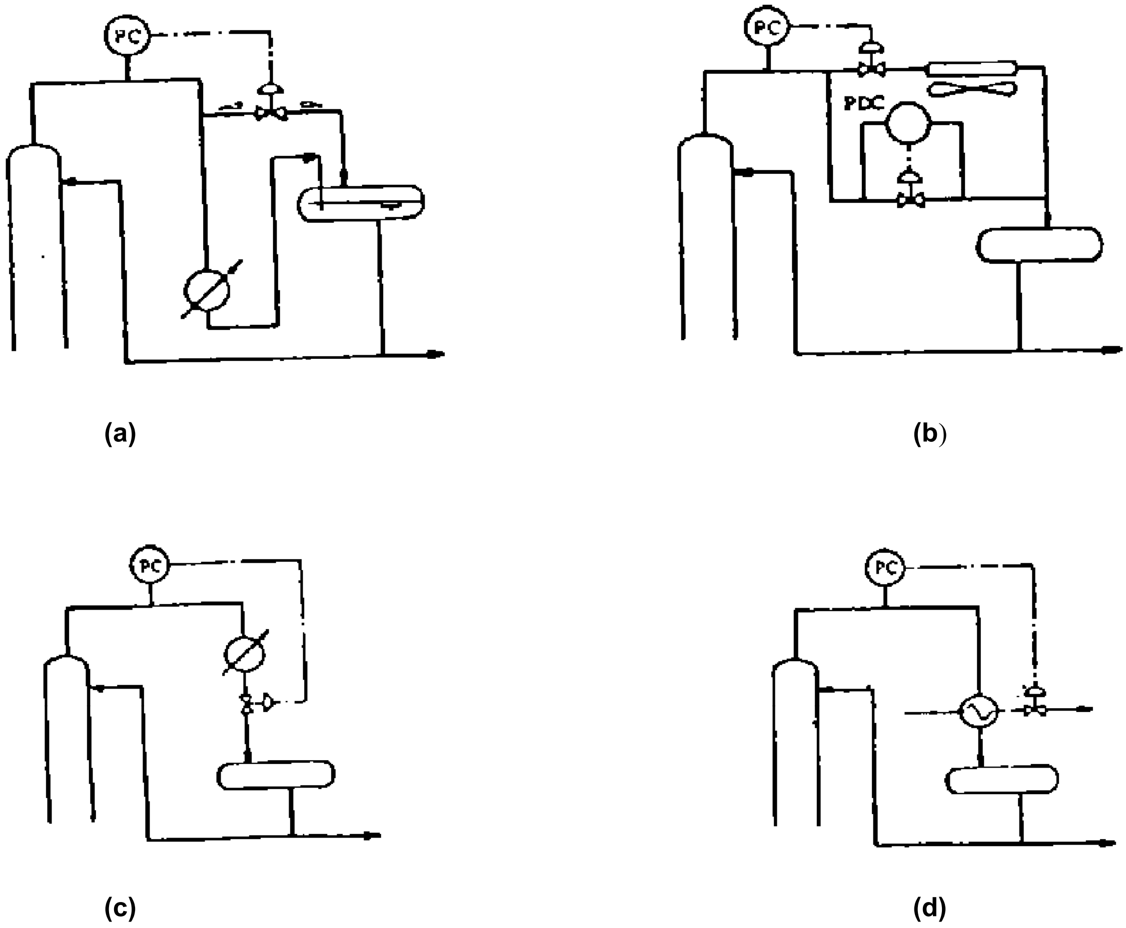
PRESSURE CONTROL OF DISTILLATION TOWER
(PRESSURE POSITIVE, NON-CONDENSIBLE GASES ARE NOT EXISTING)
Fig. A.1

2) Pressure is positive and non-condensible gas is existing: in this case, gas introduction to the system is not required (e.g.,deethanizers, hydrodesulfurization strippers, catalytic reforming stabilizers, etc., Fig. A.2).



PRESSURE CONTROL OF DISTILLATION TOWER
(PRESSURE POSITIVE, NON-CONDENSIBLE GAS IS PRESENT)
Fig. A.2

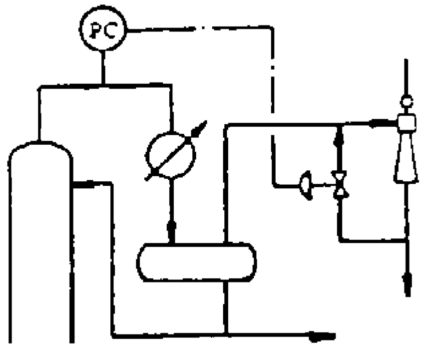
3) Pressure is positive and all gases are condensible: for the control scheme shown in Fig. A.3-(a), adequate hot bypass flow calculation and condenser design shall be considered. If the condensers are air fin coolers, the control shown in Fig. A.3-(b) must be used, as the receiver cannot be elevated above them. For this case, a bypass shall be provided to control the differential pressure to keep the receiver pressure at a certain level. In the control scheme shown in Fig. A.3-(c), a valve is provided on the condensate line and the pressure is controlled by adjusting the heat transfer area for condensation. In the control scheme shown in Fig. A.3-(d), pressure is controlled by adjusting the condensation rate and the condensation rate is controlled by regulating the flow rate of the cooling water. This control system shall be only used for cases where subcooling difficulty and excessive cooling water outlet temperature rise are tolerable.



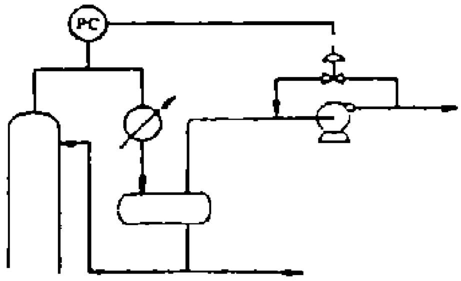
(a) (b) (c) (d)

PRESSURE CONTROL OF DISTILLATION TOWER
(PRESSURE POSITIVE, ALL GASES CONDENSIBLE)
Fig. A.3

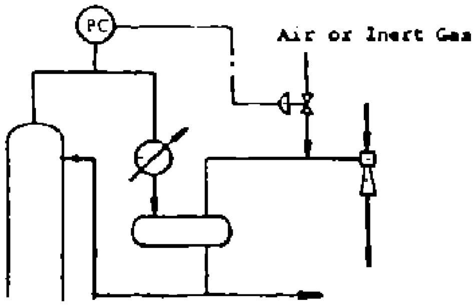
4) Vacuum distillation towers: unless otherwise specified, pressure control in vacuum towers shall be conducted by regulating the load of the vacuum producing equipment and this load regulation shall be carried out by circulating a part of the exhaust gases from the ejector or vacuum pump or by air introduction (Fig. A.4).



(a)



(b)



(c)

PRESSURE CONTROL OF VACUUM DISTILLATION TOWER
Fig. A.4

A.4.1.2 Temperature control

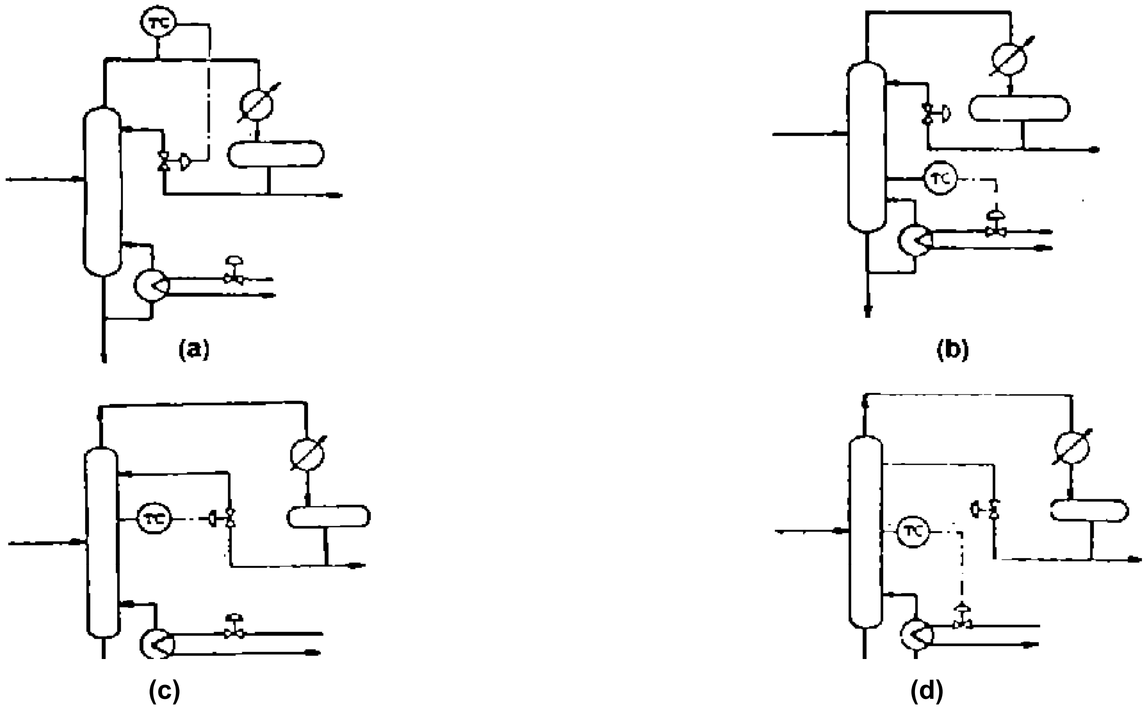
For the purpose of maintaining the composition application of overhead or bottom temperature control shall be considered for distillation towers, in conjunction with previously discussed pressure control as follows:

- the temperature of the intended product shall be controlled as a rule;

- in cases where fluctuation of the purity/composition of the intended product is expected to be minor, temperature control shall be conducted for the purpose of maintaining the yield.

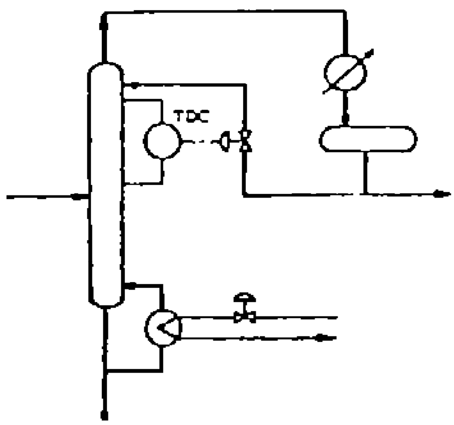
Normally, control valves are provided on the reflux line in the case of overhead temperature control and on the reboiler heating medium line in the case of bottom temperature control.

As shown in Fig. A.5-(a) and Fig. A.5-(b), temperature sensor is placed on the overhead line or on the bottom line in usual cases, but in cases where temperature variations related with composition fluctuations are too small at those locations, temperature measurement has to be at an intermediate tray where it can be done with high accuracy as shown in Fig. A.5-(c) and Fig. A.5-(d).



TEMPERATURE CONTROL OF DISTILLATION TOWER
Fig. A.5

In the case of super-fractionation (where a large number of trays are used and the temperature difference between the top section and the bottom section is small), the temperature difference between the two points, several trays apart, is measured to control the product purity as shown in Fig. A.6. In such a case, as temperature variations are caused by pressure fluctuations rather than by composition fluctuations, mere temperature control cannot serve the requirement of quality control of the intended product.



TEMPERATURE DIFFERENCE CONTROL OF DISTILLATION TOWER
(TYPICAL FOR SUPER FRACTIONATORS)
Fig. A.6

For this reason, the effects of pressure fluctuations (which will be possible) may be offset by the application of a control scheme based on the temperature difference (in which case, pressure control is required).

For cases of temperature control at intermediate trays and temperature difference control, suitable locations shall be selected from the standpoint of dynamics, to avoid the problem of an excessively large number of trays between the two points or between the top or bottom and the intermediate tray (required by high accuracy consideration). Further, in special cases, where no temperature control is provided at any point in the tower, other considerations (for instance flow control in each section) are required to maintain stable operating conditions and at the same time, some allowances shall be considered for the operating conditions, which may affect the design of the related equipment.

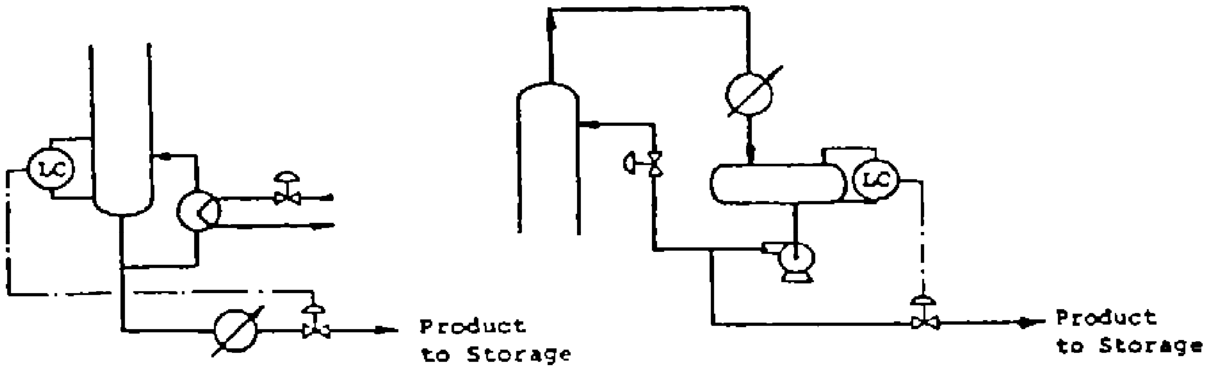
A.4.1.3 Flow control

In the case of single distillation tower, flow controls shall be provided for the feed, reflux and reboiler heating medium if neither pressure control nor temperature control are provided.

Overhead and bottom products are normally withdrawn under level control, but in cases where they are directly fed to other equipment, flow control may be required, demanding a thorough study of the whole system.

A.4.1.4 Level control

In the case of distillation towers, where the flow stability of overhead/bottom liquids is not important (in cases where the liquids are run down as products), level control has to be used, with control valves provided on the relevant lines as shown in Fig. A.7.



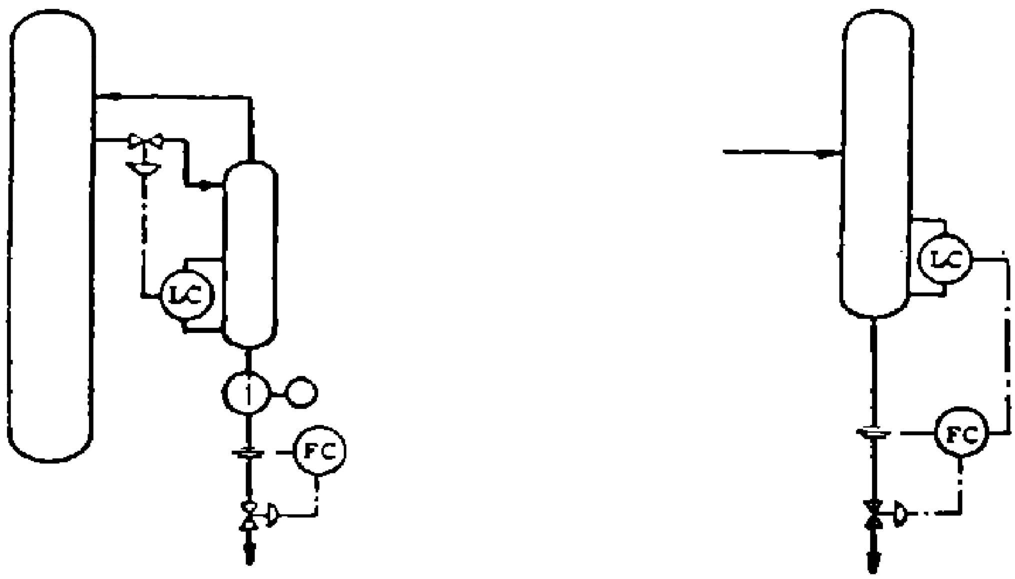
(a) (b)

LEVEL CONTROL OF DISTILLATION TOWER
(PRODUCT FLOW STABILITY IS NOT REQUIRED)
Fig. A.7

In the case of high temperature fractionators where bottom liquid deterioration is probable, even if the flow stability of bottom product is sacrified, the liquid level must be held as low as possible to minimize the holding time. For cases where these liquids are utilized for heat recovery in reboilers and/or feed preheaters, selection of required control schemes shall be based on a thorough study of the whole system.

In cases where flow stability is required for the feed to the downstream equipment, the outgoing stream shall be flow controlled and the level of the liquid shall be controlled by regulating the inlet rate as shown in Fig. A.8-(a).

The level control and flow control may be cascaded as shown in Fig. A.8-(b) for cases where large disturbances are expected to occur or product properties are affected by flow rate variation and in single loops with long response cycles.



(a) (b)

LEVEL CONTROL OF DISTILLATION TOWER
[(a) PRODUCT FLOW STABILITY IS REQUIRED (b) CASCADE CONTROL]
Fig. A.8

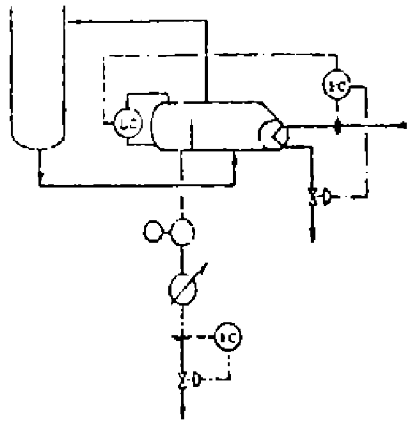
A.4.1.5 Reboiler control

A.4.1.5.1 Reboilers in which steam is used as the heating medium

Reboiler control scheme can be classified as flow control and temperature control [Fig. A.9-(a) and Fig. A.9-(b)], depending on the conditions of the tower, for which special attention shall be paid to the location of control valve and flow measuring point. Fig. A.10 shows a typical control scheme for the outlet stream from a kettle type reboiler.

(a) (b)

CONTROL OF REBOILER
(HEATED BY STEAM)
Fig. A.9

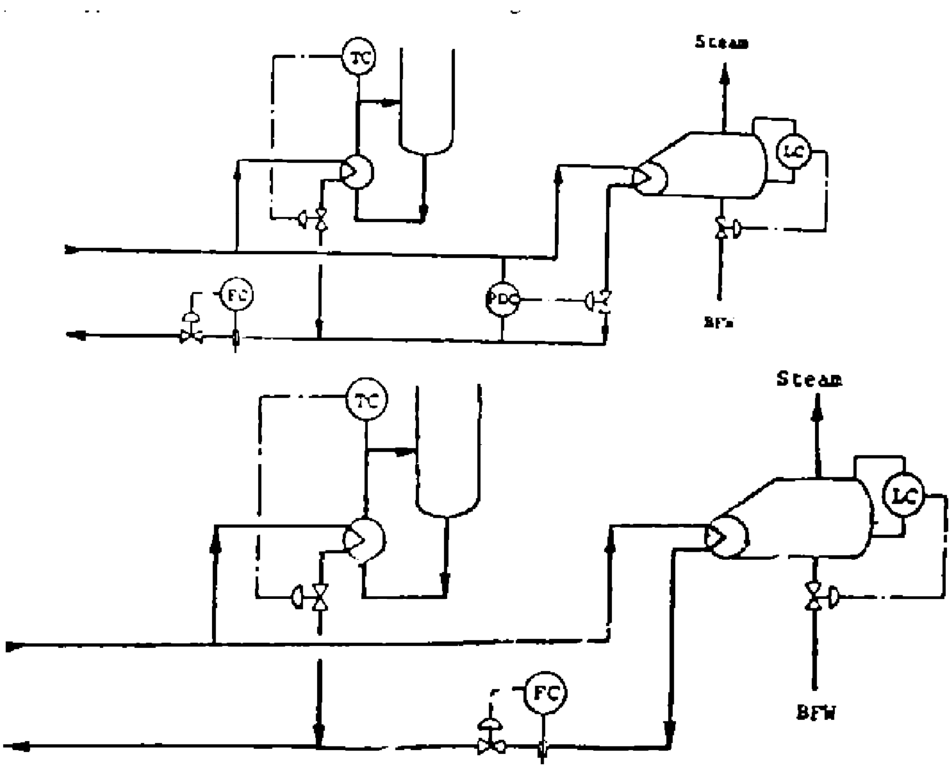


CONTROL OF REBOILER
(KETTLE TYPE, HEATED BY STEAM)
Fig. A.10

A.4.1.5.2 Reboilers in which main fractionator side-stream or effluent is used as the heating medium

Fig. A.11-(a) and Fig. A.11-(b) show typical control schemes for this kind of reboiler in topping Units. Fig. A.11-(a) presents typical reboiler control scheme for cases where the heating medium is a fractionator side-stream, while Fig. A.11-(b) shows typical reboiler control scheme where the heating medium is fractionator bottom effluent.

(a)

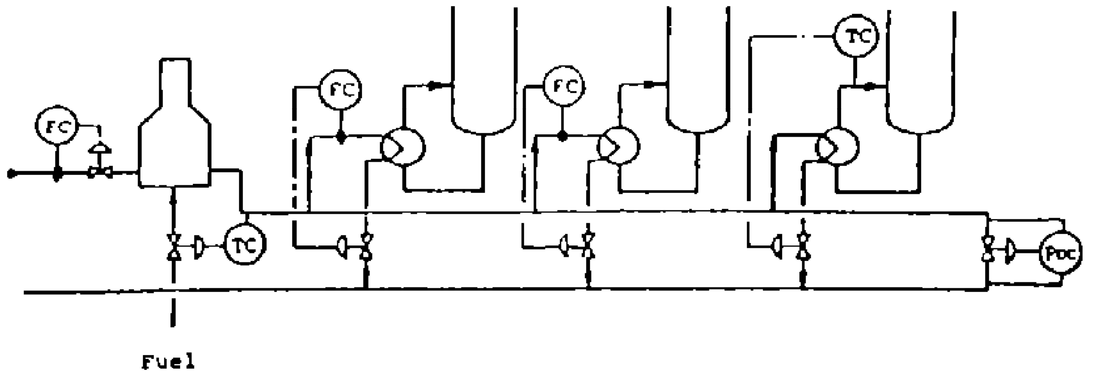


(b)

CONTROL OF REBOILER
(HEATED BY FRACTIONATOR SIDE-STREAM OR EFFLUENT)
Fig. A.11

A.4.1.5.3 Hot oil system

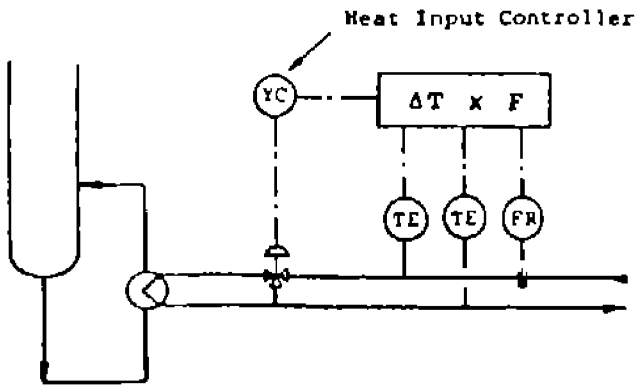
Fig. A.12 shows a typical control scheme of an hot oil system covering several reboilers. Flow control or temperature control may be provided for each individual reboiler, depending on the conditions/configuration of the fractionator side.



REBOILER CONTROL FOR HOT OIL SYSTEM
Fig. A.12

A.4.1.5.4 Reboilers with heat input controller

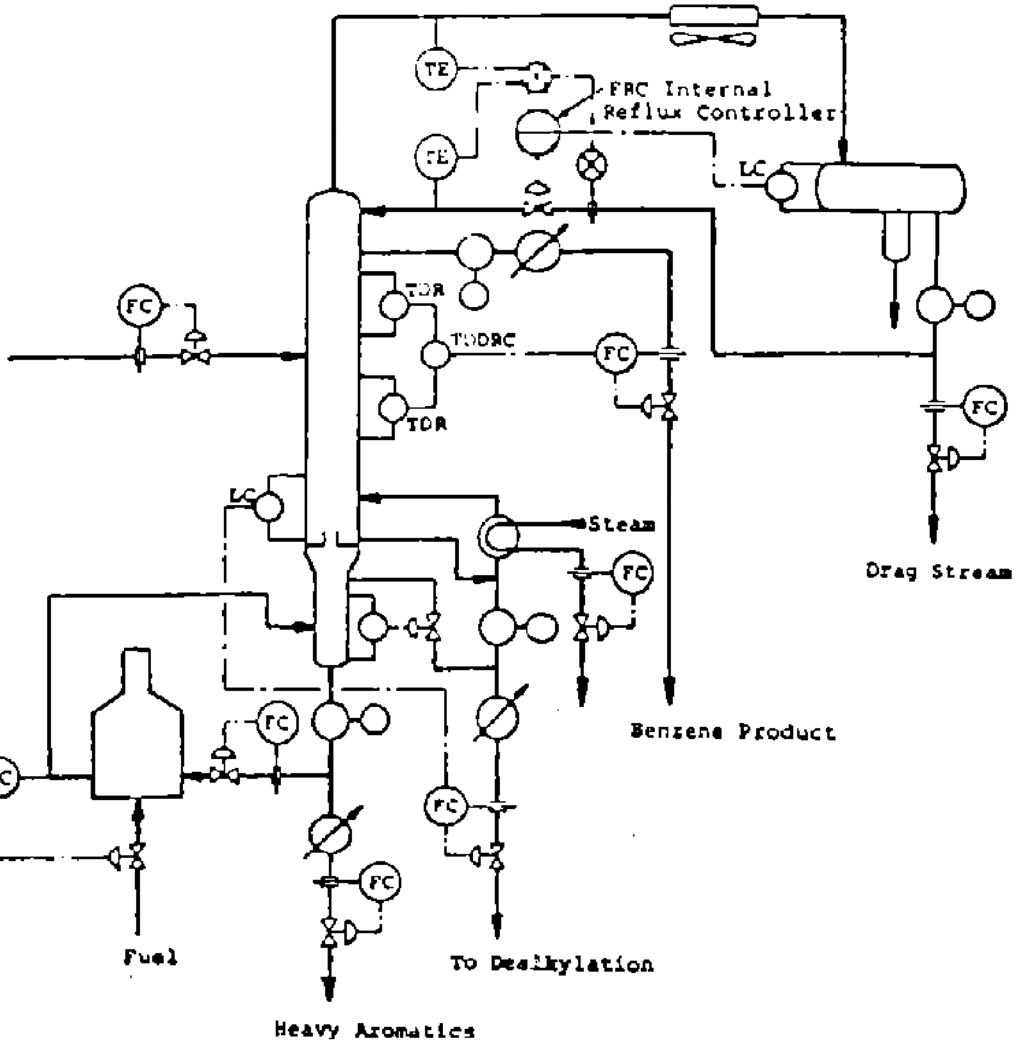
There are cases where heat input control is required other than flow, level, pressure and temperature control. The principle of heat input control is as shown in Fig. A.13, the amount of the heat input is calculated from the flow rate and inlet/outlet temperatures and is controlled to keep required value of heat input to the reboiler.



HEAT INPUT CONTROL OF REBOILER
Fig. A.13

A.4.1.6 Internal reflux control

In cases where the reflux rates are controlled in fractionation, if only the external reflux rates are controlled without regulating their temperatures, the rates of the internal refluxes which are the substantial refluxes, will vary with temperature, namely temperature variations will act as disturbances. Such disturbances must be precluded in the case of towers designed to produce high purity products. Hence, controllers must be provided for the purpose of controlling the internal reflux rates as typically shown in Fig. A.14 (the internal reflux controller is cascaded with the overhead receiver level controller and the difference between the overhead temperature and reflux temperature is measured to correct the external reflux rates).



INTERNAL REFLUX CONTROL
Fig. A.14

A.4.1.7 Quality control and distillation tower control

Distillation tower control generally used are based on either of the following which are to be selected for the purpose and conditions in each individual case after review and discussion.

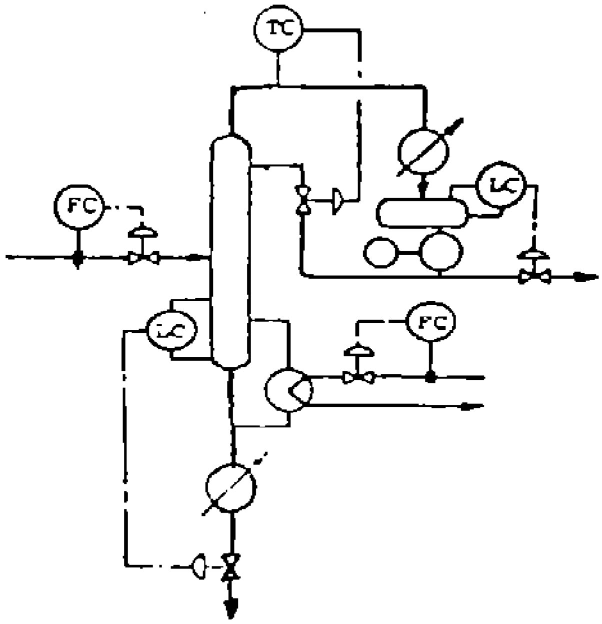
Since pressure controls can be used in combination with any of the above-mentioned controls, most suitable combinations can be selected for the conditions involved in each individual case.

Fig. A.15-(a) shows a typical case of product quality control in which the heat input to the bottom section is kept at a fixed level and the overhead temperature is regulated by a temperature controller.

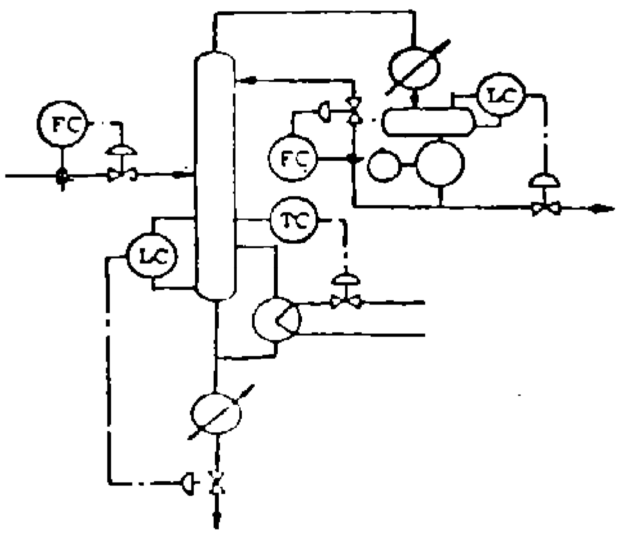
Inversely, in Fig. A.15-(b), the reflux rate is fixed and a temperature controller is provided in the bottom section to control the bottoms quality.

In high reflux ratio towers (separation of component with small boiling point difference), the product composition and flow rates are considerably affected by variations in the reflux ratio.

(a)

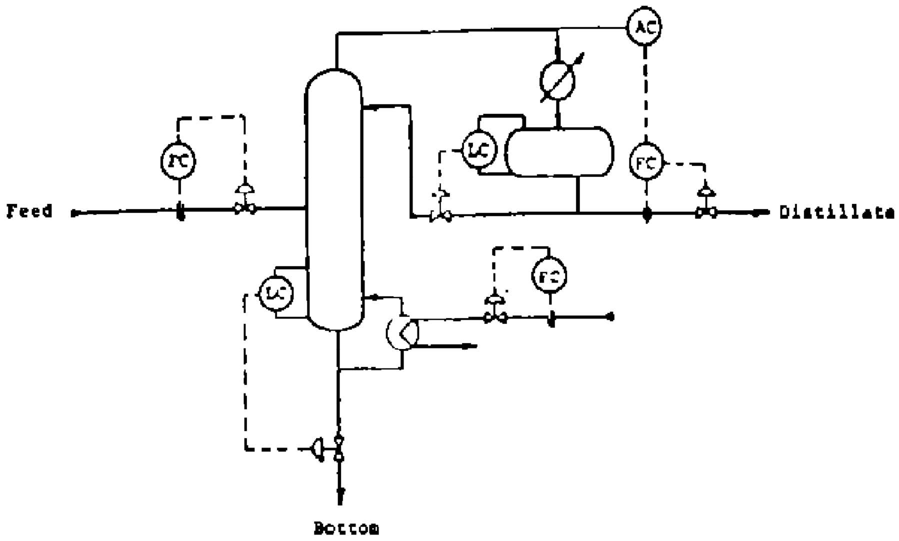


(b)



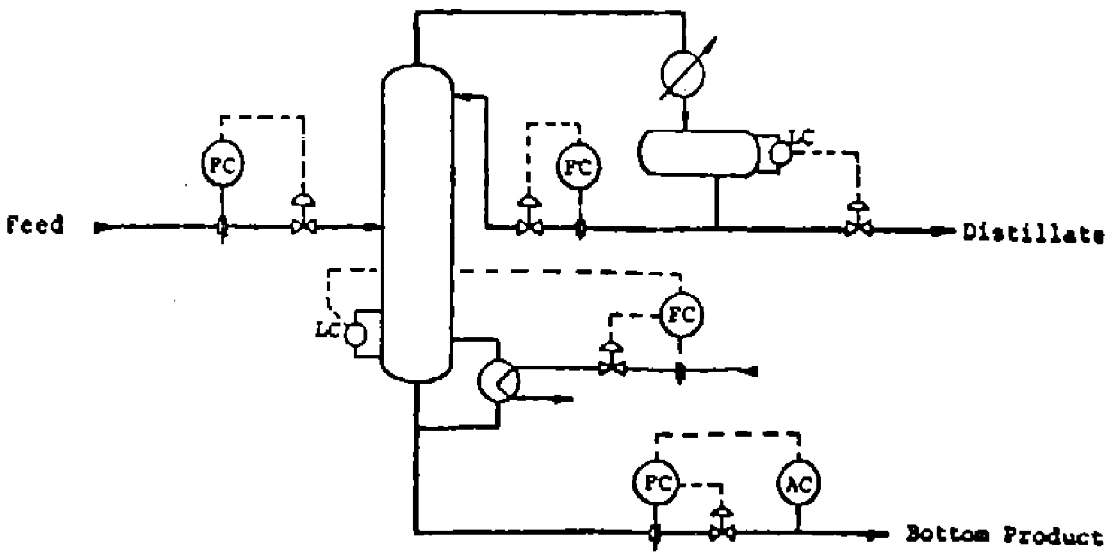
PRODUCT QUALITY CONTROL
Fig. A.15

In order to maintain an appropriate material balance, the distillate rate must be regulated by flow control and the product composition must be monitored by analyzers (as shown in Fig. A.16).



MATERIAL BALANCE CONTROL SYSTEM 1
Fig. A.16

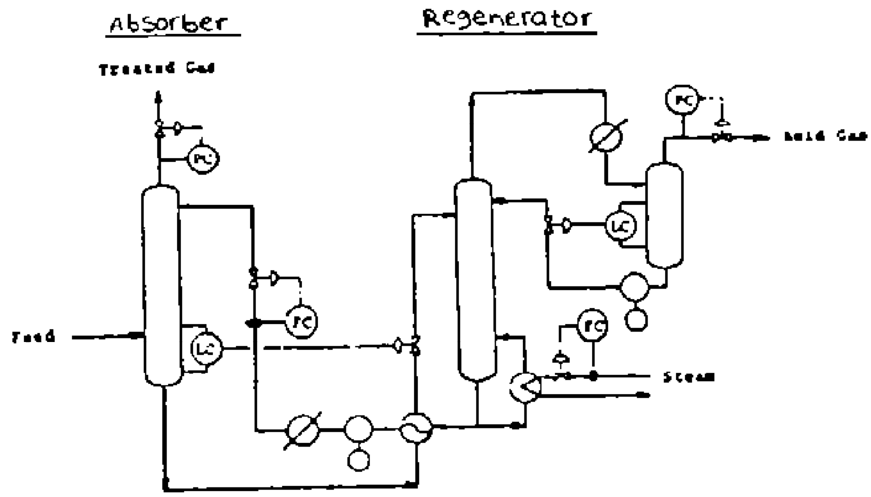
Fig. A.17 shows the typical control scheme to be used when the bottom product rate is smaller than the distillate rate.



MATERIAL BALANCE CONTROL SYSTEM 2
Fig. A.17

A.4.2 Control scheme for absorber-regenerator

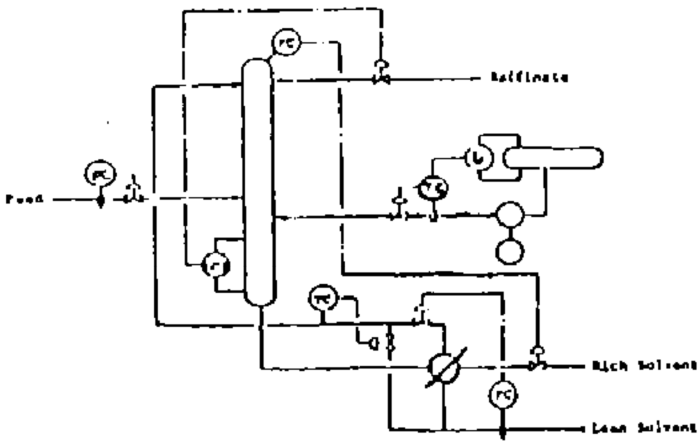
Typical control scheme for absorber-regenerator is shown in Fig. A.18 (acid gas removal process).



CONTROL OF ACID GAS REMOVAL PROCESS
Fig. A.18

A.4.3 Control scheme for extractor

Fig. A.19 shows typical control system for the extractor of a process for which a liquid-liquid interface controller is provided in the bottom. Operating temperature of this extractor is governed by the temperature of the lean oil charged to the tower for which a temperature control loop has been provided.



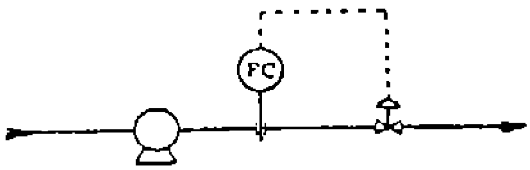
CONTROL OF EXTRACTOR
Fig. A.19

A.4.4 Control schemes for pumps

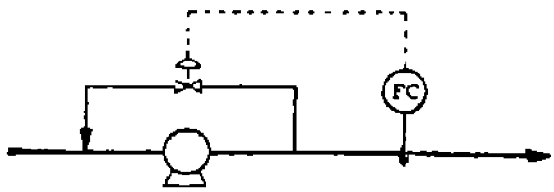
Pump control systems can be classified basically into the following two categories:

1) flow control with control valve on discharge (Fig. A.20-(a));
2) flow control with control valve on spill-back line (Fig. A.20-(b)), used in the case of high capacity pumps expected to conduct shut-off operation to prevent pump seizure.

(a)

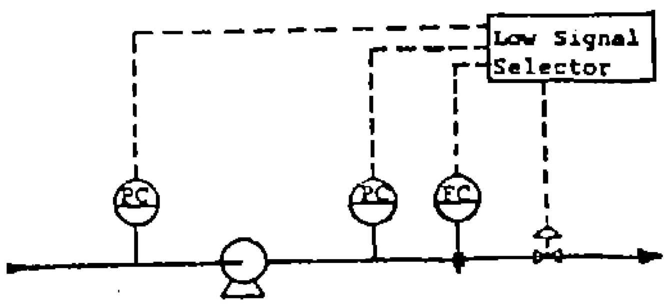


(b)



PUMP CONTROL SYSTEM 1
Fig. A.20

In the case of high capacity pumps as those used in offsite facilities, necessity of application of override control shall be checked for the purpose of pump protection (Fig. A.21).



PUMP CONTROL SYSTEM 2
Fig. A.21

APPENDIX B
TYPICAL VENDOR'S PROPOSAL ATTACHMENT FOR PSA SYSTEMS

B.1 PSA Process Data Sheet

B.1.1 Guarantee items
B.1.1.1 Throughput (for each case)
B.1.1.1.1 Total products as H_2 gas (for each case)
B.1.1.1.2 Feed to each PSA as H_2 feed gas (for each case)
B.1.1.2 Hydrogen recovery efficiencies (for each case)
B.1.1.3 Product specification

(1) H_2 purity (%)
(2) $CO + CO_2$ content
(3) HCI content

B.1.1.4 Absorbent life

(1) Guaranteed
(2) Expected

B.1.2 Design basis
B.1.2.1 Operation condition

(1) Turn down (%)
(2) Continuous operation time (hours)
(3) Expected on-stream factor (%)
(4) Product gas pressure [bar (ga)] temperature (°C)
(5) PSA off gas pressure [bar (ga)] temperature (°C)
(6) Number of equalization steps
(7) Number of adsorber in one adsorption step
(8) Operation with reduced number of adsorbers and change of H_2 recovery efficiency

B.1.2.2 Adsorbers

(1) Number of adsorber vessels
(2) Vessel size (mm)
(3) Adsorbent volume

B.1.2.3 Surge drum

(1) Number of drums
(2) Drum size (mm)
(3) Total drum volume

B.1.3 Utility requirements
B.1.3.1 Operation utilities

(1) Instrument air (Nm^3/h)
(2) Electric power (kW)

B.1.3.2 Start-up utilities

(3) Nitrogen (Nm^3)

B.1.4 Control system

(1) Automation feature
(2) Control unit
(3) Trouble shooting and detection
(4) Switchover system
(5) Maintenance of control valves and instruments.

(to be continued)

APPENDIX B (continued)

B.1 PSA Process Data Sheet

SERVICE | ITEM

		TEMPERATURE	PRESSURE
OPERATING CONDITIONS	SHELL		
	JACKET		
DESIGN CONDITIONS	SHELL		Int.
			Ext.
	JACKET		Int.
			Ext
	COIL		

FLUID | DENSITY

POSTWELD HEAT TREATMENT (FOR PROCESS) YES ○ NOT ○

	MATERIAL	C.A.
SHELL		
LINING		
HEADS TOP		
HEADS ATM		
JACKET		
COIL		

INSULATION: NOT ☐ YES ☐ THICKNESS

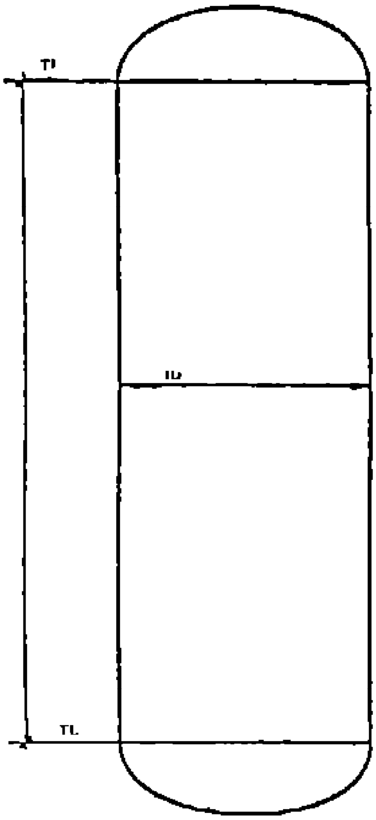
HEAT CONSERVATION ☐ COLD ☐ HOT ☐

FIRE PROTECTION ☐

PERSONNEL PROTECT. ☐

NOZZLES

ITEM	NO	SIZE	RAT & FAC	



NOTES

REV		DATE	CHECKED	APPROVED
3				
2				
1				
0				

APPENDIX C

TYPICAL DATA SHEETS OF CHEMICAL INJECTION SYSTEM

C.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 .... Direct Acting........

4 Metering heads: Simplex.... Duplex .... Triplex .... No. Per head........

5 Liquid handled........ Stroke adjustment: Manual .... Automatic ....

6 Maximum capacity, m³/hr .... While running .... Stopped ....

7 Pressure, discharge, bar(ga) .... Local .... Remote ....

8 Suction, bar(ga) .... Signal: Pneu. .... Elec. .... Hyd. ....

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 .... TEFC .... TENV .... Other ....

18 400 Volts 3 Phase 50 Cycle* .... HP*(kW) .... r/min (RPM) ....

19 . ...

20 ....

21 .... Tank-Item No. ....

22 Liquid handled .... Design press, @ Temp. .... bar(ga) ....°C

23 Capacity, m³ .... Freeboard %........ Operating press, @ Temp. .... bar(ga) .... °C

24 Connections, size: Drain .... Tank size: .... mID × mH ....

25 Gage glass .... Materials: ....

26 Fill........ Side .... Bottom ....

27 Suction .... Tank legs ....

28 Relief valves .... Pump platform ....

29 Bottom: Flat .... Cone .... Dished........ Basket ....

30 Top cover:........

31 Corrosion allowance .... mm .... Lining ....

32 Thickness: Side* .... Bottom .... Paint ....

33 Basket size, m³........ PERF. .... Seismic zone No. ....

34 ....

35 .... Mixer-Item No. ....

36 Mfg'r.* .... Model No.* ....

37 Motor drive: AC .... DC .... Exp. proof .... TEFC .... TENV .... Other ....

38 .... Volts .... Phase .... Cycle* .... HP* (kW) .... r/min.(RPM.) ....

39 Type mounting bracket .... Paint: ....

40 Materials of construction wetted parts ....

41 Chemical mixed .... Liquid .... Solid ....

42 ....

43 .... Piping and instruments ....

44 Piping included: Suction .... Discharge .... Drain .... Other ....

45 Line class spec. req'd or state materials ....

46 Instruments included: Relief valve .... Level gage .... Pressure gage .... Other ....

47 Mfg. and type req'd.* ....

48 Remarks:* All blanks to be proposed by Vendor ....

49 ....

50 ....

(to be continued)

APPENDIX C (continued)

C.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

OPERATING CONDITIONS

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 ———
LOCATION:
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 ———
SITE DATA:
c TEMPERATURE (°C) MAXIMUM ——— MINIMUM ———

CONSTRUCTION FEATURES

NOZZLES	SIZE	RATING	FACING	LOCATION
SUCTION	———	———	———	———
DISCHARGE	———	———	———	———
FLUSH	———	———	———	———

LIQUID END

TYPE: c DIAPHRAGM c PLUNGER
b DIAPHRAGM DIAMETER (mm) ——— No. REQUIRED ———
REMARKS: ———

VALVES PER FEED	SUCTION	DISCHARGE
TYPE	———	———
NUMBER	———	———

MATERIALS

LIQUID END ———
CONTOUR PLATE ———
HYDRAULIC DIAPHRAGM ———
PROCESS DIAPHRAGM ———
PLUNGER ———
LANTERN RING ———
PACKING GLAND ———

PACKING ———
VALVE ———
VALVE SEAT ———
VALVE GUIDE ———
VALVE BODY ———
VALVE GASKET ———
FRAME ———
REMARKS: ———

MANUFACTURER'S DATA

PERFORMANCE:
b NUMBER OF FEEDS ———
b RATED CAPACITY ———
b NPSH REQUIRED (m) ———
b kW. RATED ——— AT RELIEF SETTING ———
REMARKS: ———

b PLUNGER SPEED (strokes/min) ———
DIAMETER (mm) ———
LENGTH OF STROKE (mm) ———
b PUMP HEAD: ———
MAXIMUM PRESSURE (kPa gage) ———
HYDRO TEST PRESSURE (kPa gage) ———