



# **HI-TEC MODEL 10-30 TOPPING PLANT**

**600 BPD THROUGHPUT  
30,000 METRIC TON PER YEAR THROUGHPUT**

## **Technical Description**





## **Introductory Information**

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

The basic crude oil atmospheric distillation unit (ADU) produces LSR, naphtha, diesel and residuum. Additional processing units can be supplied by Val Verde that are capable of producing specification high-octane motor fuel, commercial jet fuel, kerosene, winter and summer 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 basic, small ADU plants:

- can be set up and be in operation within several days after arrival at a fully-prepared and completed site,
- allow a single operator to restart the plant from a cold start in less than one hour 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, steam, instrument air or external fuel supply.

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 arctic weather, and
- portable laboratory and control buildings with supplies.



## **HI-TEC Topping Plant**

### **Summary**

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 following data is specifically for the HI-TEC 10-30, which is a 600 bpd (30,000 metric tons per year) plant. Since our HI-TEC models have a turndown capability of 3 to 1, the 10-30 implies that this plant can operate at a rate of 10,000 to 30,000 metric tons per year (200 to 600 bpd).

The Val Verde HI-TEC Model 10-30 topping plant is a modularized, highly portable topping plant capable of processing 600 barrels per day of a wide range of crude oil and produces naphtha, diesel and fuel oil. The plant can be set up within several days after arrival at a completed plant site and can be operational within a week 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 side draw temperature, diesel reboiler temperature, the level of the tower bottoms, diesel stripper level and the naphtha and water levels in the naphtha accumulator.

The tower and stripper are made of 316 stainless steel and the heater tubes are 9% chrome. The piping (2” and smaller) is 316 stainless steel tubing with bends and Swagelok fittings having no welds. The naphtha pump is a “canned” pump having no seals and the feed pump is a stainless steel lobe positive displacement pump that turns at only 360 rpm.

### **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 600 barrels per day of 35° to 41° API crude and the products from the plant are naphtha, diesel 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 naphtha depends on the initial TBP cut point of the diesel being produced at the time. A selectable ending TBP cut point of 300 °F (149 °C) to 400 °F (205 °C) can be produced. The octane of the naphtha depends on the characteristics of the crude, the ending TBP cut point of the naphtha and the vapor pressure. The quantity of additives required to raise the octane of the naphtha depends on the desired octane for the motor gasoline and the susceptibility of the naphtha to the additive used.



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

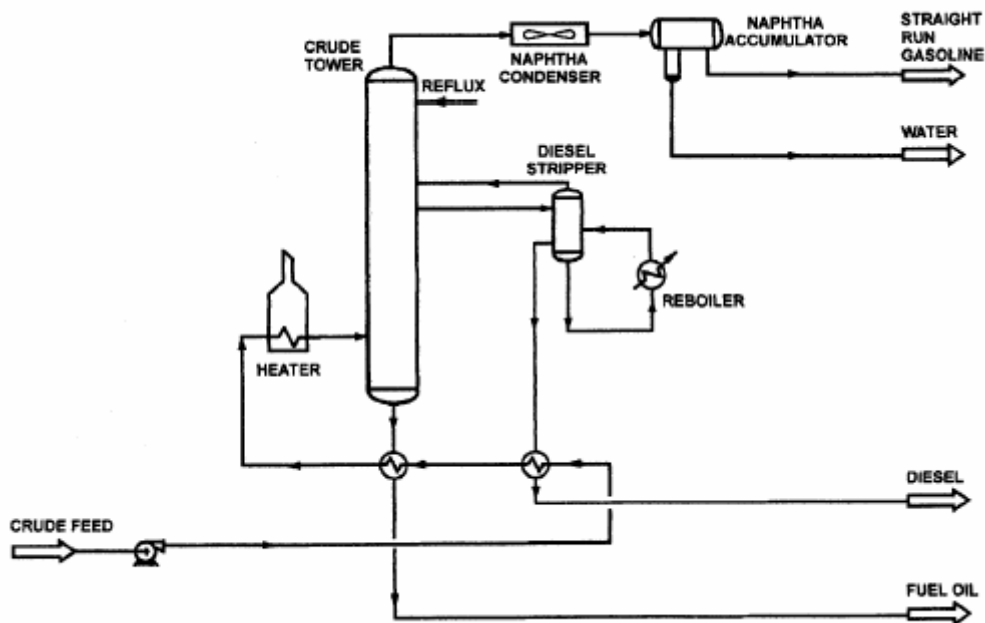
Reduced crude is the bottom of the barrel with a minimum flash point of 150 °F (66 °C) and is normally used as a #6 fuel oil.

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

Naphtha Product: a minimum of 50 feet (15 meters) of head and a maximum temperature of 20 °F (6.7 °C) above ambient temperature, or 100 °F (38 °C), whichever is higher.

Diesel: a minimum of 50 feet (15 meters) of head and a maximum temperature of 125 °F (52 °C).

Reduced Crude: a minimum of 50 feet (15 meters) of head and a maximum temperature of 250 °F (121 °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 end of the skid from the control room and heater end of the skid. A seal is placed in all conduits that pass through the firewall. The heater end of the skid is unclassified.

All process vessels are designed and fabricated in accordance with the ASME Code, Section VIII, Division 1. The tower and stripper, 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 SA 335 P9 (9 chrome)
- Fittings: ASTM & ASME SA 234 WP9
- Flanges: SA 182 F9
- 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.
- Five days 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:

- All permits and permitting costs i.e. building, environmental, operating, etc.
- Sales tax, use tax, duties, customs fees, or other taxes, if applicable
- Freight and hauling the plant from the port to the site (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.
- Travel and living expenses for the start-up engineer



## Equipment Provided

This plant consists of a process skid and a tower 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.

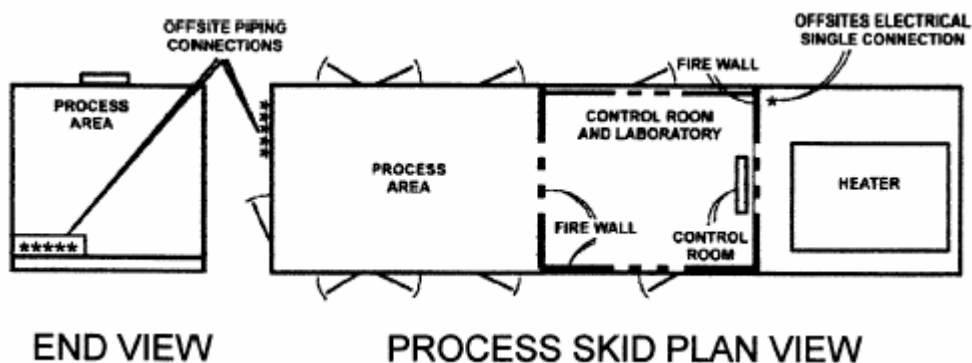
The process skid is divided into a heater section, control room/laboratory section and a process section. The sides and top of the control room/laboratory section are separated from the heater and process sections by a firewall. A firewall is also on top of the heater section. The process area is also enclosed by a firewall.

The process section includes a feed pump, naphtha pump, diesel/crude exchanger, reduced crude/crude exchanger, naphtha accumulator, and all associated piping, valves, insulation, electrical and instrumentation.

All off-site piping connections are made about 1'6" (0.5 meters) above the concrete foundation and on one corner of the process skid. The single point electrical connection is made in the heater end of the process skid. The plant uses about 22 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 arctic conditions of -58 °F (-50 °C) to tropical conditions.

Delivery is approximately six (6) months after contract execution and completion of funding arrangements.

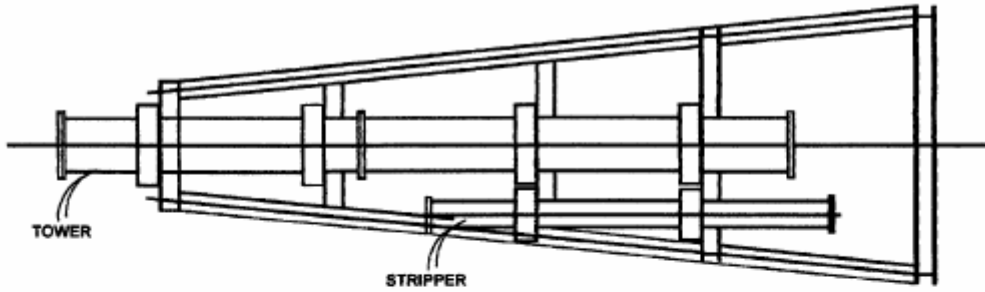
The process skid weighs less than 33 tons (30 metric tons) and is 10'-6" (3.2 meters) wide by 45' (13.7 meters) long with a center height of 14' (4.3 meters) and a side height of 11'-9" (3.6 meters). The following sketch shows views of the process skid.



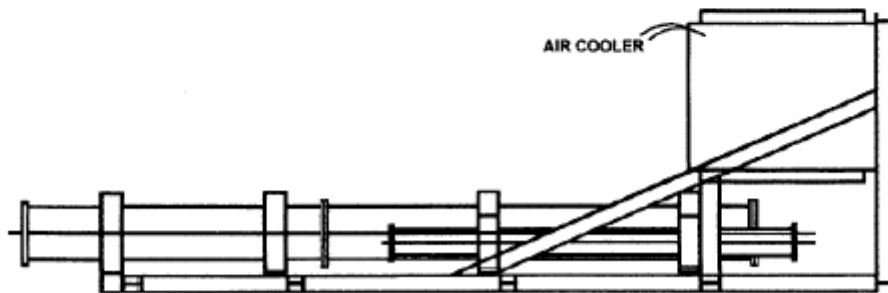


The tower skid includes the tower, stripper and overhead air cooler with associated piping, electrical, insulation and instrumentation. The tower and associated equipment is supported by steel beams and is shipped on its side.

The tower skid weighs less than 16.5 tons (15 metric tons) and is 10'-6" (3.2 meters) wide by 11'-9" (3.6 meters) high by 34'-6" (10.5 meters) long. The following sketches show views of the tower skid.



TOWER SKID PLAN VIEW: SHIPPING POSITION

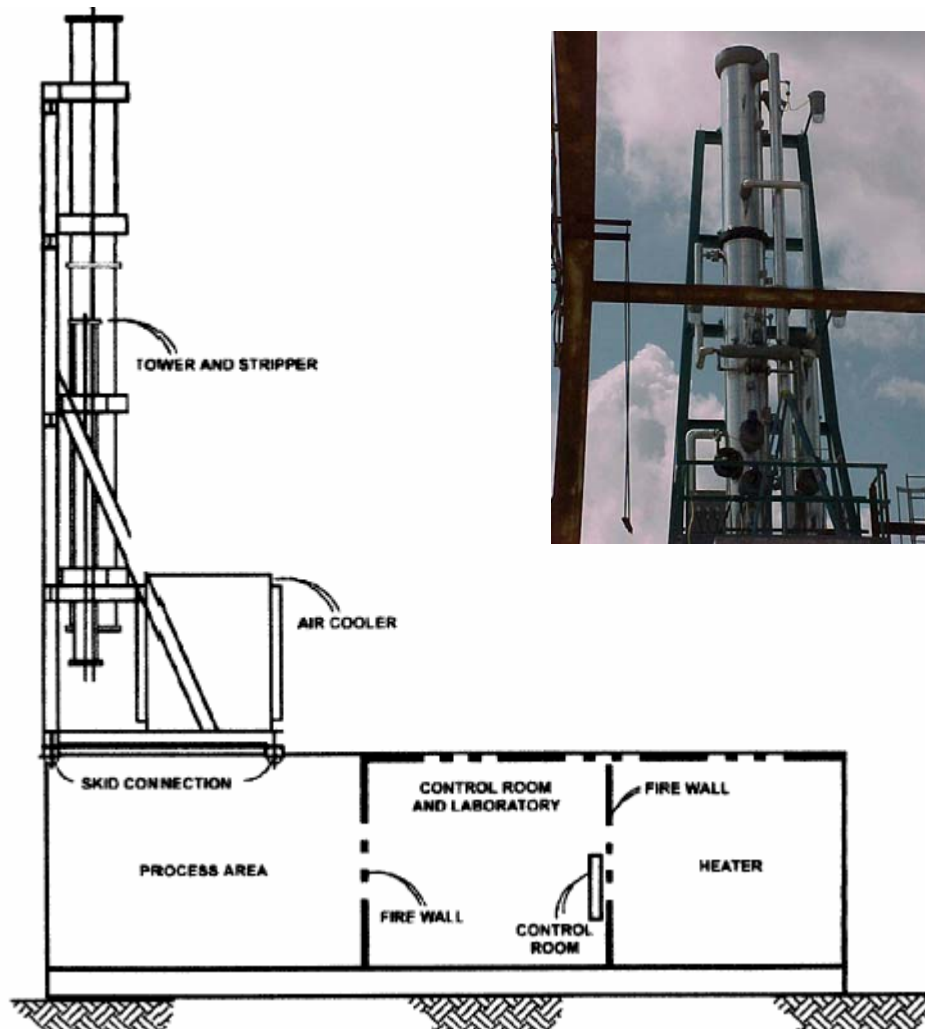


TOWER SKID SIDE VIEW: SHIPPING POSITION



Upon arrival at the plant site, the process skid is set on a concrete slab at least 11' (3.4 meters) wide by 46' (14 meters) long and is designed for a loading of at least 210 pounds per square foot (1033 kilograms per square meter).

The tower skid is then lifted and attached on top of the process skid as shown below. Piping and electrical connections are made between the tower skid and process skid. No welding or special tools are required. The off-site piping and electrical connections are then made to the process 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 days of arrival.





## Plant Operation

Cold crude oil from off-site storage is received at the plant battery limits and is pumped by the crude charge pump on flow control. The crude oil exchanges heat with the diesel product and reduced crude product streams.

The crude then flows to the crude heater where it is further heated and partially vaporized. The crude heater is a direct-fired heater, designed to burn off gas, natural gas or liquid fuel. Constant heater outlet temperature is maintained automatically by controlling the fuel flow to the heater.

The partially vaporized crude oil from the crude heater flows to the flash zone of the atmospheric tower where the vapor and liquid separate. The vapor flows up the tower where it is cooled and partially condensed by reflux to form the side stream product. The liquid joins with the overflash liquid from the first tray above the flash zone and flows to the reduced crude stripping section in the bottom of the atmospheric tower.

The overhead vapor from the atmospheric tower is cooled and partially condensed in the overhead condenser and flows to the overhead accumulator where liquid unstabilized naphtha, liquid water and uncondensed gas separate. Liquid water is automatically withdrawn from a boot on the overhead accumulator and flows to the skid edge. A portion of the liquid naphtha from the accumulator is returned to the top of the atmospheric tower as reflux to maintain the overhead vapor at a constant temperature and the remainder flows to the skid edge. Uncondensed gas from the accumulator flow on back-pressure control to be used as supplemental fuel for the crude heater.

Unstripped diesel product flows from its side draw tray on the atmospheric tower to its stripper on temperature control. The diesel product is stripped with reboiled vapor to control the flash point. Product flows from the bottom of the stripper on level control, is partially cooled by exchanging heat with crude and then flows to the skid edge.

Reduced crude product (normally #6 fuel oil) flows from the bottom of the atmospheric tower on level control through the reboiler, as required, and is then further cooled by the reduced crude/crude exchangers before flowing to the skid edge.

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 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 pump.
- 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 10-30 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<sub>2</sub>: 13.68 lbs/bbl (45.92 kg/metric ton)
- NO<sub>x</sub>: 57.34 lbs/bbl (192.5 kg/metric ton)
- SO<sub>x</sub>: 0.009 lbs/bbl (0.03 kg/metric ton) per 1/10<sup>th</sup> of 1% sulfur in the fuel

For each 1/10<sup>th</sup> 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).