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PROCESS REQUIREMENTS OF CRUDE DISTILLATION and HYDROGEN PRODUCTION UNITS

(PROJECT STANDARDS AND SPECIFICATIONS)

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SCOPE

This Engineering Standard Specification set forth the content and the extent of the minimum process and control system requirements of Crude Distillation and Hydrogen Production Units. For design of any equipment inside the subject plants, reference shall be made to the relevant IPS standards. This Standard Specification is further intended to cover the minimum process requirements and guidelines for process engineers to define control systems of process plants.

DEFINITIONS AND TERMINOLOGY

Back Pressure - The pressure on the outlet or downstream side of a flowing system. In an engine, the pressure which acts adversely against the piston, causing loss of power.

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

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.

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.

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.

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

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

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.

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

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.

Hunting - Prolonged self-sustained oscillation of undesirable amplitude.

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

Slurry - A free-flowing mixture of solids and liquid.

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

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.

Programmed Controller - A controller incorporating a programmed controlling element.

Set Value, Set Point - The command signal to a process control system.

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.

SYMBOLS AND ABBREVIATIONS

AC : Analysis Controller.

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.

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.

No. : Number.

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.

TDCR : Temperature 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 : Heat Input Controller.

UNITS

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

PROCESS REQUIREMENTS OF ATMOSPHERIC AND VACUUM DISTILLATION UNITS

The purpose of the crude distillation Unit shall be to make the initial separation of crude oil into desired fractions. The Crude Distillation Units typically 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 producing of paving and roofing asphalts.

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. 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. The Crude Distillation Unit typically consists of 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.

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. Lube Distillation Section typically consists of the following facilities:

a. Charge heater;
b. Lube distillation column;
c. Vacuum jets and all related equipment;
d. Instrumentation and piping.

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

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.

General Design Criteria

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

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

   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.**

3. Recommended minimum tray spacing are 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").

4. Tray spacing shall be greater than the minimum figures given in 6.2.3 above where required for access to column internals, manway location, vapor disengaging, nozzle interference or other reasons.
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. Minimum trayed column size shall be 800 mm inside diameter.
7. Leak tight trays shall be specified for the following services:
    a. Once-through reboiler draw off boxes;
    b. Side draw off tray draw pan;
    c. Chimney trays.
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.
9. Vessels shall be provided with vent, drain and steam-out nozzles, in accordance with the "Basic Engineering Design Data".
10. Drain nozzles on horizontal vessels shall be located at the opposite side of the liquid outlet line.
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

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

Design Requirements

1. Design temperature

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.

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 and no block valve existed downstream 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.

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:

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.

2. **Columns and drums**

   a. **Tray design**

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

   b. 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.

   c. **Flooding factor for fractionating trays**: 78% maximum.

   d. **Flooding factor for pumparound trays**: 85% maximum.

   e. **Flooding factor for steam stripping trays**

      And side cuts strippers regardless of strip ping medium: 75% maximum.

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

   g. **Type of internals**:

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

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

3. **Hold-up time**

Water settling requirements take priority over these times where applicable

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

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

c. **Columns feeding heat exchangers trains:** 300 seconds (HLL- LLL) on net liquid product.

d. **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).

e. **Vacuum column bottom:** 240 seconds (HLL-LLL) with quench.

f. **Feed surge drums:** 1200 - 1800 seconds (HLL-LLL).

g. **Columns or drums feeding multistage charge pumps (5 or more stages):**1200-1500 seconds (HLL-LLL).

h. **Drums feeding other equipment for further processing:** 600 seconds (HLL-LLL).

i. **OVHD receivers:** 300 seconds on reflux plus net product (HLL-LLL).

j. **Drums feeding fired heaters:** 600 seconds (HLL-LLL) on total liquid.

k. **Gas and water separators:** 300 seconds (HLL-LLL) on water flowrate.

l. **Water boots:** 300 seconds below normal interface level or 600 seconds on water (HLL-LLL), whichever is greater.

m. **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.

n. **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 HLABTM tangent line) or a 3.6 m (14") level range, whichever is greater.

4. **Shell and tube heat exchangers**
   a. **Cooled water condensers** : 10% on maximum duty and flowrate.
   b. **Cooled water cooler** : 10% on maximum duty and flowrate.
   c. **Pumparounds exchangers** : 15% on rated surface.
   d. **Reboilers** : 10% on maximum duty and flowrate.
   e. **Steam generators** : 10% on maximum duty and flowrate.
   f. **Air cooler and air condensers** : 10% on maximum duty and flowrate.

5. **Pumps**
   a. **Unit feed** : No over design unless otherwise specified by Company.
   b. **Feed booster** : No over design unless otherwise specified by Company.
   c. **Unit product** : 10% on maximum normal flowrate.
   d. **OVHD reflux** : 20% on maximum normal flowrate.
   e. **Pumparound** : 20% on maximum normal flowrate.
   f. **Reboiler feed** : 15% on maximum normal flowrate.
   g. **Boiler feed water** : 10% on maximum normal flowrate.
   h. **Surface condensers condensate:** 10% on maximum normal flowrate.
   i. **Chemical injection** : 20% on maximum normal flowrate.
   j. **Metering pumps** : 100% on maximum normal flowrate
   k. **Reciprocating and rotary pumps:** 15% on maximum normal flowrate.
   l. **All other pumps** : 10% on maximum normal flowrate.
   m. **Pump shut-off pressure:** Suction maximum operating pressure plus 120% of differential pressure at design capacity plus static head.

6. **Compressors and blowers:** 10% on maximum normal flowrate as minimum (not Licensed Units).

7. **Turbines:** Steam turbines: 10% on design brake horse power in kW of the driven pump or compressor.

8. **Heaters and waste heat boiler fans**

   a. **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.

   b. **Forced draft fans:** 15% on design (100 percent) flowrate (including any defined leakage from the preheater and other system losses) at design excess air.

Process Requirements for Distillation Unit

1. **Product fractionation**

   a. 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 in accordance with the project requirements. However, the following figures could be used in case of no requirements specified in the project.

      - Light SR Naphtha-Heavy SR Naphtha + 15°C
      - Heavy SR Naphtha-Blending Naphtha + 10°C
      - Blending Naphtha-Kerosene + 8°C
      - Kerosene-Atmospheric Gasoil + 14°C

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

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

2. **Other design requirements**

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

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.
3. Compression facilities shall be provided for crude Unit overhead gases. Spare compressor is not required.
4. The Atmospheric Distillation Section and Vacuum Distillation Section can be integrated for maximum recovery within their own battery limit (Light End Section excluded).
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. Heat exchanger network optimization should be considered for distillation units (e.g., pinch method).
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 as minimum requirement.
8. The stripped water from the Sour Water Stripper Unit shall normally be used as desalter feed water. Suitable treated water supply to the desalter shall be considered as an alternative source.
9. The Unit heaters shall be designed for 10 percent excess capacity for flow and duty.
10. Firing system of all the heaters (fuel gas, fuel oil or combination of them) shall be in accordance with the project requirements.
11. All heaters shall be designed for maximum energy conservation. Minimum efficiency of 90 percent should be considered for the charge heaters.
12. Crude and vacuum heaters shall have forced draft fans and air preheat system. Heater forced draft fans shall have a spare.
13. The fuel gas knock-out drum shall be provided in the Unit.
14. Atmospheric Crude Tower shall have kerosene and gas oil circulation refluxes.
15. Coalescers shall be provided for the Atmospheric and Vacuum gas oils for the cases that they are considered as finished products.
16. Vacuum column ejectors shall have 50% spare capacity for each set.
17. All continuous pumps shall have individual spares. Spare pumps shall be provided as follows: