Separating FACT from FICTION

John L. Furstenberg, P.E., and Kirsten Nelson, USFilter Envirex Products, USA, explain the intricacies of US standards as they apply to oil/water separators and the systems needed to keep them safe.

According to the US Environmental Protection Agency's National Emission Standards for Hazardous Pollutants (NESHAP) for benzene (EPA 40CFR61, March 1990), petroleum refineries must enclose their oil/water separators with a floating cover system or a fixed cover with a closed-vent system followed by an emission control device.

With fixed cover systems, refineries must consider possible hazards including safety devices, access, monitoring equipment, instrumentation and separator equipment. Purging, enclosure and vapour control should also be taken into consideration when designing a control and treatment system.

Ignition sources

Potential ignition sources exist in the vapour space beneath the fixed covers on oil/water separators. An explosion may result when a chemical, electrical or mechanical heat energy source generated in or around the separator brings volatile hydrocarbon vapour (a combustible material) to its flash point in the presence of oxygen (an oxidising agent).

Chemical heat energy is created when metallic separator components made from carbon steel or aluminum corrode. Hydrogen sulfide corrodes carbon steel to produce an iron sulfide scale. When the oil/water separator is taken offline, moisture evaporates, allowing the scale to dry out, creating an environment ripe for spontaneous ignition. Similarly, aluminum in contact with methylchloride forms pyrophoric aluminum alkyls, which may violently ignite when exposed to air.

Electrical heat energy originates either inside (at motors, drives and controls) or outside (static electricity or lightning) oil/water separators. Correctly sizing motor enclosures for each application and situating switchgear and motor starters far from the oil/water separator area helps minimise the risk of generating excess electrical energy. Electrical devices and controls located in the immediate vicinity of the separator should be housed in explosion proof enclosures.

Mechanical heat energy results from frictional resistance from belt or friction disc variable speed drives or improperly sized hydraulic drives on the oil/water separators. Other potential ignition sources from mechanical heat energy include mechanical devices that remove floating oils from the surface of the separators or settled solids in the bottom of the units. All equipment should be grounded.

Vapour space purging

Combustible concentration reduction (CCR) and oxygen concentration reduction (OCR) are two explosion prevention methods commonly used to control oxidising agents mixing with combustibles. Of the two, the CCR method is more sensitive to the volatile hydrocarbon vapour concentration and to the vapour's flammable range. It dilutes the vapour space with air to maintain the enclosed atmosphere at a concentration below the lower flammable limit. Sophisticated instrumentation and monitoring equipment must be used with this type of system.

Used more often than the CCR system in designing vapour space purging, the OCR system uses gas sources, other than air, to control the oxidant concentration in the vapour space to a point above the upper flammable limit. Purge gas (inert, steam or fuel) exerts a slight pressure on the system under all operating conditions and flows continuously to maintain the required level of oxygen deficiency.

Figure 1. The API separator's heavy-duty design and ability to separate and continuously remove oily solids that can plug and foul other separation equipment has made it a preferred technology in heavy oil/ high solids applications.

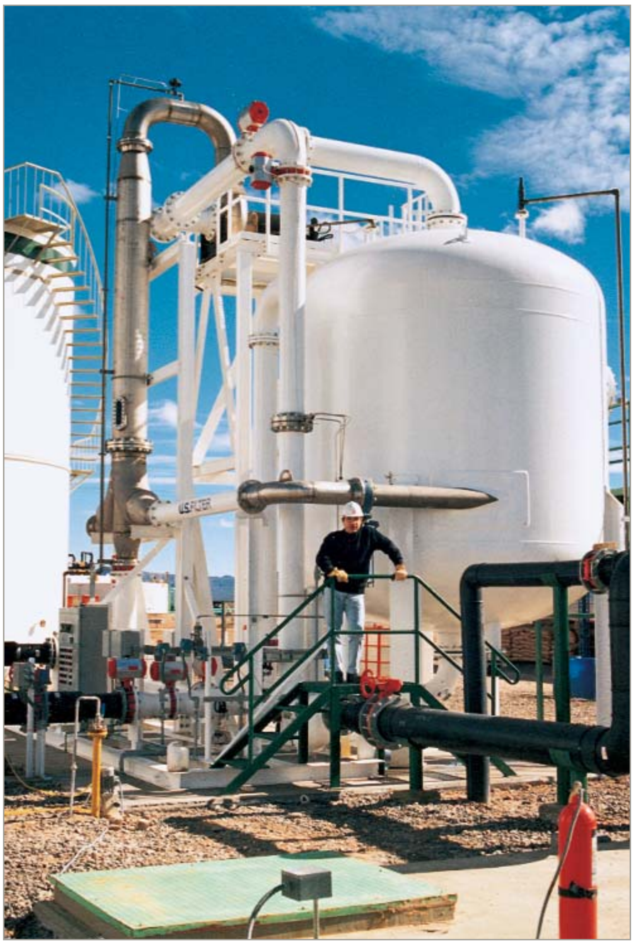

Figure 2. Tertiary produced water separation treatment methods include walnut shell, media, cartridge and activated carbon filtration.

Purge gases

Replaceable pressurised cylinders, gas generators or membrane permeation systems commonly supply inert gases, such as nitrogen, argon, helium and carbon dioxide. Nitrogen gas is the most widely accepted inert purge gas for refinery applications. Argon and helium are commercially available in gaseous or liquid form, but are not as economical to produce. Carbon dioxide is commercially available in liquid form only and being slightly acidic, it can potentially corrode separator components.

Steam is an acceptable purge gas, provided the enclosure's temperature remains above the steam's condensing temperature. The steam's condensing temperature should not exceed the design temperature limits of the enclosure or separator equipment.

Fuel gas, such as methane or natural gas, may be appropriate for vapour control systems that use a flare or incinerator. Such systems require a greater volume of gas than comparable systems that use inert gas purging. To avoid serious safety problems, the fuel gas volume must adequately dilute the vapour stream and reduce variations in vapour volume and heating value.

To feed the control device on OCR purge systems, the atmosphere within the enclosure must remain above the upper flammable limit and at 500 Pa to 1500 Pa (2 in. w.c. to 6 in. w.c.). If gas pressure falls below this range, refineries may install a downstream gas booster, such as a blower. Whenever possible, the control of the purge gas to the enclosure should exclude electrical devices that have the potential to fail during power outages, becoming an ignition source.

Pressure can significantly affect the structural integrity of the oil/water separator tank and covers. Sensing and maintaining a preset pressure within the enclosure can accommodate a variable rate of purge gas and also completely prevent air from entering the vapour space. Temperature changes, leaks, rapid atmospheric changes and separator startup affect the maximum purge gas demand. Determining peak demand is important to ensure sufficient purge gas is available and to prevent a vacuum from developing.

Cover material

Oil/water separator covers are typically made of lightweight and easy-to-maintain materials like aluminum or fiberglass reinforced plastic (FRP) instead of steel and concrete. An arched or sloped roof design discourages liquid ponding and snow accumulation, and helps direct corrosive condensate that forms on the underside of the cover toward the tank walls. A drip lip attached to the cover conveys the condensate into the tank to prevent it from concentrating and, in turn, deteriorating the separator tank.

Low profile aluminum, used to make oil/water separator covers, expands and contracts with temperature fluctuations. Variations between ambient and wastewater temperatures of 10 ˚C to 50 ˚C (50 ˚F to 120 ˚F) are common and, as a result, a vapour tight seal may be difficult to achieve and maintain under normal operating conditions. Additional caulking may help ensure a vapour tight enclosure. A corrosion resistant coating should be used to reduce the potential for chemical ignition from aluminum alkyls. The structure should also be grounded to reduce the potential for mechanical ignition.

FRP covers are not as susceptible to thermal expansion as aluminum. They are typically custom moulded and usually contain resin additives that resist fire and other environmental elements, improve structural integrity and dissipate static charges. In addition, the covers' moulded construction also accommodates variations in the design of external separator tank drive arrangements yet still maintains a positive seal at the cover penetration. The high humidity within the enclosure makes ignition from static charges unlikely.

Figure 3. In DAF separators, influent is mixed with countless micron sized air bubbles as the flow enters the tank.

Gasketing and caulking material used with oil/water separator covers must withstand the aggressive atmosphere within the enclosure. For example, closed cell nitrile foam type SBE42 per ASTM D1-56-67 provides a chemically resistant, durable and vapour tight seal for oil/water separators used in treating refinery petroleum wastewater.

A safety relief device protects the separator cover from internal pressure and vacuum conditions that may compromise the enclosure's structural design. Pressure vacuum relief valves allow air and/or vapours to escape and not damage the enclosure. A flame arrester and additional emergency venting capacity further relieve pressure in the oil/water separator tank that may result from fire outside of the enclosure.

Vent devices

Rupture diaphragms, hinged panels, and blow out panels are three types of deflagration vent devices. After the rupture diaphragm or blow out panel design systems relieve, the diaphragm or panel should be replaced to ensure the enclosure's vapour tight condition. Weighted and spring loaded hinged devices can easily be closed and reused after relieving. When selecting any type of deflagration vent device, corrosion-resistant materials should be considered.

Individual separator systems should never be interconnected, as ignition in one system could cause the others to explode. If refineries must use interconnections, they should install flashback devices to prevent the spread of fire.

Reliable instrumentation is critical for monitoring the enclosure's environment. Pressure gauges verify proper operation of the purge system. Pressure sensors indicate excessive pressure and vacuum relieving conditions. Oxygen analysers provide continuous verification of the atmosphere within the enclosure. Multiple units should have monitoring equipment as backup.

Under pressure and oxygen deficient, the enclosure should be accessed cautiously during maintenance and service. Warning labels about the volatile atmosphere should be posted at various locations around the enclosure and at every access point to the interior.

Vapour control device

According to the NESHAP requirements, the closed vent system with control device should be operated any time waste is present in the separator except when maintenance or repair cannot be done without shutting down the control device. Three main types of control devices, enclosed combustion, vapour recovery and flare, should be designed to operate at external detectable VOC emissions of 500 vppm above background levels.

Enclosed combustion devices

Enclosed combustion devices, such as thermal and catalytic incinerators, operate between 14 kPa - 35 kPa (2 psi - 5 psi). Operating pressure is either maintained at the oil/water separator or provided through a blower at the enclosure vent outlet. Maintaining the required pressure at the enclosure normally requires adding structural reinforcement and alternate safety devices designed for higher pressures to the vapour cover and separator tank. Installing a blower is often the most economical means of supplying the high pressure required for combustion at the incinerator.

In thermal incineration, vapour passes through a preheater to increase vapour temperature, and subsequently reduce the amount of supplemental fuel required for complete combustion, to between 650 ˚C - 870 ˚C (1200 ˚F - 1600°F). The preheater uses hot incinerator exhaust to transfer heat to the influent vapour stream.

Similarly, catalytic incinerators pass vapour over a catalyst material such as platinum, copper chromates, copper oxide, chromium, magnesium or nickel. Raising the catalyst temperature releases adsorbed gases on the metal's surface, which increases the catalytic oxidation reaction rate. This also allows complete combustion to occur between 315 ˚C and 370 ˚C (600 ˚F and 700 ˚F), and reduces the supplemental fuel requirement below that of thermal incineration. The concentrations of oxygen, carbon dioxide and water vapour may considerably reduce the heat value of the VOC in vapour. With catalytic incineration, lightens may suddenly surface in the exhausted vapour and cause an explosion. This poses a serious safety hazard, as temperature monitoring equipment normally does not react fast enough to prevent destruction of the catalyst.

Since incinerators are a constant source of ignition, a flame-arresting device must be installed in the vapour exhaust line between the vapour enclosure and incinerator, a certain distance from the flame source. Condensate traps can also prevent moisture from accumulating in the vapour line leading to the incinerator.

Vapour recovery devices

Condensers and carbon adsorption are two types of vapour recovery systems. With condensation, the vapour stream is saturated before being condensed into a liquid. Removal efficiency depends on the partial pressure and the hydrocarbons concentration in the vapour stream. The lowest temperature necessary to condense the vapour dictates which coolant is used (water, brine solutions or Freon). The condensation process does not produce any additional waste, but the recovered product may contain partially oxidised VOC that requires special disposal.

Carbon adsorption is more commonly used for vapour recovery, as it does not require elevated pressures or refrigeration to remove hydrocarbon vapour. The higher molecular weight of hydrocarbons, combined with temperatures below 38 ˚C (100 ˚F) and less than 50% humidity, results in higher removal efficiencies. Despite fluctuating flow rates and concentrations, carbon adsorption systems safely remove contaminants at very low pressure losses 249 Pa (1 in. w.c.). These systems do not require blowers. The carbon can be regenerated a finite number of times, on or offsite, before it is completely spent.

Flare devices

In general, flares operate similarly to incinerators, in regards to vapour content. A flame arresting device and condensate accumulators should be installed on the vapour line leading to the flare.

Conclusion

The NESHAP regulations for benzene stipulate the need to contain emissions from oil/water separators used in the petroleum refining industry. The regulations recommend using fixed cover enclosures with a closed-vent system, along with a vapour control device. Monitoring should be used to ensure a continuous flow of vapour to the control device.

Enclosed oil/water separators greatly reduce the health and safety risks associated with concentrated vapour coming in contact with the outside atmosphere and potentially igniting. Installations must be evaluated on a site specific basis for purging, enclosure and vapour control.

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