Mohr Separations Research, Inc.

DESIGN, TESTING, AND OPERATING EXPERIENCE OF AN AIRPORT FUELING APRON STORMWATER SEPARATOR

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ABSTRACT

Environmental regulation of oil in stormwater discharges is becoming increasingly more stringent, especially in environmentally sensitive areas. When modifications were done to the Camarillo (Ventura County), California Airport in 1997, a high efficiency oil-water separator was installed to treat the stormwater runoff from the area where the trucks used to refuel the airplanes were filled.

The system includes a precast concrete separator vessel, provided with multiple angle enhanced gravity separator plate packs. Performance tests were performed on the system as part of the acceptance procedure, and results of the testing are presented, along with the results of three years of operation and maintenance.

Keywords: Oil-Water Separator, Stormwater, Design, Testing, Operating, Airport Fueling Apron

INTRODUCTION

The truck fueling area has three bermed divisions, two containing tanks, and the third comprising the area where the fueling trucks are filled before carrying the fuel to the airplanes. The area is approximately 60 ft x 100 ft. A schematic of this area is shown below in Figure 1.

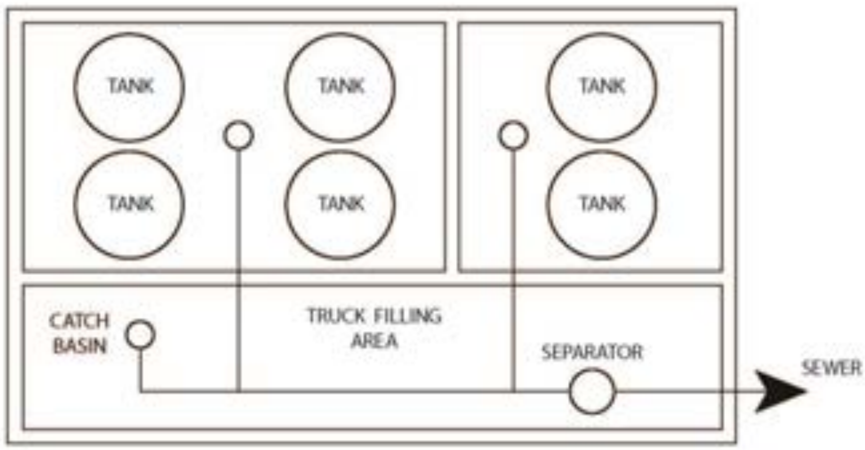

FIGURE 1 TANK FARM BERM AND DRAINS

The system includes catch basins in each bermed area with drains leading to a precast concrete separator vessel, provided with multiple angle enhanced gravity separator plate packs.

The separator installed at the Ventura County Camarillo airport is a round precast vertical cylindrical concrete tank of 48" inside diameter. Its design includes a 4" diameter inlet pipe, inlet chamber for grit collection, separating chamber containing 10 cubic feet of multiple angle polypropylene coalescing media, 6" outlet pipe, and a cast iron access cover.

The system is a permanent structural BMP designed to process up to 50 US GPM of stormwater from the fueling area and remove all hydrocarbon droplets down to 10 mg/L or less. This is intended to meet the requirements of the Clean Water Act of "no sheen" on outlet water. A drawing of the separator is shown below in Figure 2.

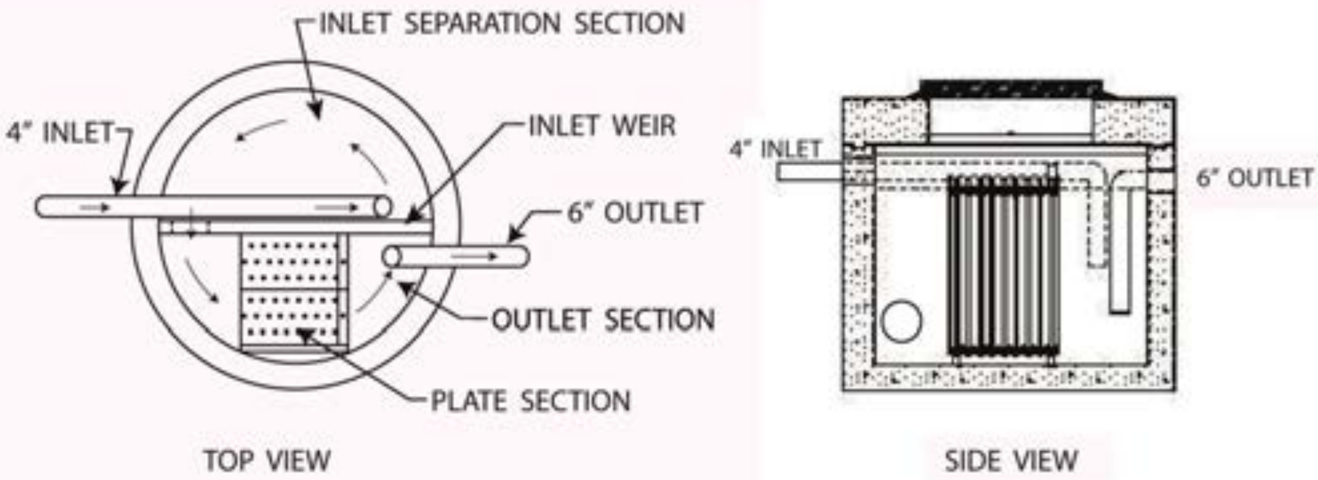

FIGURE 2 STORMWATER SEPARATOR

PROCESS DESIGN

The fueling apron was provided with a berm to contain any stormwater that might fall (or a spill if that happened) and drains to direct the stormwater flow to an oil-water separator. Rainfall calculations by the user indicated that a suitable flow for this application was 50 US GPM.

An enhanced gravity separator system, manufactured by Pre-Con Products, utilizing multiple angle coalescing plates was chosen as a means to ensure that the effluent of the separator remained within the statutory "no sheen" requirement of the Clean Water Act. This requirement was interpreted to mean an effluent of 10 mg/L or less.

To design the separator to meet the requirements, it was necessary to consider the nature of the hydrocarbons present and their configuration.

The hydrocarbons present in stormwater can exist in one or more of several conditions. These are shown below, arranged in general order of difficulty of removal (Cheremisinoff):

1) Free oil - large droplets or sheets that rise freely to the surface. This oil is easily removed in simple gravity separators.

2) Mechanically dispersed oil - fine droplets ranging in size from a few microns up to a few millimeters. The oil found in droplets is usually the result of some mechanical mixing of oil and water, such as is found in pumping or in turbulent

flow through a pipe. The oil droplets can be found in a "bell curve" of droplet sizes with some small, some large and a predominance of average size droplets. The average size will vary dependent on the amount of mixing that the two liquids have undergone, as well as the presence or absence of emulsion causing surfactant chemicals. These dispersions may be removed by the use of an enhanced gravity system.

3) Chemically stabilized emulsions - droplet dispersions similar to mechanically dispersed oil, but with droplets stabilized by surface-active agents (surfactants). More surfactants or more mixing will cause a smaller average droplet size. The average droplet size is important because many separation devices are designed to capture droplets by gravity or enhanced gravity separation, and if the average droplet size is smaller, the separator will have to be larger and consequently more expensive.

4) Oil adhering to solid particles. These can be removed by filtration or by enhanced gravity separation if the combined specific gravity is different from the water.

5) Dissolved oil - either truly dissolved oil or finely dispersed droplets so small (less than 5 microns) that removal by normal physical means is impossible. Dissolved oil must be removed by biological treatment, absorbents, distillation, or other non-gravity means.

In a stormwater stream, the majority of the oil will be present as either free oil or mechanical dispersions of oil (American Petroleum Institute "Design and Operation of Oil-Water Separators, Publication 421"). These may be treated readily by enhanced gravity systems for removal of the hydrocarbons. Most hydrocarbon removal systems depend on gravity or enhanced gravity separation, taking advantage of the buoyancy of the droplets.

The rising of hydrocarbon droplets in a separator is governed by Stokes's' Law (Perry). This function, simply stated is shown in the following equation:

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

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

From the above equation, it may be seen that the important variables are the viscosity of the water, the difference in specific gravity of the water and hydrocarbons, and the hydrocarbon droplet size. After these are known, the droplet rise velocity, and therefore, the size of separator that is required, may be calculated. Stokes's Law is only valid for spherical particles or droplets, and only in a laminar flow range.

An estimate of droplet sizes was made, and this along with an assumption of operating temperature was used with Stokes's Law to determine the rise rate of the droplets present, and therefore, the size of separator needed to perform the separation.

The separator was constructed of concrete, pre-cast and installed by Pre-Con Products Company. It includes concrete baffles and plastic inlet and outlet pipes. Separation media was provided by Mohr Separations Research, Inc.

The contract for supply and installation of the separator required testing the separator at simulated operating conditions.

TESTING

The test was conducted utilizing potable water under pressure from a local fire hydrant. The oil was injected under controlled conditions and the water-oil mixture was directed through a conditioning tube of known Reynolds number to thoroughly mix the two liquids before it was directed into the separator inlet pipe at a sewer inlet grating. The design of the test system was intended to closely simulate actual operations of the system, although the test was conducted using corn oil instead of jet fuel for environmental safety reasons. Corn oil has a somewhat higher specific gravity than jet fuel, therefore making the test a bit more rigorous. The use of oil injected at a set rate and conditioning tube of known turbulence (as evidenced by the Reynolds number in the tube) is a method paralleling that specified by the US Coast Guard and the International Marine Organization (IMO) for testing shipboard bilgewater separators. A test schematic is provided below in Figure 3.

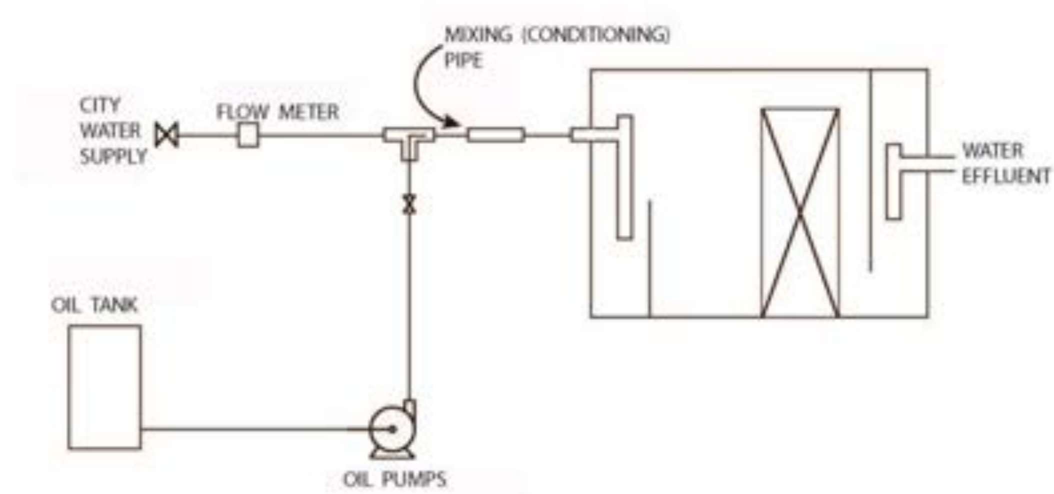

FIGURE 3 SCHEMATIC OF FLOWS DURING TEST

City water was obtained from a convenient fire hydrant. The normal fire hydrant valve was utilized to regulate the water flow rate. A test oil injection system was fabricated using PVC pipe and including a 1" turbine type flow meter (previously calibrated) with digital readout. This meter measured the water flow upstream of the oil injection point for accuracy and included a digital electronic readout of instantaneous flow, as well as total flow. The oil was injected into the conditioning pipe through an injection tee. The injection pumps used were two small electrically operated bellow type pumps operated in parallel to provide the appropriate flow rate. The pump stroke was adjusted to regulate the flow of oil to the injection tee. The conditioning pipe used was 2-1/2" schedule 80 PVC. A calculation of the Reynolds number and velocity in the conditioning pipe was made, indicating a Reynolds number in the pipe of approximately 19,000.

The first day of the testing, November 24, 1997, was spent preparing for the actual testing and the test was conducted on November 25, 1997.

During the testing, samples were taken at approximately 30-minute intervals. A redundant sample was taken each time the main sample was taken for use in the event of inadvertent sample loss. Instantaneous flow measurements were made at each sample time. At 12:30 AM (end of the test) the flow meter read 47.9 US GPM. The oil flow was tested again at the end of the test and found to be 78 ml/min. At 50 US GPM flow, this oil flow is equivalent to 412 mg/L.

Samples were taken and analyzed by an independent third party laboratory. Results of the test are summarized in the table below:

Ventura Camarillo Airport Fuel Farm Separator Test November 25, 1997			
Sample Number	**Time**	**Water Flow, US GPM**	**Effluent Oil Content, mg/L**
1	10:00	50.0	Non Detect
2	10:32	48.0	3
3	11:26	48.0	Non Detect
4	12:01	47.3	Non Detect
5	12:30	47.9	Non Detect

Note: Detection limit considered to be less than 3 mg/L.

Water temperature: 72°F (initial)
Water temperature: 74°F (final)
Water pH: 6.5

The test was attended by the third-party analytical chemist and representatives of the Airport Authority and the California EPA.

MAINTENANCE

Since the separator was installed in late 1997, maintenance has mostly consisted of yearly cleanings to remove accumulated oil and sludge. Minimal amounts of oil have been captured, and it is believed that this is because the fueling system is relatively new and is well maintained, keeping leakage to a minimum. Operators have been trained to be careful to avoid spilling, even small amounts of hydrocarbons, during fueling operations and are diligent in avoiding spills.

SUMMARY AND CONCLUSIONS

The fueling system was designed to minimize hydrocarbons getting into the environment from leaks and spills and the stormwater processing system was designed to capture any hydrocarbons that escape the design and operating precautions.

The separator was tested under conditions simulating the design conditions, and performed better than predicted. Several samples were taken at intervals and showed consistent results. No sheen was seen in the outlet of the separator, which tends to confirm the analysis results.

The overall system is working as designed, and maintenance requirements have been within reasonable limits.

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