Mohr Separations Research, Inc.

DESIGN AND INSTALLATION OF A HYDROCARBON REMOVAL SEPARATOR FOR INDUSTRIAL STORM RUNOFF

Kirby S. Mohr, P.E.
Mohr Separations Research, Inc.
1278 FM 407 Suite 109
Lewisville, TX 75077
Phone: 918-299-9290   Cell: 918-269-8710

Adam La Rusic, P.Eng
Project Engineer, Morrow Engineering, Ltd.
111 B-980 West First St.
North Vancouver, BC V7P 3N4

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ABSTRACT

A new stormwater collection and treatment system was installed at Vancouver Wharves in 1997 to process surface runoff from approximately 25000 M^2 of yard area. The proposed construction of a new building at the site necessitated the removal of the previous oil-water separator. Morrow Engineering, Ltd. was asked to design a stormwater collection and treatment system to discharge effluent water within permitted levels. A number of factors had to be considered, including the influx of detergents from vehicle washing areas, high concentrations of various solids, and sewer flood conditions resulting from the proximity of tidally-influenced waters. The new system included a redesign of the stormwater collection system and a new oil-water separator utilizing multiple angle coalescing plates for high efficiency removal of oil in the water, while shedding solids to the bottom of the separator.

Keywords: Oil, Water, Separator, Stormwater, Runoff, Design, Installation, Solids

INTRODUCTION

The topic of our discussion is "The Design and Installation of a Hydrocarbon Removal Separator for Industrial Storm Runoff," using the specific example of an oil-water separator installed at Vancouver Wharves in December 1997.

The Vancouver Wharves case demonstrates many of the complicating factors that need be considered in the design of a stormwater treatment system incorporating a high efficiency oil-water separator.

The presentation is divided into four sections:

1. Discussion of complicating factors at the site
2. Design of the new system
3. Results of the new system
4. Design considerations for other systems

BRIEF DISCUSSION OF HOW COALESCING PLATE OIL-WATER SEPARATORS OPERATE

Coalescing plate separators will remove both solid particles and immiscible droplets. They operate using the principle of Stokes's law which governs both the settling of solid particles and the rising of oil droplets. Stokes's law, simply stated is (Perry, 1963):

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

Where: V_p = particle rising or settling velocity, cm/sec
G = gravitational constant, 980 cm/sec^2
μ = absolute viscosity of continuous fluid, poise
d_p = density of particle (or droplet), gm/cm^2
d_c = density of continuous fluid, gm/cm^2
D = diameter of particle, cm

A negative velocity is referred to as the particle (or droplet) rise velocity.

From above, it may be seen that the important variables are the viscosity of the continuous liquid and the particle or droplet size. After these are known, the settling velocity, and therefore, the separator size required may be calculated.

Stokes's law assumes settling of spherical particles and laminar flow regime.

The viscosity of the water is readily obtained from literature data. The oil droplet size, however, is much more difficult to obtain as the droplets exist in a spectrum of sizes, not a single size.

The effluent calculation must therefore be done in a statistical manner. Using a statistical computer program, it is possible to show that the separator will capture enough droplets so that those that pass through will cause an effluent oil content less than or equal to that allowable, under regulations. It is then possible to confidently predict that the separator will meet the effluent standards necessary under the law.

DISCUSSION OF COMPLICATING FACTORS AT THE SITE

Located on the North Vancouver waterfront, Vancouver Wharves is a major port terminal with activities including truck, rail and vessel onloading and offloading, and bulk storage of several materials (including dried pulp, sulphur, metal concentrates, methanol and several others). There are several separate stormwater collection areas with corresponding treatment facilities at Vancouver Wharves. The treatment facilities in each area are designed to reduce the stormwater contaminant levels specific to each area to meet discharge permits. The project involved Vancouver Wharves drainage area 1.3, which includes a vehicle parking area, maintenance shop, pulp storage building and a large paved general yard area. Sources of leaked or spilled hydrocarbons include common vehicular traffic, hydraulic and lubricating oil from heavy equipment, on-site maintenance shops and two fuel dispensing facilities.

The previous separator was installed in 1991. The separator design included an approximately 11.5 x 3.5 x 3 m concrete vault, corrugated coalescing plates, a differential density skimmer and an underground waste oil collection tank. The separator received drainage from all catch basins in the area. A proposed construction project necessitated a review of the existing oil-water separator and it was decided that a new separator should be constructed at a new location. Several complicating factors had to be included in the design of the new separator.

Solids in the Separator Influent

The influent water to the previous separator contained high solids content, primarily due to the water from a high pressure washing facility where loading equipment was cleaned. A significant amount of solids was contributed by tracking and blowing mining concentrates and sulphur from other areas (these storage areas are drained to a separate area). This high concentration of solid particles can cause plugging of the coalescing plates and exacerbate separation problems.

Emulsion Problems Due to Detergents

Emulsions caused by surfactants (detergents and soaps) from the pressure washing facility were also a design consideration.

An emulsion is a mechanical mixture, not a true solution, of one immiscible fluid in another. A good definition, offered by Love (1 948), is "an emulsion is an apparently homogenous mixture in which one liquid is dispersed as droplets throughout a second immiscible liquid."

Detergents typically accumulate at the droplet oil-water interface; basically in a larger sphere encasing the smaller sphere, which is the oil droplet. This property hinders the coalescing of smaller droplets into larger ones, and therefore, preserves smaller and harder to remove droplets in the flow stream. These droplets may then make their way through the separator without being removed and cause higher effluent oil concentrations. Very small concentrations of surfactants can make substantial differences in separation capability.

The property describing the separability of emulsions is referred to as the stability of the emulsion. Some emulsions are so tightly combined that they will virtually never separate, although this would be very uncommon in stormwater processing applications.

Often, the major influence on the stability of emulsions is the emulsifying agent. In addition to surfactants, emulsifying agents can include surfactants, both natural and artificial, iron oxide, iron sulfide, and dirt.

Emulsification problems due to the use of surfactants can often be solved by the use of "quick break" detergents that are designed to act as cleaners and remove the oil from equipment, but then allow the emulsion to break quickly. This releases the oil and allows it to be removed more easily.

Sewer Flooding Due to Tidal Action

Due to area elevations, separators can be subject to flooding at high tides, as saltwater from Vancouver Harbor is able to backflow via the main outfall to the separator. When storm events occur during high tide conditions, the backflow can flood over the top of the coalescing plates. This can lead to a situation where oily water entering the separator virtually bypasses treatment.

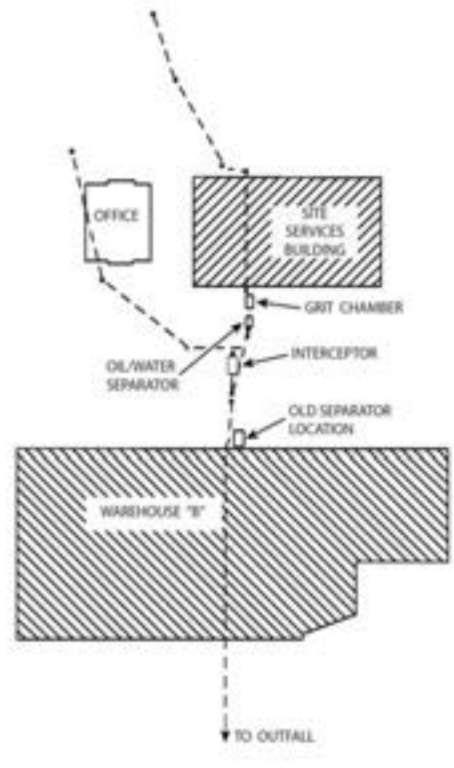
Bypass Operation

The separator was designed with a high-flow bypass operating on a weir system. At high flows, it was assumed that the oil in the stormwater was diluted to within permitted concentrations, and the bypass allowed some of the flow to circumvent the separator. This allowed some cost savings, as the separator could be built somewhat smaller. The bypass was later sealed because Vancouver Wharves had no assurance that large flow concentrations were necessarily within permit limits. This created the likelihood that the separator would be subject to higher flows than that for which it was designed.

ASSESSMENT AND DESIGN OF THE NEW SYSTEM

The construction of a new site services building and expansion of a pulp warehouse necessitated the relocation of the oil-water separator, installation of new storm sewer lines and catch basins, and general site regrading. After a review by Morrow Engineering and the identification of the above deficiencies, Vancouver Wharves decided to construct a new stormwater treatment facility at a new location.

As part of the assessment of the new system, Morrow Engineering located all catch basins and determined the routing of existing storm sewer lines. A schematic of the revised sewer system is shown below in Figure 1.



STORM SEWER SYSTEM

FIGURE 1

Interceptor

It was determined that several stormwater sources, such as drainage from the office parking lot area and roof drains did not need to be treated by the oil-water separator. Drainage from the office parking lot area was rerouted to a 900 US GPM oil interceptor - essentially a concrete holding chamber with baffles that allow gravity separation of oil and provides emergency containment of 5000 USG in the case of a spill. The effluent from the interceptor joins the main outfall downstream of the separator. Roof drains bypassed the stormwater treatment facility entirely, as it was expected to be free from contaminants.

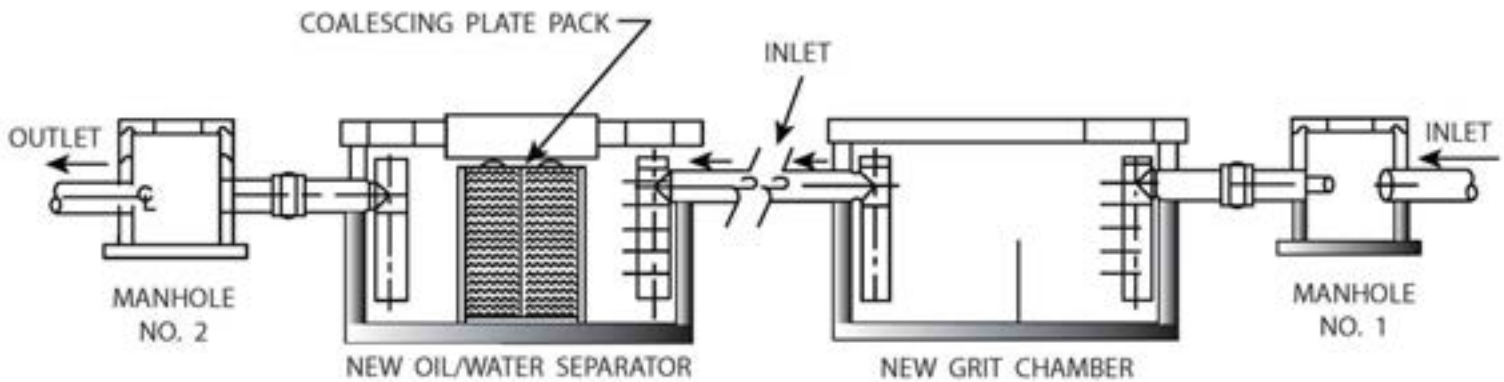
Pressure Washing Facility

By far the most problematic drainage source was the high-pressure washing facility. A sample of wastewater analyzed from this area showed high concentrations of various solids, oil and detergent. A self-contained treatment system that recycled washed water was determined to be the most viable option for the facility. A baffled concrete clarifier pit and a commercially available integrated wastewater treatment unit were recommended. The wastewater treatment unit includes a chemical treatment chamber for oxidation, pH adjustment and coagulation, gravimetric settling of particles, and filtration to 25 microns. Tankage for treated water, piping, valving and high and low level controls were also incorporated to create a relatively small, low maintenance wastewater treatment plant. Sludge is removed and makeup water is added periodically. This system is virtually effluent-free.

DESIGN OF THE NEW OIL-WATER SEPARATOR

Catch basins that drained areas close to maintenance shops, or other areas of potentially high oil concentrations, were routed through the new oil-water separator.

The separator itself is a 3680 x 2500 x 1980 mm pre-cast concrete vault, and a similarly sized grit chamber was located directly upstream of the separator. Influent and effluent lines to the separator were 300 mm diameter PVC pipe. A schematic of the new system is shown below in Figure 2. The influent line to the grit chamber and the effluent line from the separator were equipped with butterfly valves to isolate flow during maintenance operations.



SEPARATOR & GRIT CHAMBER

FIGURE 2

The grit chamber was included due to the high incidence of particulate matter at Vancouver Wharves, particularly metal concentrates, which can foul the separator. As the densities of these contaminants compared to water are high, the concentrates tend to drop out quickly, depending, of course, on the particle size and drag. The grit chamber is also easier and less costly to clean than the separator, and reduces frequency of required separator maintenance.

The separator and the grit chamber were designed to treat influent flows of up to 700 US GPM at a concentration 400 ppm of oil and grease. Effluent was designed to be less than 10 ppm of oil and grease. Separator design was in accordance with the SC Waste Management Act Petroleum Storage and Distribution Facilities Storm Water Regulation (except where the facility permit exceeded regulatory standards). The separator was designed to accommodate the flow rate from a one-in-ten-year storm event of 60 minutes duration.

A skimmer was not included in the new design. Automatic skimmers are finicky to install and relatively high maintenance. A skimmer also necessitates associated piping, valving, tankage and controls, which add to the capital and maintenance costs of the system. It was considered more effective to arrange to have the separator regularly monitored, and the oil and sludge pumped out as part of a regular maintenance schedule.

A bypass was not installed around the separator. Bypasses are often accidentally left open. Also, other plant upsets can happen during a storm event, and the separator is the last defense against depositing spilled materials into the environment. It is important that the separator operates during a storm event.

MULTIPLE ANGLE COALESCING PLATE SEPARATOR DESIGN

The new separator was specified with multiple angle coalescing plates, which are designed for maximum separation of oil droplets and also to shed the captured solids to the bottom of the separator. The integral plate supports form a solids collection area under the plates. The coalescing plate system utilized was multiple angle coalescing plates. This system was chosen because of its ability to meet requirements and ease of maintenance. A process simulation was performed to ensure that the coalescing system, as provided, would meet the regulations.

The separator has a concrete lid to access the main chamber and two manholes which access inlet and outlet piping, and are convenient sampling ports. The separator was not installed with a continuous skimmer; continuous skimmers are high maintenance and/or expensive. It was considered more cost-effective to call in a vacuum truck periodically to remove accumulated oil. Because a significant portion of the yard area flow was diverted away from the separator, use of a moderately sized separator was feasible and a bypass around the separator was not necessary.

DESIGN SUGGESTIONS FOR SEPARATION SYSTEMS

It is suggested that, during the design of an oil-water separator system, the engineer and owner should consider, at the least, the following factors:

- Design return period storm and rainfall intensity
- The area served by the separator should be minimized to decrease separator size and cost
- Factors such as tidal influence, surfactants, or high solids content water that can affect the design/operations of the separator
- Should the separator be designed for full flow of the storm sewer, or should some bypass arrangements be made?
- Effluent quality desired at the time of design, and should provisions be made for a future lower effluent oil content or higher flow rate requirement?
- Expected maintenance and any special maintenance considerations. Is the coalescing system design proven and is an effluent warranty provided?

SUMMARY AND CONCLUSIONS

A proposed construction project necessitated a review of the existing oil-water separator at Vancouver Wharves, and it was decided that a new separator should be constructed at a new location. The area served by the new separator was reduced, a tidal valve was installed to prevent back flooding with tidal waters, and a new system of solids-tolerant multiple angle separator plates was installed. The new system has been in operation for approximately 5 months at the time of this writing, and has proven to provide an effluent quality superior to that required by regulations and requires only minimum maintenance efforts.

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