PROCESS ECOLOGY

# Emulsion Heater Treaters - Sizing Methodology

Heater treaters are used to further separate water from crude oil emulsions in cases where this cannot be achieved with normal gravity separation. Treaters are designed to break the emulsion by applying heat and retention time, causing the water droplets to coalesce and separate from the emulsion to achieve a basic sediment and water (BS&W) specification in oil. API (Ref. 1) states that most crude oils are treated to a range of 0.2% to 3.0% BS&W. Currently in Canada, crude oil to pipeline generally must contain less than 0.5 % by volume BS&W to reduce the risk of internal corrosion.

Applying heat to the emulsion lowers the viscosity of the oil, which enables more rapid settling according to Stokes law. Treating temperatures normally range from 38˚C to 70˚C (Ref. 2) to surpass the paraffin crystal melting point and approach the boiling point of water at the operating pressure. The higher the treating temperature, the easier it will be to break down the emulsion; however, a treater temperature should be selected which provides the most cost-effective method of meeting the BS&W specification. Note that treating heavy crudes may require high temperature of 150 ˚C.

If the incoming fluid has significant free water, a free water knock out drum upstream of the treater should be installed. Treaters are usually designed to break the oil and water emulsion rather than operating as a separator. However, some treaters have a free water knock out section in the vessel which is not exposed to the firetube section.

The sizing approach in this article is based on Surface Production operations (Ref. 2);there are alternative simpler approaches as laid out in API 12L - Specification for Vertical and Horizontal Emulsion Treaters based on retention volume, as well as in the Shell DEP based on the area calculated from the oil flux rate.

**Sizing Steps and Example**

The main parameters to consider when sizing the treater are the retention time and heat required. The treater should provide enough retention time for the large oil particles to coalesce and be separated from the water phase. It is typical to design the treater for 20 to 30 minutes retention time. Besides retention time, the other major factor in sizing the treater is the duty provided by the fire tubes. A method for specifying the fire tubes is as follows:

- Specify a treating temperature.
- Determine the heat input required, based on the inlet and treating temperature.
- Calculate the minimum droplet size that must be separated based on the BS&W specification (0.5% is used in this example).
- Using the settling equation (Stokes Law), develop a table of effective lengths vs standard diameters.
- Using the retention time equation, develop a table of effective lengths vs the same standard diameters considered above.
- Select a treater geometry which satisfies the larger effective length requirements calculated using the settling and retention time equations for the selected diameter.

- Finally, verify with a vendor if the selected size will allow the fire tube to deliver the required duty.

Based on the above methodology, the following example shows how a preliminary treater sizing is carried out according to Surface Production Operations, Volume 1, Third Edition (Ref. 2).

| Description | Unit | Value | Remarks |
|---|---|---|---|
| Treater Temperature | °C | 58 | |
| Oil Inlet temperature | °C | 32 | |
| Fire Tube Heat Capacity | MMBtu/h | 4.7 | Assuming 70% fire-tube efficiency |
| Oil Viscosity @58°C ($\mu_0$) | cP | 1.2 | |
| Oil Specific gravity @ 58°C | | 0.730 | |
| Water Specific gravity | | 1.04 | |
| Target BS&W ($W_c$) | Vol % | 0.5 | |
| Oil Flowrate to treater ($Q_o$) | barrels/day | 7636 | |
| Diameter of water droplet for 1% water ($d_{mi}$) | micron | 208 | $d_{mi}\% = 200\mu^{0.25}$ |
| Diameter of water droplet for 0.5% water ($d_m$) | micron | 165 | $\frac{d_m}{d_{mi}\%} = W_c^{0.33}$ |
| D.$L_{eff}$ | | 457 | **Settling Equation** $dL_{eff} = 438\frac{FQ_o\mu_o}{(\Delta SG)\,d_m^2}$ F=1 if the treater has a spreader and collector |
| $D^2l_{eff}$ (for 30min Retention Time $t_{ro}$) | | 218,171 | **Retention Time Equation** $d^2L_{eff} = \frac{Q_o(t_r)_o}{1.05}$ |

Based on the above settling and retention time equation for effective lengths ranging from 5 to 30 ft., diameters are calculated as shown in the table below.

| Effective Length (ft) | Diameter - based on Settling Equation (in.) | Diameter - based on Retention Time Equation of 30 minutes (in.) |
|---|---|---|
| 5 | 91 | 209 |
| 10 | 46 | 148 |
| 15 | 30 | 121 |
| **20** | **23** | **104** |
| 25 | 18 | 93 |
| 30 | 15 | 85 |

Based on the above table, a practical solution would be to select 20 ft. as effective length. In this case, the retention time equation results in a higher diameter for the same effective length compared to the settling equation. For 20 ft. of effective length based on the retention time of 30 minutes, the required diameter is 104 in. (8.6 ft). The total length of the vessel is the Effective Length times two (total length includes Coalescing Section + Front section that includes Fire Tube).

The final step would be to verify if the selected dimension of 8.6 ft. (diameter) X 40 ft. (length) allows installation of a fire tube providing a capacity of 4.7 mmbtu/h.

When sizing a treater, it is not possible to reach a unique solution; note that the treater geometry could be decreased by increasing the treater temperature.

Finally, it is worth noting that the sizing procedure outlined above uses generic correlations. However, some treaters are equipped with special internals to reduce the heat duty as well as help with the water-oil separation.

**References**

1.API Specification 12L Specification for Vertical and Horizontal Emulsion Treaters Fifth Edition, October 2008.

2.Surface Production Operations Volume 1 Third Edition – Design of Oil Handling Systems and Facilities, Ken Arnold and Maurice Stewart.

Contact us for more information.