OIL-WATER SEPARATORS FOR ELECTRIC UTILITIES – PROTECTING THE ENVIRONMENT WITHOUT THE HIGH COSTS OF MAINTENANCE

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ABSTRACT: Environmental regulation of oil in water discharges is increasingly becoming more stringent. Electric utilities have a number of possible applications for MSR coalescing plate separators. These applications can be found in hydroelectric facilities with leakage water or deluge systems, fossil fuel facilities with deluge systems, transformer stations, transformer storage and maintenance yards, and vehicle maintenance operations. Those facilities with water effluent streams that go directly to lakes and rivers must have permits under the Clean Water Act. The other option of pretreatment before discharging to sanitary sewer facilities requires permission from the sewer facility authorities to discharge to the sanitary sewer. This is because the sewer facilities are required to have permits governing their effluent water to surrounding lakes and rivers.

Little information has been available to address specific actions for the handling of contaminated water within the boundaries of such facilities that utilize electric utilities. The purpose of this paper is to offer suggestions for specifying and designing separation systems to meet the requirements for treating the contaminated waters. Overall, oil-water separator system designs are discussed and recommendations for ensuring system efficiency, regulatory compliance, reliability, sustainability and effective procedures are presented.

Keywords: Oil-Water Separator, electric utilities, electric power generation, hydroelectric, fossil fuel, deluge systems, transformer stations, transformer storage and maintenance, wastewater, specification, design, vehicle maintenance

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BACKGROUND AND INTRODUCTION

Electric utility companies have numerous sources of oily water that must be processed regularly before discharge. Most of this contamination comes from leaking oil (in seals and bearings) and fuel spills associated with hydroelectric facilities, fossil fuel facilities, transformer stations and transformer storage and maintenance facilities, and vehicle maintenance operations.

It is necessary to remove the oil from the water before it may be discharged from electric utilities because of environmental and economical problems. In some cases, electric utility facilities will have dedicated wastewater treatment equipment, but most wastewater is directed to the local sanitary sewers. The purpose of the following information is to provide some guidance on the nature and quality of the wastewater to be expected and to offer some design suggestions for the pretreatment of wastewater, prior to discharging the source.

LAWS AND REGULATIONS

Oil in water discharges from industrial and other facilities, including facilities with electric utilities, are governed by a variety of federal, state and local laws. Included in these laws are the Clean Water Act (CWA) and its amendments, the Oil Pollution Act of 1990, the Coastal Zone Management Act and others (Findley and Farber, 1992).

The basic law covering discharges is the Clean Water Act. It was originally enacted as the Federal Water Pollution Control Act of 1972, but was extensively amended in 1977. The 1977 amendments, in conjunction with the earlier legislation, became known as the Clean Water Act. Under the terms of this Act, amended Section 402, the National Pollutant Discharge Elimination System (NPDES) permit method was created. Permits for point sources under this system are granted by the Environmental Protection Agency (EPA) or by states with EPA approved programs. After enactment of this law, any discharges other than those covered by the permit are illegal. Although the Clean Water Act was enacted primarily to control discharges from Publicly Owned Treatment Works (POTWs, also known as sanitary sewer treatment plants) and toxic discharges from industrial plants, it also controls the discharges of petroleum and other hydrocarbons into the waters of the United States.

> The Clean Water Act (CWA) regulates the discharges of pollutants into US waters as well as the quality standards for surface waters.

The Clean Water Act directly governs the effluent from all electric utilities if the effluent is not further treated. If the effluent from the facility is further treated downstream, either at a public or private treatment plant, the Clean Water Act governs the effluent from that plant. In circumstances such as this, the management of the treatment plant controls the allowable effluent from the facility (which is entering their treatment plant). It is often possible to check with the engineers at the treatment plant and find out the allowable oil content discharge.

Most POTWs set their inlet criteria substantially above the Clean Water Act requirement because the oil in the effluent from the facility is significantly diluted by mixing with the other inlet water. The criteria for water entering the POTW's tends to range from 75 mg per liter of oil allowable up to about 200 mg per liter allowable, but some plants still have lower allowable oil thresholds.

In the event of direct discharge to lakes or rivers, most states and localities require discharges to contain 15 ppm or less of oil and grease, based on a 24 hour composite sample. Oil and grease may include petroleum hydrocarbons as well as animal and vegetable oils. Some localities have established lower discharge limits. King County, Washington, which includes the Seattle area, requires discharges to be less than 10 ppm (Romano, 1990).

In Canada, local regulations and the Fisheries Act govern discharge of contaminants into any body of water which “either contains or may contain fish” (Government of Canada, 1978).

APPLICATIONS OF COALESCING SEPARATORS FOR ELECTRIC UTILITIES

Hydroelectric Facilities

There are a number of places within the hydroelectric system for coalescing separators. Most hydroelectric dams experience a certain amount of water leakage and some lubricating oil leakage around the turbine seals and bearings. Hydroelectric dams also contain very large water control valves that are generally hydraulic powered and lubricated with different greases and oils that may spill. As a result, the water can become contaminated and must be treated (to remove the oil) before it can be discharged.

> Absorbents are not suitable for use in situations where there is the possibility of a spill because they have very limited capacity and are quickly spent. Maintenance departments seldom replace absorbents as often as necessary, partly because of pressing other work and partly because of the cost of fresh absorbents and also the cost of disposing of spent absorbent pads or pillows. Coalescing separators do not have these problems because the media is permanent and the recovered oil is generally recyclable.

Many hydroelectric dams are provided with water sumps designed so that only the water leaking from the turbines, and sometimes water leakage throughout the dam area, can travel by gravity flow to the sumps. Once the water is collected in the sumps, it can be treated one of two ways:

1. The water can be pumped up to the surface or near the surface to some freestanding separator where the oil is removed.

2. Oil removal equipment, such as coalescing plates, can be installed within the sumps.

If the sumps are large enough to accommodate both the flow rate and coalescing media, the following is usually the most cost-effective way to treat the water since:

- Under those conditions, the oil droplets present within the water are as large a droplet size distribution as can be expected because no pumping as disrupted the droplet size.
- The sump constitutes the container, which holds the coalescing media, so no additional separator needs to be provided.
- The best thing to do for the water separators is to pump out of the sump to an above grade, in which a progressive cavity pump would be necessary to do the pumping. Centrifugal pumps are very difficult and hard on the droplet sizes and, as a result, a much larger separator would be needed for the same flow rate. However, if separation of the oil from the water, before it is pumped, is possible, any kind of pump can be used for the outlet side of the oil-water separator. In general, centrifugal pumps are the least expensive kind of pumps available for a given flow rate. So, if pumping downstream of the separator is possible, a much less expensive pump can be used if it is necessary to pump upstream of the separator.

Another place where oil-water separators can be utilized in power generation facilities is in large transformer stations, which may or may not be provided with water deluge systems. The deluge systems are intended to automatically supply large amounts of firefighting water in the event of a major transformer fire or sometimes a transformer failure. The systems can deliver as much as 500 US GPM of water depending on the severity of the situation. The duration of the deluge systems are usually preset by the plant operators or through the systems having an automatic timer, but is usually of short duration (5-10 minutes). The deluge timing is normally of short duration because the amount of fire necessary to set off the system is likely to be put out in just a few minutes.

In any case, it is not uncommon to have several thousand parts per million of oily water that needs to be treated. In the event of a spill, laboratory equipment has provided 5000 parts per million of oil, that is present in the water, as a persistent assumption.

Fossil Fuel Facilities

Some fossil fuel facilities also utilize several deluge systems in case of a transformer fire or transformer failure. Various systems can be used to clean dirty oil tanks or wash lube oil reservoirs. During transformer failure, the transformer could break or crack and release oil into several areas of the facility. In any case, hydrocarbons will contaminate the water of the deluge system and this water will need to be treated before it can be discharged. Many fossil fuel facilities also have above ground fuel oil storage tanks. It is not uncommon to have oil spills and leaks from these storage units. As a result, rainwater or nearby waterways will become contaminated from the mixtures and will need to be treated.

Transformer Stations

As stated earlier, large transformer stations may come equipped with deluge systems. When these systems are activated, contamination can occur from the mixture of the water supplied and the oily area. Many transformer stations also utilize transformer oil (or insulation oil) for cooling purposes. Usually, collection basins are constructed around the stations in order to catch any leaked oil. Rainwater that falls within the basins will eventually become contaminated from the mixture of the two fluids.

Transformer Storage and Maintenance

Transformer storage and maintenance facilities will often have deluge systems, or other suppression systems, to “drown” fires. Many of these systems are designed to allow burning oil to be washed off into nearby waterways. This is a violation of the Clean Water Act and can result in penalties and other expenses. As said earlier, transformer oils are utilized to insulate and act as a coolant for the transformers. Transformers can leak or spill into surrounding areas during normal operation. When the fire containment systems are activated, the spilled or leaked oils will mix with the water discharged and contamination will occur.

Vehicle Maintenance

Not all facilities with electric utilities will have vehicle maintenance operations. However, for the plants that do, please refer to our “Vehicle Maintenance Separator Design” document.

SOLIDS SETTLING AND OIL RISING

Separation of oil and water is different from the settling separation of solids. Oil droplets coalesce into larger, spherical droplets, while solids agglomerate into larger masses, but do not coalesce into particles that have lower surface/volume ratios like oil.

Settling of Solid Particles

The settling of solids particles is governed by Stokes’ Law. This function, simply stated, is (Perry, 1963):

$$Vp = \frac{G}{(18x\mu)} x(d_p - d_c) x D^2$$

Where: V_p = droplet settling velocity, cm/sec
G = gravitational constant, 980 cm/sec^2

μ = absolute viscosity of continuous fluid (water), poise
d_p = density of particle (droplet), gm/cm^3
d_c = density of continuous fluid, gm/cm^3
D = diameter of particle, cm

Because the equation was developed for solids falling, a particle (or droplet) rise velocity is a negative number. Assumptions Stokes made in this calculation are:

1) Particles are spherical
2) Particles are the same size
3) Flow is laminar, both horizontally and vertically

From the above equation, one can see that the most important variables are the viscosity of the continuous liquid, specific gravity difference between the continuous liquid and the particle, and the particle size. After these are known, the settling velocity and, therefore, the size of separator required may be calculated.

The velocity of settling or rising is dependent on the hydrodynamic drag exerted on the settling particle by the continuous fluid. This drag is dependent on the shape of the particle as well as the viscosity of the continuous fluid. Solid particles present in maintenance systems do not perfectly obey Stokes' Law because of their particle shape.

Rising of Oil Droplets

The rise rate of oil droplets is also governed by Stokes' law. If the droplet size, specific gravity, and continuous liquid viscosity are known, the rise rate and, therefore, the required vessel size may be calculated.

To calculate the size of an empty-vessel gravity separator, it is first necessary to calculate the rise velocity of the oil droplets by the use of Stokes' Law. The size of the separator is then calculated by considering the path of a droplet entering at the bottom of one end of the separator and exiting from the other end. Sufficient volume must be provided in the separator so that the oil droplet entering the separator, at the bottom of the separator, has time to rise to the surface before the water carrying the droplet exits the opposite end of the separator (the API Method requires 45 minutes of residence time).

Calculation of rise rate by this method is a gross simplification of actual conditions because oil droplets are not all the same size, and they tend to coalesce into larger droplets.

Droplet rise-rates follow Stokes' law as long as laminar flow conditions prevail. Laminar flow regimes (in the direction of rise) exist with most droplets. The rise rate of larger droplets may exceed the velocity of laminar flow. When the droplets coalesce, they do not form flocs as with solids. Instead, they coalesce to become larger droplets. Interfacial tension (sometimes referred to as surface tension) of the liquid allows for the assumption of spherical shaped droplets since this is the smallest possible shape for a given mass.

According to the API method listed in publication 421, the calculation for the performance of the separators assumes the use of a 45 minute residence time for the removal of the oil. It further assumes the use of Stokes' law in the droplet size removal calculation. One of the preconditions for Stokes' law is laminar flow, and this condition is seldom, if ever, met in an API separator because of convection currents and other flow currents that preclude the orderly rising of small droplets. Large droplets rise well, but the small ones do not.

> The API separator calculation method was originally designed, in 1947, for the removal of oil from refinery effluent streams for resource recovery, and was not intended for removing oil down to levels required by environmental laws. The API's own survey notes that most of their members' separators do not remove oil to less than about 150 mg/L, which does not meet the Clean Water Act.

The oil droplet size is difficult to determine with any accuracy. Particle sizes of solid particles are fairly easy to determine in the laboratory, but oil droplet size information is much more difficult to obtain because most of the methods for determining sizes change the droplet size.

Even if the droplet size is unknown, or a large range of droplet sizes is present (the normal situation), it is still possible to determine the rise rates of the droplets and, thus, the size separator required by judicious application of conservative assumptions. This is discussed below.

Oil in the outlet should not be present in quantities great enough to cause oil sheen if the effluent is not directed to a sanitary sewer. In order to minimize the possibility of such discharge, it is wise to proceed carefully and cautiously in the design of oil-water separator systems.

SYSTEMS AVAILABLE FOR REMOVING OIL FROM WATER

Systems for removing oil from water range from very simple tanks to very elaborate membrane technology-based systems. For most applications in removing oil, the simplest systems are inadequate (although often used) and the most complicated are either too expensive or too maintenance-intensive, or a combination of both. Therefore, most of the following information provided will concentrate on methods of separation intended to meet regulatory requirements with minimum cost and maintenance.

Gravity Separation

One of the simplest possible separators is an API separator. In 1947, the American Petroleum Institute (API) commissioned a study by the University of Wisconsin that provided design criteria for an oil-water separator system intended for gross oil recovery at the water outlet of oil refineries. A diagram of a typical API separator is shown in Figure 1 below (Adapted from API Publication 421, 1990).

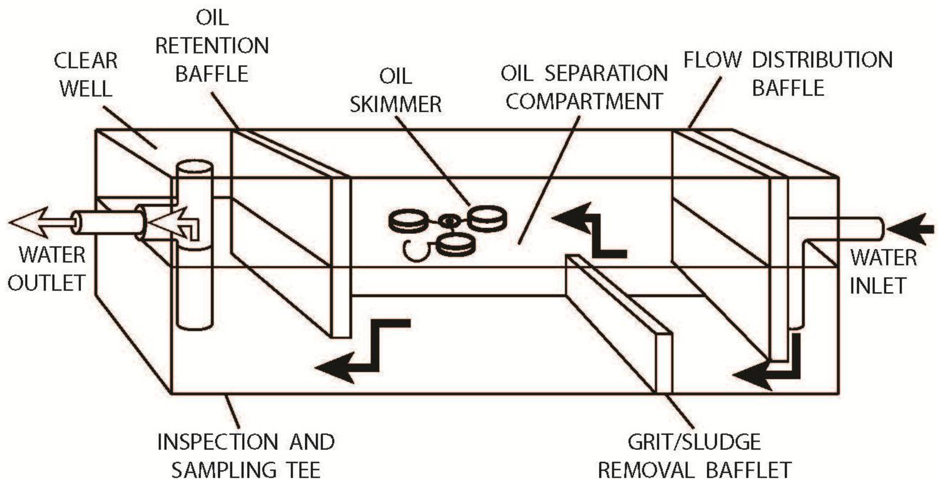


Figure 1: API Separator

Systems are often sold as “API type separators”, which commonly means that they have the same universal baffle arrangement as a regular API separator, but do not conform to the design criteria of a 45 minute residence time (established by the API). Separators which have a lesser residence time (and are therefore smaller and less expensive than rigorously designed API separators) do not meet the API design criteria and, therefore, cannot be expected to meet the API’s modest effluent expectations.

Advantages of the API and API type separators are simplicity of design, low cost, low maintenance, and resistance to plugging with solids. The primary disadvantage of these simple gravity separators is the poor quality of separation that they provide.

Enhanced Gravity Separation

Enhanced gravity separators provide better quality separation than is possible with simple gravity separators, while still maintaining the low capital and maintenance cost benefits of the simpler systems. In many ways, the enhanced gravity separators substitute sophisticated design and internals for the settling time provided in pure gravity separators. These enhanced gravity separation systems have some similarity to API separators, but include coalescing media that enhances the separation of the oil and water.

Multiple Angle Plate Separators

Multiple angle plate separators such as the MSR *HE-Media* systems were developed to take advantage of the effects of gravity to the fullest and optimize the oil removal process. A drawing of a typical above-ground multiple angle separator at a maintenance facility is provided below in Figure 2.

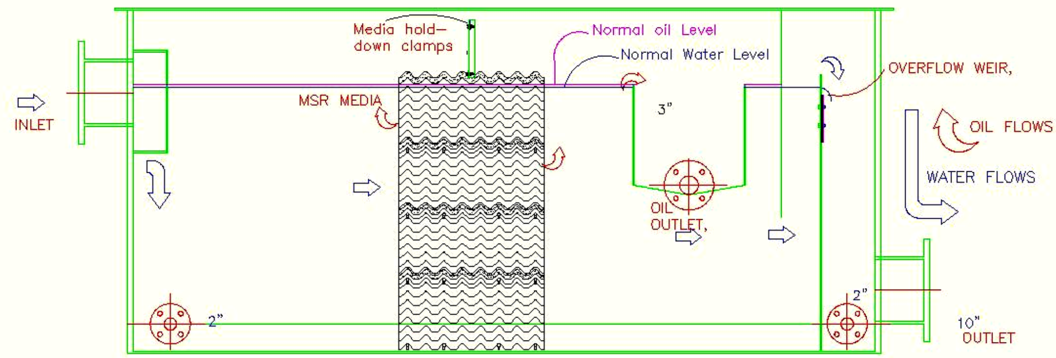


FIGURE 2: TYPICAL ABOVE–GROUND MAINTENANCE FACILITY SEPARATOR

The coalescing plates are corrugated in both directions, making a sort of "egg-carton" shape. This is done so that all of the underside surfaces slope upward, encouraging captured oil to move toward the surface. Spacers are built into the plates for two vertical spacing sizes (8 mm and 16 mm). The narrow spacing is more efficient and the wider spacing is more tolerant of solids.

The specifying engineer should be cautious of the use of any type of separator which includes coalescing mesh, coalescing pads, or coalescing tubes. This is because the coalescing mesh and coalescing pads, if they are finely woven or otherwise dense enough to operate, can easily become plugged with solid particles -- or more likely -- a combination of solid oil particles. Coalescing tubes depend on oil droplets passing and impacting on the plastic of the tubes, being captured there, and eventually migrating to the surface. The streamlines of the flow, however, tend to carry the oil droplets around the solid portions of the tubes. This defeats the theory of how the tubes operate.

Applications of the Different Systems

In recent years, more stringent effluent requirements have required the conversion of numerous API separators to have more efficient designs. New facilities are being engineered with these requirements in mind and are utilizing the more sophisticated designs as discussed above. Historic designs for separators are still used for many non-critical uses and where the effluent will be treated downstream.

Coalescing plate separation systems offer better performance than the simpler systems, but at higher costs (Romano, 1990). It is often necessary to balance the cost versus the benefits in order to meet the regulatory requirements. Where applications require high efficiency oil removal as well as the ability to tolerate solids, MSR coalescing plate systems have proven sustainability under difficult conditions and still provide effluent oil concentrations that meet the normal regulatory requirements.

Advantages of the multiple-angle plate separator system are:

1) The plates are designed to shed solids to the bottom of the separator, avoiding plugging and directing the solids to a collection area. The solids drop directly to the bottom of the separator. If desired, troughs to collect the solids can be incorporated.
2) The double corrugations provide surfaces that slope at a 45° angle in all directions, so that coalesced oil can migrate upward.
3) The holes in the plates that constitute the oil rise paths and solids removal paths also provide convenient orifices for inserting cleaning wands. Other types of pack systems are not available with such holes and are more difficult to clean when plugged with the solids.

SPECIFYING COALESCING SEPARATORS FOR ELECTRIC UTILITIES

There are a number of components that affect the design of coalescing separators for electric utilities. These include the water flow rate, water temperature, amount of oil present in the water, and the use of existing equipment (if applicable), just to name a few.

Flow Rate

The first step in determining the required design of separators for electric utilities is to determine the maximum flow rate. This flow rate must be calculated on an instantaneous basis because any treatment equipment must be able to handle that flow rate at any given time.

In some facilities, the quantity of wastewater emanating from the electric utility operations is well-known because it is the result of a pumped flow system and the capacity of the pump should also be known. The quantity of the wastewater may also be established by the flow of other equipment such as pressure washers. The flow capacity of a standard pressure washer is approximately 4.5 US GPM (17 L/min), although there are much larger ones available. In the event that the major amount of flow results from the pressure washer, it is often possible to determine the flow from the nameplate of the pressure washer or the manufacturer’s websites.

Sometimes the maximum flow rate will be the result of the use of one or more garden hoses for floor washing. A reasonable flow rate to use for designing under these circumstances is approximately 10 US GPM (37.8 L/min) per garden hose.

The most common flow rates for the water emanating from electric utility facilities range from approximately 5 US GPM to 20 US GPM (75.6 L/min).

If no other information is available concerning the operations of the facility, it is possible to determine how many hours per day the facility is in operation, and how much water is used to wash down specific areas, and thus, use this data to determine a design flow rate.

Operating Temperature

The operating water temperature is an important variable in the design because it governs the viscosity of the water. This is usually known, or may be measured, but if is unknown, in cold climates, a reasonable attention is 32°F. This is the most conservative, worst case possible. In milder climates, a reasonable assumption is 55°F because it is generally the average groundwater temperature worldwide.

Oil Content

The oil content is seldom known, and varies wildly with the operations of the electric utilities. Mohr Separations Research has historically used 1000 mg per liter (0.1%). This was based on some conversations with a municipal engineer in the Pacific Northwest. While it may not be supported by scientific evidence it has proven to work satisfactorily.

Oil Specific Gravity

MSR generally uses 0.85 as an estimate for the hydrocarbon specific gravity. This is typical for diesel fuel and is based on some analyses of captured oil from working separators. Lubricating oil is somewhat denser than diesel fuel, but evidently more diesel fuel tends to leak than lubricating oils. Gasoline is so volatile that it evaporates almost immediately and does not enter into the drains. Thus it does not enter the oil-water separator.

> With the flow rate, operating temperature, oil content, specific gravity and average droplet size (many of which will be estimated); it is possible to determine an appropriate size design for a separator. In addition, it is often necessary to consider several process situations to determine which is most stringent.

Solid Particles

There will be solid particles of various sizes, types, and specific gravity present in the water in almost all cleaning and maintenance systems. The heaviest solids loading can be found at mines and other facilities where large quantities of solids are processed, however many other facilities also have solids present.

Except in unusual circumstances, such as coal mines, where the nature of the solid particles is dictated by the application, the characteristics of the solids will be mixed. The quantity, size, and type of solids present will vary minute to minute, depending on the applications being processed and other factors. MSR generally uses as an estimate for typical solids at a specific gravity of 1.4, which is given in Perry's Chemical Engineer's

Handbook for river mud (Perry, 1963), and an average particle size of 60 μm, which is the ASCE estimate for the average particle size of road dirt.

Because the quantity of solids present varies so much over time, MSR usually prepares calculations based on an inlet of 100 mg/L and determines the percent removal. The customer may then determine if the percent removal is satisfactory and, if necessary, MSR can make revisions to the suggested size if necessary.

GENERAL DESIGN CONSIDERATIONS

Numerous factors must be considered in the selection and design of oil-water separation systems. Among these are:

1. Flow rate and flow conditions
2. Degree of separation required - effluent quality
3. Amount of oil in the water
4. Existing equipment
5. Emulsification of the oil
6. Treated water facilities
7. Recovered oil disposal method

For industrial and some municipal applications, flow rate, amount of oil, flowing temperature, and other conditions affecting separation (such as whether flow is laminar or turbulent) may be easily determined. For electric utilities applications, however, it may be necessary to estimate water flow quantities by other means. The degree of separation required is usually a matter of statutory or regulatory requirements, but if the water is discharged to a POTW or industrial treatment plant it may be negotiable.

Existing equipment, such as API separators, may affect the design of equipment to be used. Often it is possible to retrofit existing equipment with more sophisticated internals to enhance separation quality.

It is necessary to ensure that adequate size piping is provided for downstream treated water removal to avoid flooding the separator. A downstream test point should be provided to allow for effluent testing.

Adequate means for recycling the oil should be provided (usually a recycling company). Careful records of removed and recycled oil should be kept to avoid possible future regulatory problems.

The following is a brief discussion of several of the points touched on the above, concerning the design of oil-water separation systems.

Inlet Flow (Influent) Conditions

Much of the performance of an oil-water separator depends on the influent conditions. Pumps, valves, restrictions in piping and other pressure-drop (shear) causing equipment will form a distribution of droplets with a smaller average droplet size than would otherwise be present in the flow stream. These smaller droplets are more difficult to separate because they rise more slowly. A separator designed to remove these smaller droplets must be significantly larger (and more expensive) than one designed for the larger average size droplets that would be present if no shear-causing equipment were utilized in the inlet stream.

Ideal inlet conditions for an oil-water separator are:

1. Gravity flow (not pumped) in the inlet piping
2. Inlet piping sized for minimum pressure drop
3. Inlet piping straight for at least ten pipe diameters upstream of the separator (directly into nozzle)
4. Inlet piping containing a minimum of elbows, tees, valves, and other fittings
5. Soaps or detergents NOT in use

Most separators are provided with an inlet elbow or tee inside the separator pointing downward. This is an exception to the above rules and is intended to introduce the influent water below the oil layer on the surface, thus not disturbing the surface oil and re-entraining some of it.

Inlet piping should be as smooth as possible to avoid turbulence caused by pipe roughness. Smooth PVC is preferable as opposed to rough concrete.

If large quantities of solid particles are expected, it is wise to provide a grit removal chamber before the separator. These chambers should be designed according to normal design parameters for grit removal as used in POTW plant design. Likewise, a design utilizing media in a metal frame, as discussed above, is a good strategy if large quantities of solids are expected.

Outlet Flow (Effluent) Conditions

Effluent designs are also important in the operation of oil-water separators. Downstream piping and other facilities must be adequately sized to process the quantity of water (and oil) from any likely event.

Effluent piping must be designed with siphon breaks so that it is not possible to siphon oil and water out of the separator during low flow conditions. One way to do this is to provide the sampling/overflow tee in the effluent line as shown in Figure 1. In most underground systems, oil must be removed manually by a maintenance crew equipped with a vacuum truck or other equipment for oil removal. If this is not done on a regular basis, this oil may become re-entrained at the next rainfall event and reintroduced into the environment (Romano, 1990). In underground systems, captured oil holding tanks are usually not provided. This will avoid possible entanglement in the Underground Storage Tank Rules paperwork. In above ground systems, special oil holding tanks are often provided.

Removing the oil from the separators is not sufficient to protect the environment; it must also be recycled to ensure that it is disposed of properly. Current U.S. law holds the owner of the oil-water separator responsible if this oil is not properly disposed of, even if the owner has paid for proper disposal.

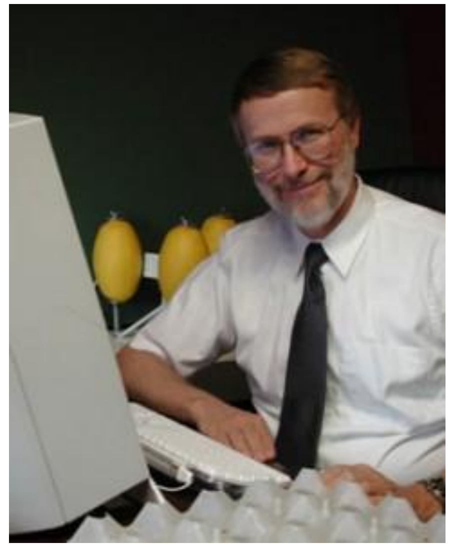
SUMMARY AND CONCLUSIONS

Environmental regulations are becoming more restrictive and requiring lower concentrations of hydrocarbons in effluent water. Some localities have much more stringent effluent standards than even the US EPA or other national bodies mandate.

Unfortunately, budgets for wastewater treatment are always very limited. Empty tank (API or API Type) systems are not adequate to ensure good treatment and it is essential to utilize a high-efficiency system to remove the oil.

Utilizing multiple angle coalescing plates, such as the Mohr Separations Research *HE-Media* design in concrete vaults or other systems, provides a cost-effective method of ensuring effluent water quality that meets or exceeds the requirements of federal, state, and local regulations. To ensure proper sizing, each system should be individually designed to meet all facility conditions and requirements. MSR green technology has proven sustainability and requires very little maintenance. Please contact MSR if you have questions or would like to discuss any aspect of this type design.

ABOUT THE AUTHOR



MSR was founded in 2001 by Kirby S. Mohr, a degreed engineer specializing in the filtration and separation of liquids. Kirby holds degrees in Chemical Engineering and Environmental Engineering from Iowa State University and Oklahoma State University, respectively, and is a Registered Professional Engineer in Texas. He has more than forty years of experience in engineering, with the last thirty specializing in separation and filtration.

Kirby is a Vietnam Veteran. He is also a member of the Society of American Military Engineers, the American Rainwater Catchment Systems Association, US Navy Supply School Alumni Association and several others.

Since the company founding, we have completed projects in the Electric Utility, Oil Production, Chemical Manufacture, Stormwater Processing, Transportation, and Vehicle Maintenance industries. Our projects are very diverse, ranging from the design of oil-water separators for US and Canadian fire training schools, to two very large separators for a large Canadian electric power generation facility, and four for a Boron production facility. Our systems have been installed from coast to coast and from Texas to near the Arctic Circle as well as international locations, including Europe and South America.

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