HI-TEC MODEL 100-300 TOPPING PLANT

6000 BPD THROUGHPUT
300,000 METRIC TON PER YEAR THROUGHPUT

Technical Description

Introductory Information

Val Verde specializes in building skid mounted modular crude oil refineries that process from 300 to 12,000 barrels per day (15,000 to 600,000 metric tons per year) of crude oil. Chemex, Inc. purchased the Val Verde modular refinery design in the late 1990's.

The Val Verde HI-TEC design comes in standard sizes of 300 bpd (15,000 metric tons per year), 600 bpd (30,000 metric tons per year), 1,000 bpd (50,000 metric tons per year), 3,000 bpd (150,000 metric tons per year) 6,000 bpd (300,000 metric tons per year) and 12,000 bpd (600,000 metric tons per year).

The basic crude oil atmospheric distillation unit (ADU) produces naphtha, kerosene, diesel and #6 fuel oil. Additional processing units can be supplied by Val Verde that are capable of producing specification high-octane motor fuel, commercial jet fuel, low sulfur diesel, fuel oil and asphalt. Two or more plants can be installed on a single site allowing the simultaneous processing of more than one type of crude oil and one plant can still be in operation in the event that one plant is down. The plant sizes can be increased in stages.

Val Verde's larger ADU plants (3,000 to 12,000 bpd):

- can be set up and be in operation within several weeks after arrival at a fully-prepared and completed site,
- allow a single operator to restart the plant from a cold start in less than four hours and have the plant in full operation,
- are completely automated and once an operator sets all the controlling points, all product temperatures and flows are controlled automatically. If a product specification drifts off, or if a potentially hazardous condition develops, the plant automatically turns itself off to a safe condition without the help of an operator. A "First Out" annunciator signals the reason for the shutdown by a flashing red light,
- require only a flat support area or concrete slab, and
- require no water or instrument air.

Val Verde designs and builds the following additional equipment for its distillation units:

- special alloy construction for processing high sulfur crudes,
- desalter packages for removing salt from the crude for corrosion prevention,
- naphtha, jet fuel and diesel hydrotreaters for sulfur removal from the products,
- catalytic reformers for producing high octane gasoline motor fuels,
- gasoline stabilizers for reducing the Reid vapor pressure of gasoline,
- vacuum distillation units for producing paving grade asphalt (bitumen),
- sulfur plants for sulfur conversion and air emissions reduction that include an amine plant, a sulfur plant and a tail gas plant,
- winterized skids for operation in artic weather, and
- portable laboratory and control buildings with supplies.

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HI-TEC 100-300 Topping Plant

Summary

The following data is specifically for the advanced HI-TEC 100-300, which is a 6,000 bpd (300,000 metric tons per year) plant. Since our HI-TEC models have a turndown capability of 3 to 1, the 100-300 implies that this plant can operate at a rate of 100,000 to 300,000 metric tons per year (2,000 to 6,000 bpd).

The Val Verde HI-TEC Model 100-300 topping plant is a modularized, highly portable topping plant capable of processing 6,000 barrels per day of a wide range of crude oil and produces light naphtha, heavy naphtha, kerosene, diesel, gas oil and fuel oil. The plant can be set up within several weeks after arrival at a completed plant site and can be operational within a month of arrival.

The plant is automatic, can be started up in one hour, has an automatic system to shut the plant down in the event that a hazardous situation occurs and a “First Out” annunciator to let the operator know the reason for the shutdown. Automatic controls control the temperature of the heater outlet, tower top vapor temperature, diesel/kerosene/heavy naphtha side draw temperatures, diesel/kerosene/heavy naphtha reboiler temperatures, the level of the tower bottoms, diesel/kerosene/heavy naphtha stripper levels and the naphtha and water levels in the naphtha accumulator.

The standard plant construction material is carbon steel. Special alloys are specified when warranted for corrosion prevention.

Plant Feed and Products

Flexibility is incorporated in the design of this plant to process a variety of crude oils. The actual capacity of the plant will depend on the percentages of the fractions of the specific crude processed. Specifically, the plant is designed to process 6,000 barrels per day of 35^o to 41^o API crude and the products from the plant are light naphtha, heavy naphtha, kerosene, diesel, gas oil and reduced crude (fuel oil). The plant can be operated at 33% of its rated capacity.

The ending True Boiling Point (TBP) cut point of the different products can be adjusted somewhat to maximize one cut over another. As an example, the heavy naphtha end point can be adjusted to 400 ^{o}F (205 ^{o}C) to maximize naphtha production while minimizing kerosene production. Conversely, the heavy naphtha end point can be reduced to 325 ^{o}F (163 ^{o}C) to minimize naphtha production and maximize kerosene production.

The starting TBP cut point of the diesel depends on the ending TBP cut point of the kerosene and the diesel product specifications. With the design basis crude, a starting TBP cut point of 300 ^{o}F (149 ^{o}C) to 400 ^{o}F (205 ^{o}C) and an ending TBP cut point of 600 ^{o}F (315 ^{o}C) to 680 ^{o}F (360 ^{o}C) is used with a minimum flash point of 125 ^{o}F (52 ^{o}C).

Reduced crude is the bottom of the barrel with a minimum flash point of 150 ^{o}F (66 ^{o}C) and is normally used as a #6 fuel oil.

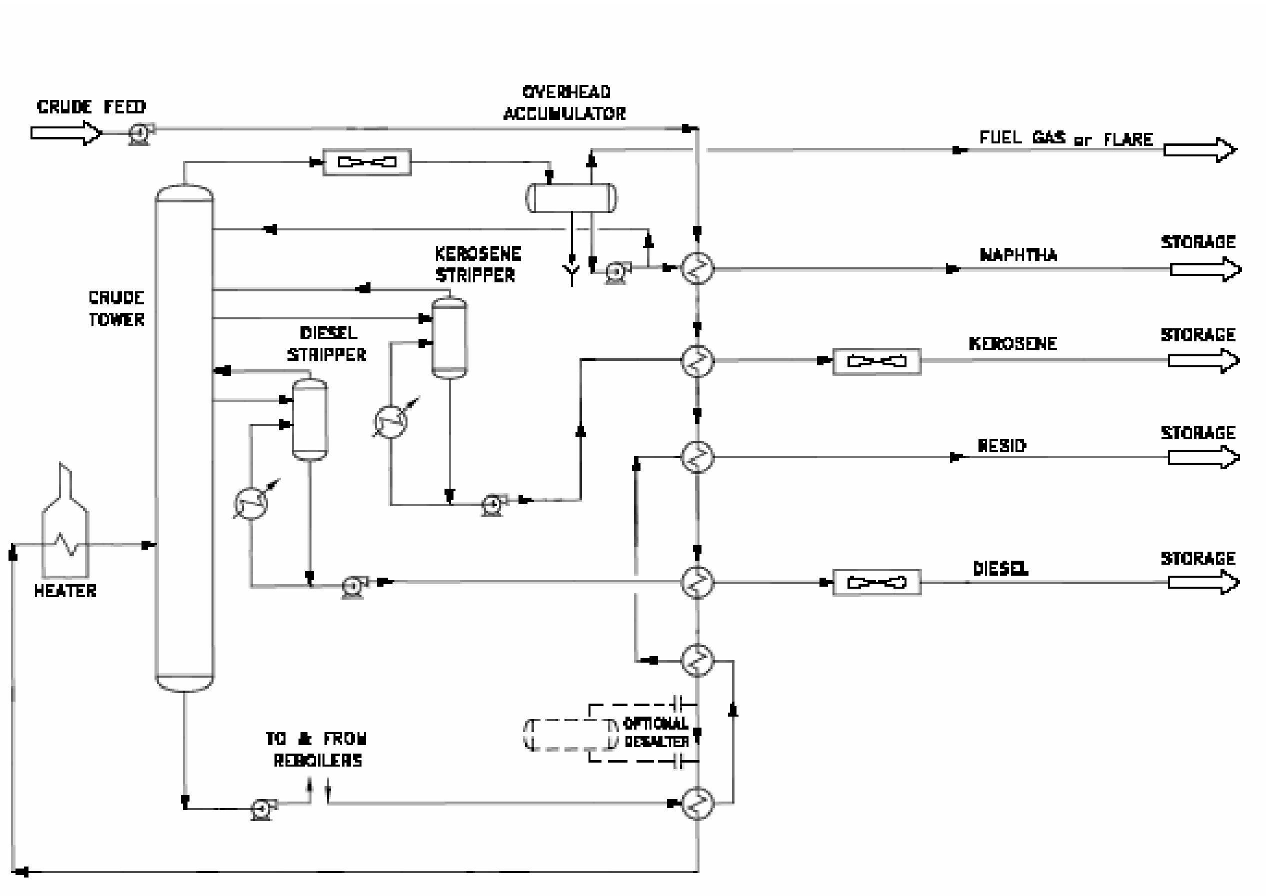
The products will be furnished at the edge of the skid at the following pressures and temperatures:

<u>Naphtha Product</u>: a minimum of 50 feet (15 meters) of head and a maximum temperature of 20 ^{o}F (6.7 ^{o}C) above ambient temperature, or 100 ^{o}F (38 ^{o}C), whichever is higher.

<u>Kerosene</u>: a minimum of 50 feet (15 meters) of head and a maximum temperature of 100 ^{o}F (38 ^{o}C).

<u>Diesel</u>: a minimum of 50 feet (15 meters) of head and a maximum temperature of 125 ^{o}F (52 ^{o}C).

<u>Reduced Crude (#6 Fuel Oil)</u>: a minimum of 50 feet (15 meters) of head and a maximum temperature of 250 ^{o}F (121 ^{o}C).



Codes and Standards

The following prevailing standards of United States engineering design and codes are adhered to in the processing, layout and selection of the various component parts used in the fabrication and assembly of this plant:

- ASME Code Section VIII, Division 1, Pressure Vessels and Heat Exchangers
- ANSI B31.3 Petroleum Refinery Piping
- FM Requirements for Burner Control
- API-RP520, Parts I and II, Design and Installation of Pressure Relieving Systems in Refineries
- API-500A Classification of Areas for Electrical Equipment in Petroleum Refineries (Class 1, Group D, Division 2) on the process end of the skid. A firewall separates the process area from the MCC/control room. A seal is placed in all conduits that pass through the firewall. The heater is located at least 50 feet from the other process equipment and control room.

All process vessels are designed and fabricated in accordance with the ASME Code, Section VIII, Division 1. The tower and strippers, with associated trays, are 316 stainless steel. Fabrication shops for the vessels are tested and certified by ASME, insurance companies and other regulatory agencies to perform fabrication in accordance with the ASME Code, Section VIII, Division 1. These shops are provided with a certificate having a certificate number and they are audited and re-certified every three years. Copies of the shop's certificate are available after a purchase order has been issued for the coded vessels.

The fabrication shops must use certified welders who are tested and certified in accordance with the ASME Code, Section IX.

Pressure gauges are calibrated annually in accordance with a dead weight tester.

Certified mill test reports on materials used on ASME Code vessels are provided and shipped with each vessel for the buyer's and customs use.

Sufficient surge capacity is provided in all vessels to assure stable control and allow corrective action to be taken in the event of a process upset or equipment failure. Sufficient elevation is provided for all vessels to assure adequate suction head at low liquid level for pumps.

The heater is a horizontal cabin-type with a convection section. Certified mill test reports on materials used to build the heater are provided and shipped with the heater for the buyer's and customs use. The heater is built in accordance with the following codes:

- Coil: ASME Section I
- Tubes: ASTM A-106 Grade B
- Fittings: ANSI B16.9
- Flanges: ANSI B16.5
- Burner: FM Requirements

All piping and valves required within the process battery limits are provided, fabricated and installed to the maximum practical extent. Piping design is according to ANSI B31.3. All process piping (2" and smaller) is 316 stainless steel tubing using tube bends, Swagelok fittings and a minimum of welds. Piping larger than 2" is A-106, Grade B seamless.

Special Services

Our standard plant includes furnishing the following:

- Three (3) sets of job books containing vendor drawings, data, spare parts lists and equipment operating manuals.
- Three (3) sets of drawings including process flow diagram (PFD), piping and instrumentation diagrams (P&IDs), equipment layout drawings, piping plans, electrical schematics, equipment specifications and data sheets.
- Three (3) sets of plant operating manuals consisting of the recommended start-up, operating and shutdown procedures.
- One (1) year supply of manufacturer's recommended spare parts.
- Four (4) weeks of a start-up engineer's time to assist in plant erection and training of buyer's operators (travel and per diem expenses extra).

Equipment and Services Excluded

The following equipment and services are excluded from a Val Verde standard plant and will be furnished only on an optional adder basis. These extras include:

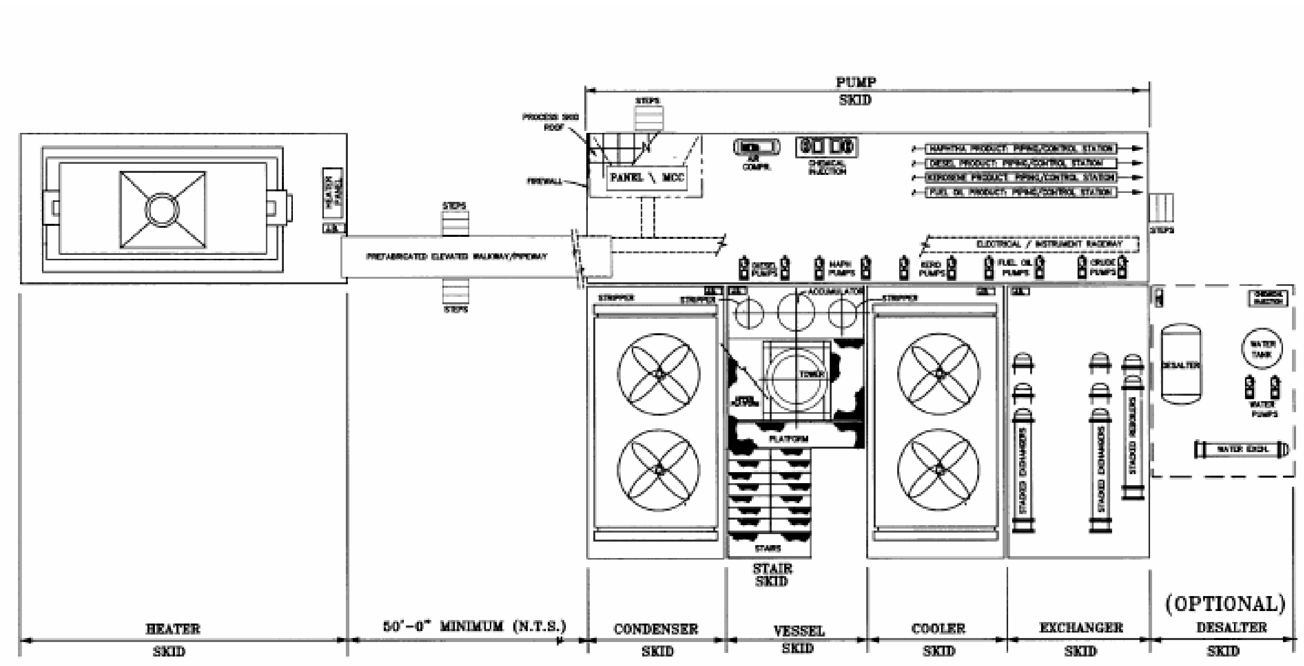
- all permits and permitting costs i.e. building, environmental, operating, etc.,
- sales tax, use tax, duties, customs fees, or other taxes, if applicable,
- freight beyond the Port of Houston, Texas (quoted price is FAS Port of Houston),
- land acquisition,
- site grading, tank berms and landscaping,
- facility roads and paving,
- main office or other buildings,
- required utilities (such as potable water, fire protection, natural gas, electrical power, telephone, sewer, etc.),
- concrete foundations for the equipment,
- unloading and erection of the plant at the site,
- crude feed and product storage tanks,
- truck or rail load/unload racks,
- interconnecting piping (and associated pipe supports) between the plant and the storage tanks,
- field (off-skid) electrical and controls wiring, etc., and
- travel and living expenses for the start-up engineer.

Equipment Provided

This plant consists of process skids (exchanger skid, cooler skid, vessel skid, stair skid, condenser skid, pump skid and heater skid) which are assembled in one of our fabrication shops (either in Bakersfield, California or Houston, Texas). After testing, the skids are disconnected, export crated and shipped FAS Port of Houston.

The pump skid is divided into a process area and a MCC/control room. The sides and top of the MCC/control room section are separated from the remainder of the pump skid by a firewall. The pump skid includes crude pumps, naphtha pumps, diesel pumps and kerosene pumps along with control stations for each product, the air compressor and chemical injection equipment.

Each skid includes all associated piping, valves, insulation, electrical and instrumentation.



PROCESS AREA PLAN VIEW

All off-site piping connections are made in a common area on one corner of the pump skid. The single point electrical connection is made in the MCC end of the pump skid. The plant uses about 220 kW of 380 volt, 50 hertz or 480 volt 60 hertz, 3-phase electricity. Other frequencies and voltages can be used if specified prior to contract execution. The plant can operate in conditions ranging from -20 ^{o}F (-29 ^{o}C) to tropical conditions.

Delivery is approximately nine (9) months after contract execution and completion of funding arrangements.

The approximate total weight of all the process skids is 150 tons (136 metric tons). The approximate area required is 40 feet (12.2 meters) wide by 100 feet (30.5 meters) long with the tallest component (the crude tower) at a height of 90 feet (27.4 meters).

Upon arrival at the plant site, the process skids and heater skid are set on individual concrete slabs. The main concrete slab for the process skids is at least 45 feet (13.7 meters) wide by 50 feet (15.2 meters) long. The concrete slab for the heater is at least 15 feet (4.5 meters) wide by 50 feet (15.2 meters) long. The concrete slabs are designed for a loading of at least 200 pounds per square foot (1000 kilograms per square meter).

Piping and electrical connections are made between the various skids. No welding or special tools are required. The off-site piping and electrical connections are then made to the pump skid. If the off-sites are complete and a suitable crane is available, the plant should be ready to start purging and begin start-up within 3 weeks of arrival.

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Plant Operation

The crude charge pump feeds crude oil from storage to the process unit. The design pumping rate is 6,000 bpd at 80 ^{0}F. The raw crude oil flows through the tube side of the heat exchanger train and is heated to 446 ^{0}F. A flow control valve controls the crude oil flow rate to the process unit. The heater is a single-pass, direct-fired cabin heater.

The crude exits the heater at approximately 680 ^{0}F and enters the flash zone of the crude tower. A temperature controller maintains the heater outlet temperature set point by adjusting the flow of the fuel to the burners thereby increasing or decreasing the firing rate of the heater.

The two-phase stream enters the flash zone of the Crude Tower. The residuum is the liquid part of this two-phase stream and flows to the bottom of the tower. The vapor part of the stream flows upward through the tower producing the remaining diesel, kerosene and naphtha products. The diesel and kerosene is fractionated as a liquid from the crude through vaporization and condensation based on the boiling range of the different products. The trays in the tower facilitate this fractionation or separation process. The naphtha, the lightest of the products, exits the top of the tower as a vapor. A reflux of liquid naphtha through a temperature control valve is used to maintain the 176 ^{0}F temperature at the top of the tower.

The tower bottoms pump moves the 669 ^{0}F residuum (also called reduced crude or #6 fuel oil) from the bottom of the tower through the Crude/Resid Exchangers and the Air Cooler thereby cooling the stream to a final temperature of 200 ^{0}F. The residuum level in the bottom of the tower is controlled by a level control valve. A small slip stream of hot residuum is pumped through the tube side of the Stripper Reboilers for re-boiling Diesel and Kerosene.

Diesel is drawn from the tower into the diesel stripper at 553 ^{0}F. The vessel is re-boiled to remove or strip light ends from the diesel to increase the flash point of the diesel. These light ends are returned to the tower. The remaining diesel is pumped from the bottom of the stripper through the Crude/Diesel Exchanger and Air Cooler to storage at 150 ^{0}F. A level-control valve controls the level in the diesel stripper.

Kerosene is drawn from the tower through a level control valve into the kerosene stripper. A reboiler provides heat to strip the light ends from the kerosene product. The light ends are returned to the tower. The kerosene is pumped from the stripper through the kerosene/crude exchanger and air cooler to storage at 130 ^{0}F. Flow is controlled by a flow control valve.

The naphtha vapor from the top of the tower is cooled to 130 ^{0}F as it flows through the Overhead Condenser into the Reflux Accumulator. Excess vapor is routed to the heater and used as fuel. Naphtha is pumped from the accumulator to the tower as reflux and to storage.

A minimal volume of water is produced based on the water content of the crude oil. This water accumulates in the water boot at the bottom of the accumulator and is automatically drained using an interface level controller. The water flows to storage.

A computer is not required for operation of this plant. The plant is operated with the following controls:

- The crude feed pump is a rotary positive displacement pump. The rate is controlled by manually setting a local control valve and reading the flow rate directly from a chart.
- An automatic temperature controller in the control panel controls the heater outlet temperature.
- The kerosene side draw product is controlled by an automatic temperature controller in the control panel that controls the temperature of the kerosene side draw by controlling the flow rate.
- The diesel side draw product is controlled by an automatic temperature controller in the control panel that controls the temperature of the diesel side draw by controlling the flow rate.
- An automatic temperature controller controls the tower top temperature by controlling the reflux flow rate.
- An automatic temperature controller in the control panel controls the diesel reboiler temperature.
- An automatic level controller controls the tower bottoms level by varying the flow rate of the bottoms pump.
- An automatic level controller controls the stripper bottoms level by varying the flow rate of the diesel/kerosene pumps.
- An automatic level controller controls the naphtha accumulator level by varying the flow rate of the naphtha pump.
- For sub-zero weather, the air cooler temperature is controlled manually by opening and closing recirculation shutters.

Environmental Impact

The Val Verde HI-TEC Model 100-300 topping plant will not make a significant contribution of air contamination to the atmosphere. Fugitive emissions are minimal due to the small number of flanged connections and pumps. Since these plant use air cooling, the only other effects on the local environment are the products of combustion exhausted into the air by the plant heater and the water that is brought in with the crude oil.

The plant would not be characterized by the United States Environmental Protection Agency (US EPA) as a major source as defined in 40 CFR 70.2 of the Code of Federal Regulations. The plant would be eligible for permit exemptions under Federal and State Regulations, even for severe non-attainment locations.

Our emissions estimates are believed to be upper bound values based on the conservative application of emissions factors found in EPA AP-42 and other accepted procedures for calculating air emissions.

The estimated air emissions from the heater are based on each barrel (or ton) of crude processed as follows:

- Water Vapor: 4.625 lbs/bbl (15.5 kg/metric ton)
- CO_2: 13.68 lbs/bbl (45.92 kg/metric ton)
- NO_x: 57.34 lbs/bbl (192.5 kg/metric ton)
- SOx: 0.009 lbs/bbl (0.03 kg/metric ton) per $1/10^{th}$ of 1% sulfur in the fuel

For each $1/10^{th}$ of 1% of water in the crude feed, one barrel of distilled water will be produced for each 1000 barrels of crude processed (1 kg per metric ton). Since the water is in equilibrium with the distillate, the water may contain up to 500 mg per liter of total organic carbon (TOC).

If a desalter is used, depending on the amount of salt in the crude, from 30 to 130 gallons per hour of brine water is discharged per 1000 barrels of crude processed (from 0.9 to 4 liters per hour for each metric ton per day).