Crude unit preflash drums and columns

Preflash drums and preflash columns have a significant effect on crude charge hydraulics. The reasons for using preflash equipment are discussed, including general design considerations and problems that are created if they are designed incorrectly

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Some crude units have preflash drums or preflash columns (preflash drums/columns) between the desalters and atmospheric column (Figures 1 & 2), while others do not. Preflash drums and columns are inherently large diameter and tall (or long). They are also high capital cost and should only be used where necessary.

Preflash Drum or Column

Preflash drums or columns are used to manage crude hydraulics during grass roots crude unit designs and to increase crude capacity when revamping. The installed cost difference between the drum and column alone is relatively small. However, adding the cost of the columns' peripheral equipment including the condensing system, overhead drum and pumps raises investment cost considerably. However, when existing atmospheric column condensers, drums and overhead pumps are major limits to raising throughput or prevent the processing of lighter crude oils, installing a column and condensing system can be more cost-effective than modifying an existing atmospheric column overhead system. This work can also be completed before the turnaround to reduce downtime.

Drums or columns flash a portion of the crude and water between the desalter and crude charge heater. The amount of hydrocarbon vapourised depends on the temperature and pressure in the drum or column. Two-phase feed is created when the operating pressure is reduced upstream of the drum or column. A drum is a single-stage flash that separates vapour from the flashed crude liquid and it must retain any foam that is created. Flashed crude leaves the bottom of the drum and the foam-free vapour stream should exit the top. The drum vapour stream has a wide boiling range and must be fed to the atmospheric column for fractionation. Flashed crude liquid is pumped through additional crude

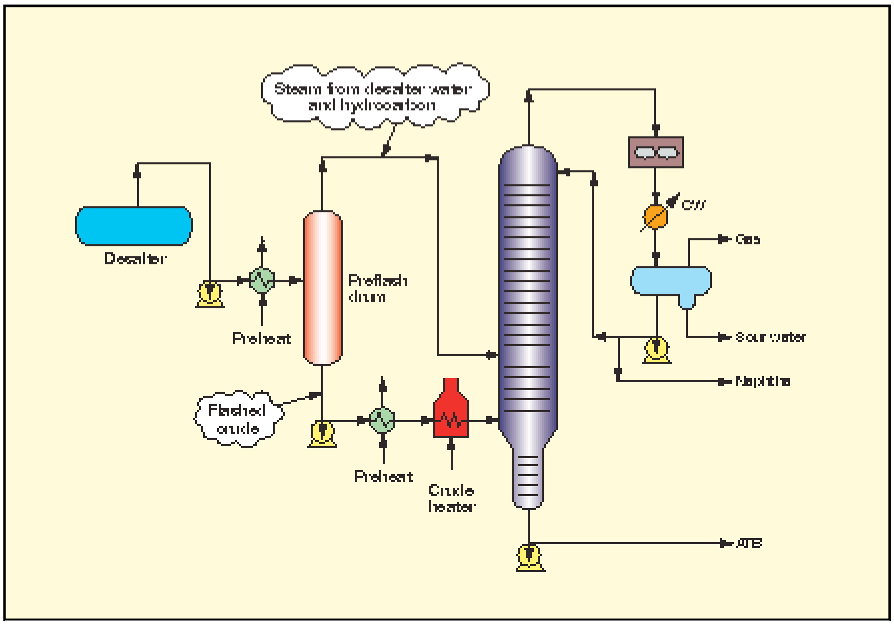

Figure 1 *Preflash drum*

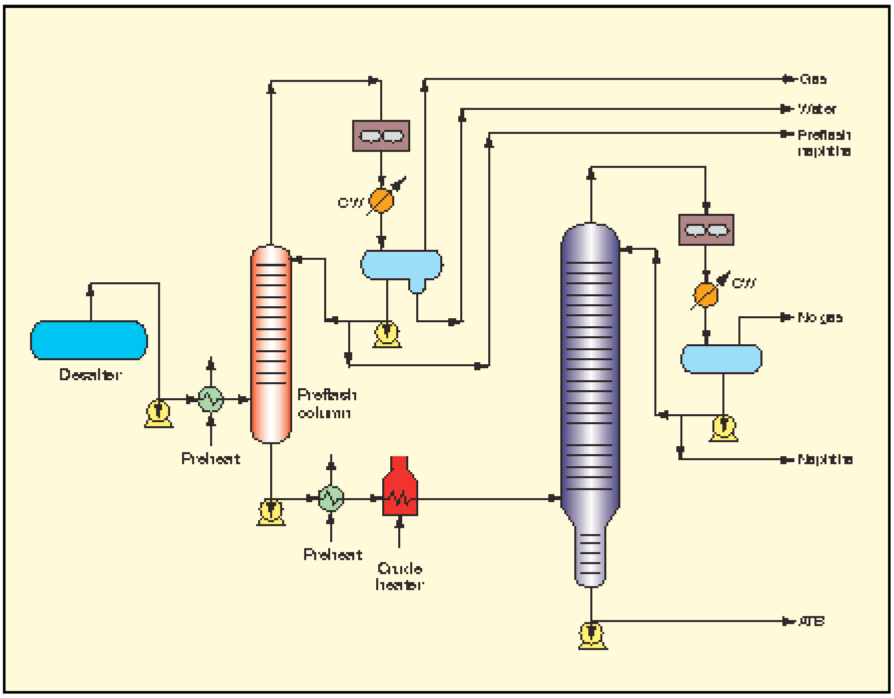

Figure 2 *Preflash column*

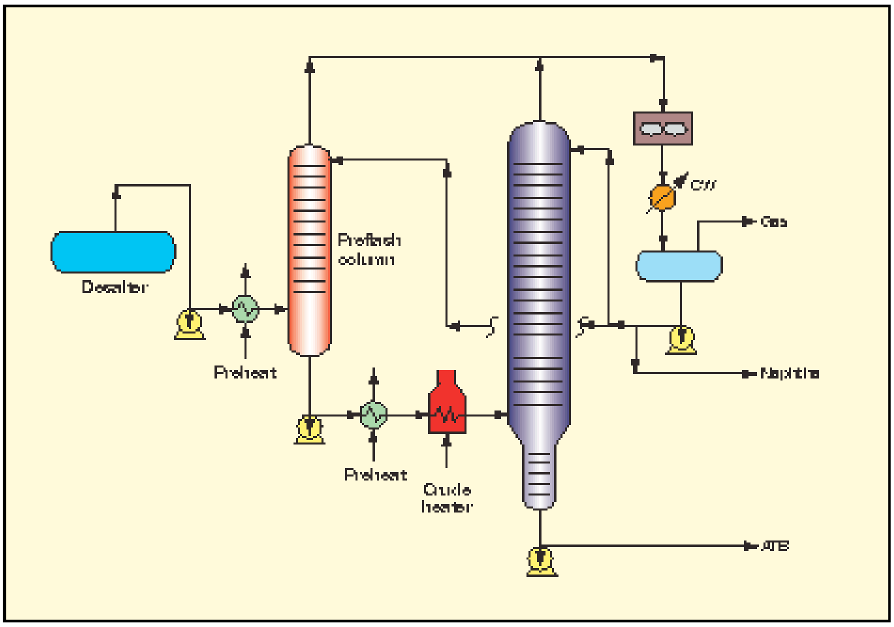

Figure 3 *Preflash column – common condenser system*

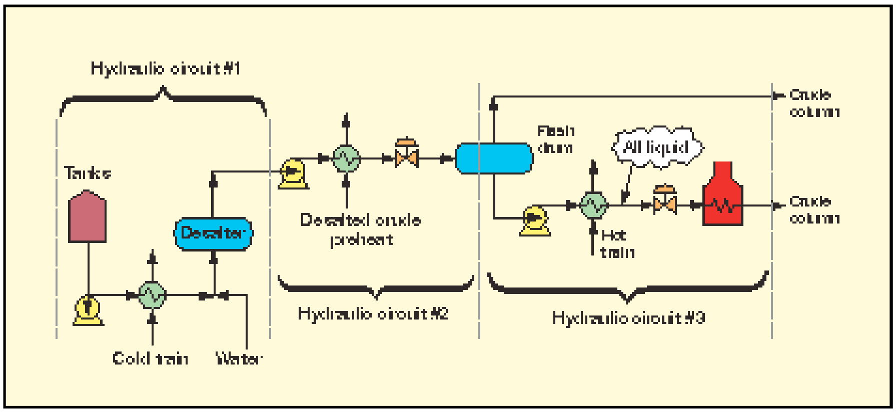

Figure 4 *Crude unit hydraulics using preflash drum*

preheat exchangers or directly to the atmospheric crude heater.

Preflash columns use trays and reflux to fractionate overhead product from side-draw or bottom product streams. The column bottom section is similar to the drum in that it must retain the foam to prevent the rising vapour from carrying foam (flashed crude) into the trays. Trays will not break foam! Preflash columns typically have their own overhead condensers, but there are many possible flow schemes including those that exchange overhead vapour with crude to recover low-level heat or others that utilise atmospheric column pumparounds or overhead condenser systems to provide reflux. One flow scheme uses the atmospheric column overhead system for condensing the preflash column overhead vapour into product and reflux (Figure 3). The two columns share a common overhead system. This design significantly reduces investment by eliminating the preflash column overhead system, but the existing atmospheric column condensers, drum and pumps must have sufficient capacity for both columns' overhead streams.

Crude hydraulics and preflash drum/column

Crude hydraulics are one of the most important considerations during the design of grass roots units or when revamping. Crude must be heated from tank temperature to atmospheric crude heater outlet temperature to vapourise the oil and this equipment generates pressure drop. The amount of pressure drop depends on the velocity through the equipment. High velocity helps prevent fouling and controls the rate of coke formation in the heater. Existing equipment maximum allowable working pressures (MAWP) are major constraints to processing more crude oil when revamping and new equipment MAWP selection is a major investment decision when building a new crude unit.

Initially, whole crude oil is pumped through the cold train of the exchanger network to the desalters. Desalter operating pressure must be high enough to keep the oil and water from vapourising at the temperature needed for efficient desalting. Desalted crude (and entrained water) is then pumped through the hot train and atmospheric column heater, if there is no preflash drum or column. The system has two major hydraulic circuits: raw crude-to-desalters and desalters-through-crude heater. Operating pressure at the heater pass inlet valves must be kept high enough to prevent the whole crude and entrained water from vapourising. Operating with two-phase fluid at the heater pass control valves can create significant heater pass flow imbalances causing rapid coking, or in the worst case, a tube rupture.

Heater inlet temperature is an important design consideration. Revamps often need to increase heat recovery to minimise heater duty and heater modifications. When designing grass roots crude units, capital investment largely determines energy recovery. As heater inlet temperature increases, operating pressure must also increase to prevent vapourisation. Once heater inlet temperature and minimum pressures are set, overall crude hydraulics can be evaluated. In some grass roots crude units, the heater inlet pressure needs to be 500psig (34.5barg) to prevent vapourisation of the whole crude and entrained desalter water. Achieving this pressure requires desalted crude booster pump discharge pressure of 800psig (55.2barg) to maintain proper exchanger tube velocities of 8–12ft/sec (2.4–3.6m/s). When designing grass root crude units, it can be more cost-effective to use preflash drums to manage crude charge hydraulics and avoid excessive pump discharge pressures and high equipment design pressures. When revamping existing equipment, MAWP will constrain pump pressures.

Preflash drums and columns are located downstream from the desalters, permitting crude hydraulics to be separated into three systems: tank-to-desalters, desalters-to-preflash drum/column and preflash drum/column-through-charge heater (Figure 4). Preflash drum/columns flash a portion of the whole crude and essentially all the entrained water from the desalter. Therefore, the operating pressure needed to prevent flashing at the heater pass inlet valves is lower. This is an important consideration when designing new units because it allows the flash crude pump discharge pressure to be reduced to more reasonable levels, especially when targeted heater inlet

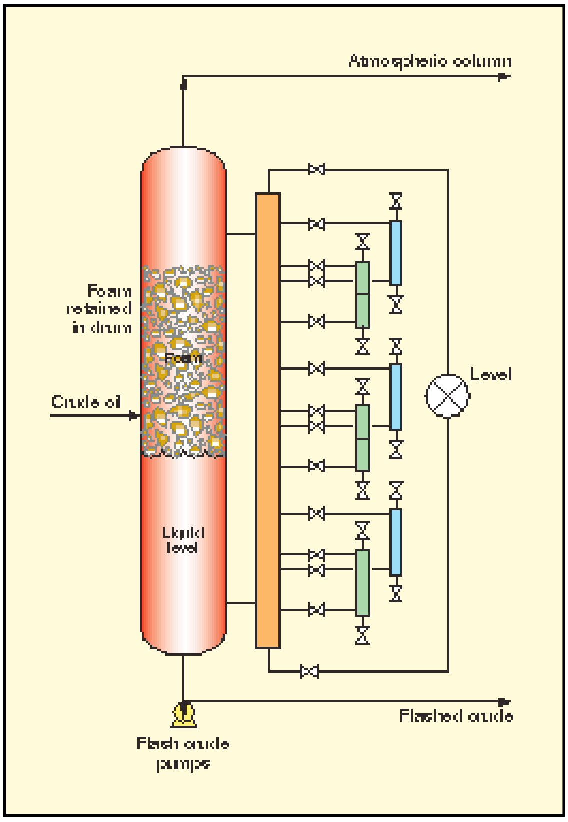

Figure 5 *Preflash drum- retaining foam*

temperatures are high [288–315°C (550–600°F)]. During revamps, crude hydraulics and maintaining high exchanger tube velocities are competing objectives. Exchanger velocities are often lowered, resulting in rapid fouling. By splitting the crude charge system into three circuits and installing one new pump, exchanger velocities can often be maintained or increased.

Preflash drums versus columns

Major equipment capacity downstream from the preflash drum/column will determine the amount of vapourisation needed when revamping. Increasing drum or column inlet temperature generates more vapour, which decreases the required heater inlet pressure to prevent vapourisation, reduces the amount of flashed crude flow rate through downstream equipment, and reduces crude heater pressure drop.

Preflash drums reduce downstream exchanger network and heater flow rates, but the atmospheric column and its overhead system needs sufficient capacity to process the vapour. Preflash columns reduce vapour flow rate through the atmospheric column. If it has its own overhead system, it also reduces atmospheric column condenser, drum and overhead pump loads. Selecting preflash drum operating pressure carefully can reduce gas compressor load or the compressor can be eliminated if the operating pressure is high enough to route the drum vapour directly to treating.

Drum and column sizing considerations

Drum or column sizing depends largely on flashed crude liquid rate and its composition. Desalted crude and entrained water are flashed when the operating pressure is reduced across the upstream control valve. Foam is created. As long as the foam is retained inside the drum (Figure 5) or in the bottom of the column, it typically causes few problems other than difficulty with level measurements. The most important sizing criterion for the drum or column bottom section is the flashed crude superficial velocity (Figure 6). It must be low enough to allow the foam to be retained inside the drum or in the bottom of the column. For a given crude or blend, the height of foam depends on the liquid superficial velocity. As long as there is sufficient height above the clear liquid level, operation is relatively smooth. The smaller the cross-sectional area for flashed crude, the higher the foam level inside. If the disengaging height above the clear liquid level is small, then the superficial velocity must be low. Conversely, if the available height to retain the foam is high, then higher superficial velocity can be tolerated before foam is no longer retained.

Ideally, preflash drums should be horizontal vessels because the cross-sectional area for flashed crude flow is larger. However, when revamping there is often insufficient plot space for a horizontal vessel. Thus, vertical drums are common. In these instances, the drum cross-sectional area will be smaller than a horizontal vessel, thereby requiring more vessel height to retain the foam. Preflash columns are always vertical vessels. The bottom section, like the drum, must be sized with sufficient cross-sectional area and height to keep the foam from reaching the fractionation trays.

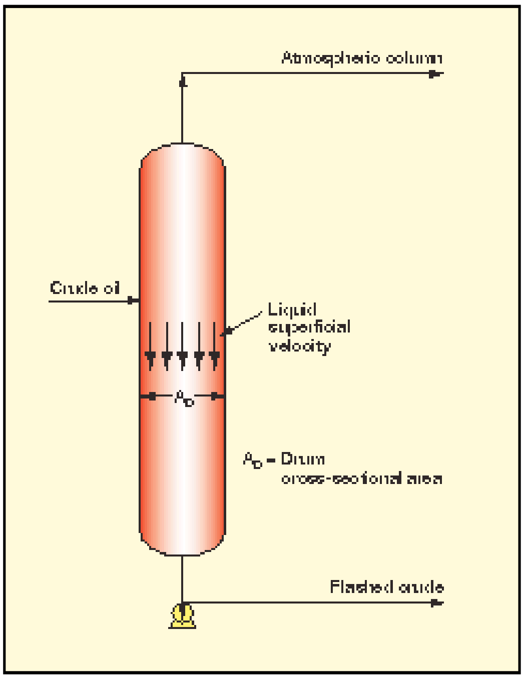

Figure 6 *Liquid superficial velocity – critical design parameter*

Undersized preflash drums

Ideally, preflash drum vapour should be fed to the atmospheric column where the composition matches the endpoint of the drum vapour. When a preflash drum is too small, foam is entrained with the drum vapour and carried into the atmospheric crude column. When this stream feeds the atmospheric column above the flash zone, all product streams below it will contain flashed crude. Flashed crude is black and has an endpoint greater than 815°C (1 500°F). Consequently, even small quantities of foam cause off-specification distillate.

Because many preflash drum are undersized and do not retain the foam, this stream is routed to atmospheric column flash zone (Figure 7). Although this eliminates off-specification distillate, it reduces atmospheric column distillate yield and raises feed rate to the vacuum unit. This occurs because foam contains flashed crude that is low temperature and has a large amount of 600ºF-minus boiling range material that vapourises at atmospheric column flash zone conditions. The heat that vapourises the entrained flashed crude comes from the condensation of atmospheric column flash zone vapour generated by the heater and the stripping section. Even when the preflash overhead stream is all vapour, it still must be heated from preflash drum temperature to flash zone temperature causing yield loss.

In one case, an 80 000bpd crude unit had 5 000bpd of flashed crude entrained with the preflash vapour, reducing total atmospheric distillate

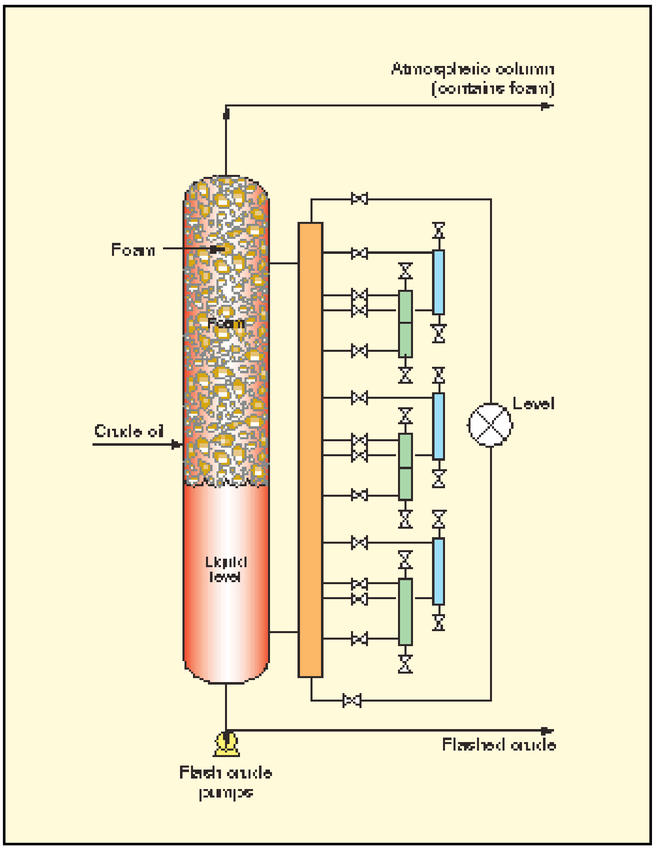

Figure 7 Preflash drum foaming

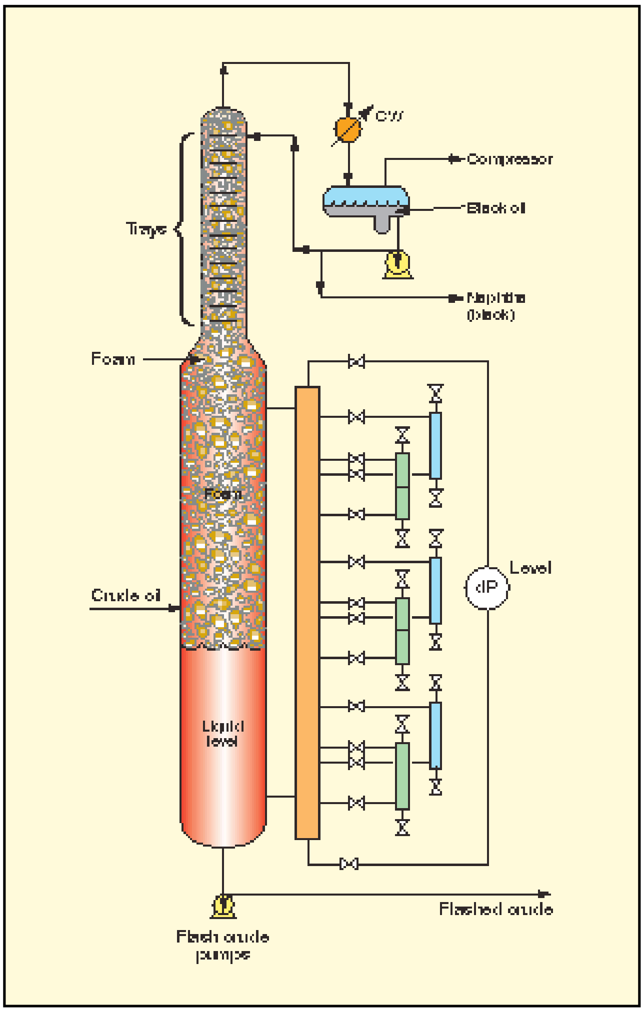

Figure 8 Column preflash foaming

yields by more than 4% on whole crude and diesel yields by more than 2%. Furthermore, vacuum unit feed rate increased, vacuum column vapour load was higher and total vacuum unit pumparound heat removal increased.

Undersized preflash columns

As with preflash drums, when the cross-sectional area of the bottom of the column is too small and available height to break the foam is inadequate, foam will reach the fractionation trays. Even if the trays are the same diameter as the bottom of the column, the trays will not break the foam. In one case, a 40ft (12m) high column of foam was created, filling the preflash column, which turned the overhead product black. Black overhead product contains contaminants and high endpoint, which creates major problems in downstream hydrotreaters and reformers (Figure 8).

Destroying foam with vortex tube clusters

Foam not retained within the preflash drum or bottom of the preflash column causes black distillate, atmospheric column distillate yield loss or black distillate product from preflash column. Vortex tube clusters (VTC) can be used to eliminate or reduce the amount of foam so that it is retained inside the vessel.

The VTC is connected to the drum's inlet nozzle. The two-phase flow is fed to the vortex tubes by a central duct or manifold that is designed to distribute the flow equally to each tube. A side opening at the top of each tube admits the stream tangentially. The phases are separated from each other by the enhanced gravitational effect generated. The gas migrates to the centre and exits through the holes at the vortex tube tops. The liquid exits via the peripheral openings at the bottom of the vortex tube.

In operation the tubes are partially immersed in the liquid, which provides an effective seal, preventing gas from blowing out of the vortex tube bottom openings. Adequate immersion is required to overcome the pressure difference generated over the vortex tubes. The liquid level is controlled in the same manner as with any conventional drum. Since there is no splashing or bubbling in the vessel and any incoming foam is destroyed in the vortex tubes, the drum or column bottoms section operates free of foam.

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