



C.I.Agent EVAC Filtration System

Testing and Technology Report

Introduction:

C.I. AGENT SOLUTIONS EVAC Engineers are at the forefront of underground vault water filtration. We designed the first generation filters for some of the largest utilities in the nation. From their feedback, the second generation filter has now been developed that provides more flow with better filtering technology.

Will it Filter or Will it Flow?

This is the most difficult problem faced in designing a water filter.

The C.I. AGENT EVAC is a combination filter. It utilizes various barriers of differing sizes to keep the flow as high as possible for as long as possible. We create a tortuous path to build our filter cake as well as separate and suspend hydrocarbons. We further utilize solidification to increase capacity of hydrocarbon filtration. It is these two unique systems that make the C.I. AGENT EVAC Filtration System so effective. This is accomplished in a size that **one** utility crew member can handle, operate and dispose.

Engineering makes the difference in Performance

The use of high performance fabrics meticulously connected with performance based stitching allows the C.I. AGENT EVAC Filter to endure not only high flows but also higher pressures. The integrated use of CI Agent Hydrocarbon Solidifiers micro encapsulates oil in order to give the C.I. AGENT EVAC Filter the highest available hydrocarbon capacity in the industry.

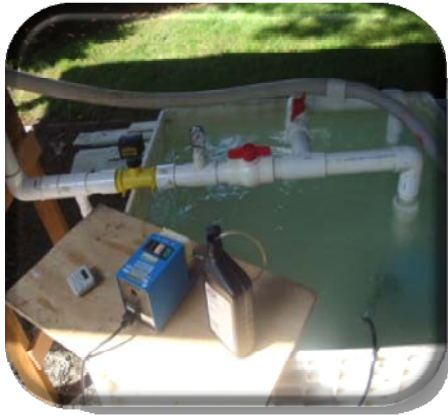
If the filter does not tell you, how do you know?

The C.I. AGENT EVAC Filter System also includes a Hydrocarbon Indicator Strip on the filter. Although it is suggested that the operators maintain observation over the pumping process, this Hydrocarbon Indicator Strip can aid in letting the operator know (many times before a sheen is visible) when the C.I. AGENT EVAC Filter has reached its hydrocarbon capacity.

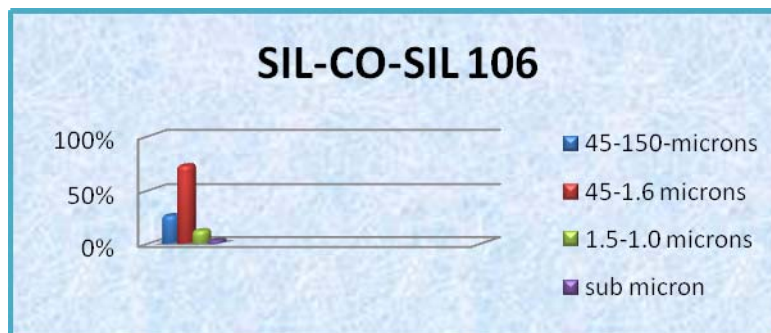
If it does not stay on the fitting, it cannot filter water

Not all fittings are created the same. The C.I. AGENT EVAC Filter fittings are specifically designed to offer the maximum mechanical advantage. They are outfitted with the tried and true interference fit approach. It simply uses a groove and a double locking band to maintain all layers of the filter media to the fitting. This groove maintains a uniform seal against the fitting in the largest available surface area. This does not allow water to bypass or allow the seal to come off the fitting. Finally the high performance based stitching is maintained throughout the individual fabric layers. We do not run one contiguous stitch throughout all of the layers. The layers are grouped together to perform the best bonding and maintain separation to not promote hydrocarbon migration from one layer to the next.

EVAC Testing for Oil & Grease and TSS Using Sil-Co-Sil 106



Full scale control testing was performed to determine the removal efficiency of standard reference sediment in a simulated vault dewatering operation. SIL-CO-SIL 106 is used as a BMP standard reference material, with **73** percent of its particles below **45** microns, **12** percent below **1.5** micron and, **3** percent being **sub** micron. Removal of 80% is considered acceptable for BMP regulatory performance.



Test Parameters

- The testing apparatus used two 340 gallon open top storage bins. One used as a mixed sediment vault and the other as a receiving drain. A plastic lined channel connecting the two bins, held the EVAC which was connected to a 150 GPM submersible centrifugal pump with 2inch hoses.
- The Reference sediment was added to 340 gallons of water with a re-circulating pump to insure suspension of the fine talc like sediment.
- Inline pressure gage, and turbine flow meter with rate and totalizer capability, monitored the duration of the test.
- A 3/4 inch bleeder valve was positioned after the flow meter and before the hose connection to get an accurate sample of the influent actually being delivered into the EVAC filtration unit.
- Samples taken with the bleeder valve, at the start, middle and end of the testing were combined to obtain the raw sediment value.
- Samples were taken in one minute intervals at the channels out fall.
- All analysis was run per EPA method 160.2 for total suspended solids.

Testing Results:

Sil-Co-Sil 106 TSS Study; EPA Method 160.2

Time Minutes	Flow GPM	Pressure PSI	TSS mg/l	Percent Removal
1	75	1	127.8	95.9
2	69	2	122.2	96.1
3	44	5	129.8	96.1
4	24	6	127.4	95.9
5	22	6	103.5	96.7
6	16	7	100.5	96.7
7	12	8	106.8	96.5
8	9.5	9	100.2	96.8
9	8.0	9	89.1	97.2
10	8.0	9	58.2	98.1

The initial raw concentration of Sil-Co-Sil 106 = 3,147.2 mg/l

The total volume of the SIL-Co-SIL water solution pumped was 330 gallons. The holding tank for the water and sediment was emptied, and the EVAC was still pumping 8.0 GPM.

Full scale testing of **Oil & Grease** removal was performed on the CI AGENT EVAC filtration unit with the following procedure.

Test Parameters

- Two 340 gallon bins were filled with water; two 80gpm submersible pumps were used with diversion valves to balance the flow between both bins.
- One of the pumps was connected with two inch piping, to an inline flow meter and pressure gage, coupled to the CI AGENT EVAC filtration unit housed within a channel which flows into the receiving bin (see photo).
- The outflow was controlled at 40gpm through the flow meter and EVAC filter unit into the receiving bin, which was balanced with same return flow back.
- Diesel and motor oil mixture 50:50 was injected into the transfer pipe behind the bleeder valve and the CI AGENT EVAC unit with a peristaltic pump.
- The peristaltic pump delivered 40 grams per minute of the diesel oil mixture into the system, and yielded an analyzed 268 mg/l of influent water stream into the CI AGENT EVAC unit for the full one hour test duration.
- Out fall samples were taken at specified intervals from the outfall flow before it entered the receiving water.
- Total oily water filtered was 2400 gallons at a constant 268 mg/l.

Testing results:

Oil & Grease Study; EPA Method 1664

Time Minutes	Total Flow Gallons	Pressure PSI	Oil & Grease mg/l	Percent Removal
Start	40	2.0	ND	100
5.0	200	2.0	ND	100
10	400	2.0	5.2	98.1
15	600	2.0	6.8	97.5
20	800	2.0	8.7	96.7
40	1600	2.0	10.4	96.1**
60	2400	2.0	15.8	94.1**

The continuous raw concentration of Oil & Grease = 268 mg/l

Total Oil pumped into system during the test = 2,343 grams or about 2.8 quarts

** Sheen of oil noticed.

ND = less than MDL of 5.0 mg/l

Batch Oil and Sediment Removal Efficiency Comparison



Vault mixing tank



before and after filtration

Test Parameters

- Oil and Sediment were added together in a 340 gallon storage bin and mixed with a circulation pump.
- One liter initial grab samples were taken in the batch tank under mixing conditions, for both Oil & Grease and TSS.
- The tank was pumped through the CI AGENT EVAC multistage filtration unit. The flow and pressure were noted on a minute basis; also Oil & Grease and Sediment liter samples were taken from the channel outfall each minute.
- Duration of the test was five minutes due to the high flow rate; total volume filtered was 330 gallons.
- The samples were analyzed by EPA Method 1664 for oil and Grease and Method 160.2 for TSS.

Cinder Clay Removal Rate; EPA Method 160.2

Time Minutes	Flow GPM	Pressure PSI	TSS mg/l	Percent Removal
1	70	1	17.8	99.5
2	69	2	12.2	99.7
3	65	2	11.8	99.7
4	64	2	10.4	99.8
5	62	2	9.5	99.8

The initial raw concentration of Cinder Clay = 4,247 mg/l

The total volume of the oil and clay water mixture pumped was 330 gallons. The holding tank for the water and sediment was emptied, and the CI AGENT EVAC was still pumping 62 GPM.

OIL & Grease Removal Rate: EPA Method 1664 Oil & Grease

Time Minutes	Flow GPM	Pressure PSI	Oil & Grease mg/l	Percent Removal
1	70	1	ND	100
2	69	2	ND	100
3	65	2	ND	100
4	64	2	ND	100
5	62	2	ND	100

The initial raw concentration of Oil & Grease = 3,211 mg/l

The total volume of the oil and clay water mixture pumped was 330 gallons. The holding tank for the water and sediment was emptied, and the CI AGENT EVAC was still pumping 62 GPM.

ND = less than MDL of 5.0 mg/l.

Conclusions: The CI AGENT EVAC multistage filtration unit, was tested for oil & grease and sediment removal efficacy separately, and combined together as normally found in a vault dewatering event. It is **extremely** important to realize that when oil and sediment are combined in a mixed batch closed system, a realistic raw sample cannot be obtained. This is because the extreme hydrophobic nature of the oil causes it to attach to the side walls of the container, float to the surface, and be adsorbed to the suspended sediment particles. This provides **very** favorable results since the actual oil content in the water may be reduced by 50-70 percent, while the oil adsorbed to the fine sediment particles makes them larger increases aggregation, greatly increasing filtration efficiency, while the oil is actually filtered out as a solid rather than a liquid.

The results from the combined sediment and oil batch mixed test are greatly improved compared to the removal efficiencies when the parameters are run separately. It is felt that the oil and grease testing should reflect what the filtration unit actually removes, not what the container walls, sediment and gravity separation remove. Accurately injecting a constant amount of oil into a constant influent stream into the CI AGENT EVAC filtration unit assures all the oil is delivered to the assembly, resulting in a realistic assessment of removal. Accurate initial samples can also be obtained from the bleeder valve using this test procedure.

The EVAC Filtration system is the second generation vault dewatering unit, designed for higher flow rates while still providing performance. The results for sediment and Oil & Grease removal run on a separate basis provide a more accurate assessment as to how the CI AGENT EVAC will perform in actual field use. If both sediment and oil are found enhanced performance will be a perk.