VortClarex®

Technical Design Manual

VortClarex Contents

Design and Operation

Basic Operation

Conventional oil/water separators operate on the principal of gravity separation, using baffles or T-pipe sections to retain free-floating oils. With their limited treatment capacities, they are only effective on oil droplets greater than 150 microns. The VortClarex® system builds on this conventional oil/water separator design by incorporating an innovative media designed to maximize the surface area available for the coalescing of oil droplets. A typically sized VortClarex is capable of removing oil droplets down to 60 microns.

The coalescing media or corrugated plates provide a surface onto which oil droplets coalesce. The calcium filled polypropylene media attracts oily substances because of its affinity for hydrocarbons (oleophilic). Oil droplets are then able to combine, forming larger droplets that rise to the surface more quickly - increasing the separation rate and reducing hydrocarbon levels in the effluent. When properly sized the VortClarex system will provide an effluent quality of 10 ppm (parts per million) or less for most stormwater applications.

Flow enters the VortClarex system via a non-clog diffuser that distributes it across the chamber width. The influent passes over a solids baffle wall where settleable solids drop out, reducing the amount of solids in the flow as it enters the coalescing media. As the flow passes through the media, oil droplets accumulate on the surface and come into contact with others to form larger, more buoyant droplets. These larger droplets rise upward through the media and are released near the water surface. The oil is trapped behind the outlet T-pipe, and treated water exits the system.

Design Process

Stoke's Law

Gravity separation occurs due to the difference in specific gravity between oil and water. The rate of this separation is calculated using a formula known as Stoke's Law. The formula predicts how fast an oil droplet will rise through water based on the droplet density, size and distance it must travel. Coalescing media improves the efficiency of oil/water separators by reducing the distance oil droplets need to rise before joining other oil droplets and rising to the surface. Once the oil comes in contact with the media, the oleophilic polypropylene material effectively removes it from the flow stream. Oil accumulates on the media surface, forming larger and more buoyant droplets that eventually break away from the media, rise to the water surface, and are trapped and isolated from the system outlet.

Stoke's Law Equations

The force needed to move a particle through a continuous fluid can be calculated using Stoke's Law.

$F=6\pi R\mu V_c$

R= radius of the sphere
μ = viscosity
V_c = velocity through a continuous fluid

This equation can be factored and rearranged to give Q_m/A_h – an important ratio used to determine the total horizontal separator surface area, given the design flow rate.

$$Q_m/A_h = c\,[(S_w-S_o)/\,\mu]$$

Q_m = design flow
A_h = horizontal separator area
c = factor dependent upon average particle size
S_w = specific gravity* of the water
S_o = specific gravity* of the oil
μ = viscosity of the water

* Specific gravity is a material's density divided by the density of water at a stated temperature.

Surface Loading Rate and Rise Rate

In order to properly design the VortClarex system, the surface loading rate must be compared to the critical rise rate, also known as the terminal velocity.

Surface loading rate equation:

$$\text{Surface loading rate} = \frac{\text{Design flow}}{\text{Horizontal separator surface area}}$$

Next determine the rise rate of the oil droplet:

$$V_t = (g/18\mu)(p_w - p_o)D^2$$

V_t = rise rate of the oil drop
g = acceleration due to gravity
μ = viscosity of the wastewater
p_w = density of the water
p_o = density of the oil
D = diameter of the oil droplet

Design of the VortClarex system should carefully consider all the aforementioned parameters.

According to the equation, larger diameter droplets of oil will rise to the water's surface faster.

If rise rate is greater than the surface loading rate, a majority of the oil droplets will reach the water surface and be trapped.

Treatment Capacity

Maintaining non-turbulent flow throughout the system allows for the maximum separation possible. Turbulent flow will disrupt the coalescing process, causing the system to perform inefficiently. The Reynolds Number, Re, is used to determine flow conditions:

$$Re = pVL/\mu$$

Re = Reynolds Number
p = particle density
V = particle velocity through a continuos fluid
L = characteristic dimension of the system
μ = viscosity of the wastewater

To maintain laminar flow conditions between parallel media plates, the Reynolds Number should be kept below 500.

The VortClarex system design conforms with the following hydraulic conditions and parameters:

- Hydraulic distribution of the influent flow must fully utilize the cross-sectional area of the media.
- Flow control and direction must be determined to prevent hydraulic short-circuiting around, under or over the media pack.
- Laminar flow conditions must be maintained (Re < 500) in order to effectively assist with oil droplet rise rate.[1]
- Horizontal flow-through velocities in the separator must not exceed 4 ft/min (1.2 m/min) or 15 times the rate of rise of the droplets, whichever is smaller.
- The media containment chamber design and the media plate angle/spacing must be sufficient to facilitate the removal of accumulating solids.
- Plates shall have smooth surface corrugations, and shall be angled at 45°.[1]

[1]Per the American Petroleum Institutes's (API) Publication 421 of February 1990.

Maintenance

Inspection

The VortClarex system should be checked periodically to determine if excessive amounts of solids and/or oils have accumulated. Solids accumulation in the lower sections of the VortClarex coalescing media will reduce oil removal efficiencies. Regular inspection and maintenance will eliminate any compromise in performance due to solids build-up.

After the first six (6) months of operation, the inlet area should be inspected and cleaned as follows:

1. Remove separator cover.
2. Dispose of separated oil per regulatory procedures.
3. Remove water from separator.
4. Clean the vault by flushing with a hose and examine the plates for blockage.
5. Remove accumulated sediment with a vacuum truck or positive displacement pump such as an air operated diaphragm pump. The sediment will contain hydrocarbons so proper disposal is required.

   Note: Measure and record the depth of the solids in the inlet chamber. If sediment level is 6 inches or more, the cleaning interval should be shortened. If the sediment is less than 6 inches deep, the interval can be increased.

Cleaning

The VortClarex coalescing media can be cleaned either while in the system or after removal from the system.

Cleaning in place

1. Using a water hose, direct spray (10-15 psi) into plate spacing on top of the plate packs.
2. Using a vacuum suction hose, remove any sediment or oily contaminants that are flushed out of the coalescing media.

Cleaning after removal

1. Pump all water and oily contaminants from the VortClarex system.
2. Remove coalescing media.
3. Place media on an impervious surface lined with 6 mil plastic sheeting surrounded by a berm to prevent discharge of contaminated water into surface or groundwater.
4. Flush media with water hose (10-15 psi) to remove heavy oil coating or sludge from between the corrugated plates.
5. Examine tank interior for damage and repair any damage to internal coating.
6. Re-Install plate packs one at a time, one row in length and one row in width, being sure the outer packs are adequately sealed against the vault wall in the same manner as before they were removed.
7. After all packs are installed, check to ensure that the packs are even and touching, forming one (or two if provided) rows of packs across the channel and that they are securely butted against the backing angle at the bottom of the separator. Install the upper channel to ensure the plates are secured in place.
8. Secure hold down channel ensuring it is snugly in place.
9. Check to see that there is no possibility of fluid bypassing around the plates and the side wall of the vault, as well as between plate pack assemblies, since this could adversely affect the efficiency of the separator.

Sample VortClarex Calculations

COALESCING PLATE "MPak" DESIGN EVALUATION

Facet International
a CLARCOR company

CUSTOMER:	CONTECH Stormwater Solutions	REFERENCE:	VCL40
CUST REF:	NA	DATE:	10/23/2006

CONTINUOUS FLUID

FLUID =	WATER
FLOW RATE (GPM) =	150
TEMPERATURE (F) =	50
VISCOSITY (Cp) =	0
DIS SLDS (K PPM) =	0
VIS CF (1) =	0
VISC CF USED =	1.000
VISC. USED (Cp) =	1.308
SPEC GRAVITY =	0
SPEC GRAV USED =	1.000

IMMISCIBLE PHASE

MATERIAL =	Oil
SPEC GRAVITY =	0.88
MEASURED @ DEG F =	60
SPEC GR @ OPER TEMP =	0.884
CONCENT - PPM =	100
MEAN - MICRONS =	130
STAND DEV =	2.5

PLATE PACK CONFIGURATION

PACKS WIDE (2)--NO =	4	NUMBER OF ROWS =	1
TTL WIDTH--INCHES =	48	FLOW PATH, INCHES =	24
HEIGHT (3)--INCHES =	48	PLATE SPACING-IN. =	1/2

OUTPUT DATA

PLATE/FLUID CHARACTERISTICS		EFFLUENT CHARACTERISTICS	Oil
FLOW RATE - GPM	150.00		
STACK FEET (4)	16.00	**PPM**	**< 10**
GPM/STACK FOOT	9.38		
FRONTAL AREA - FT2	16.00	**% REMOVED**	**90.0%**
PLATES VOLUME - FT3	32.00		
GPM/FT2 FRONTAL AREA	9.38	**SMALLEST DROPLET COMPLETELY**	
VEL IN PL-FT/MIN	1.42	**REMOVED (MICRONS)**	**57.5**
RES TIME IN PLATES-MIN	1.41		
PLATES/STACK FT	20.00	**COLLECTION RATE, LBS/HR**	**6.76**
TTL PLATE SURFACE, FT2	1920.00	**-GAL/HR**	**0.92**
FT2/GPM	12.80		
GPM/FT2	0.078	**CRIT SIZE -MICR(5)**	**378.7**
PRESS DROP- IN. WATER	0.006		
REYNOLDS NO. IN PLATES	93.2	**STOKES' LAW, FLOW(6)**	**VALID**
% LAMINAR LIMIT	4.7%	**STOKES' LAW, PART (7)**	**VALID**

NOTES: (1) VISC. CORRECTION FACTOR, FLUIDS OTHER THAN WATER, FRESH H20=1
(2) WIDTH PERPENDICULAR TO FLOW
(3) HEIGHT OF PLATES, MUST ADD SUPPORTS FOR TTL. HEIGHT
(4) ONE STACK FOOT = ONE FOOT OF PLATE = TWO CUBIC FEET
(5) CRIT. SIZE IS LARGEST SIZE DROP FOR WHICH STOKES' LAW VALID
(6) INDICATES STOKES' LAW VALID FOR LAMINAR FLOW BETWEEN PLATES
(7) INDICATES STOKES' LAW VALID FOR PARTICLE RISE

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CONTECH Stormwater Solutions Inc.

VortClarex Specifications

PART 1.00 GENERAL

1.1 INTRODUCTION

A. The VortClarex system, with the performance specifications as described in Section 2.2, shall remove essentially all free and dispersed, non-emulsified oil and settleable solids from an oil/water mixture at the specified flow rates and operating temperatures. The system design shall utilize the difference in specific gravity between oil and water (i.e., buoyancy force) to separate these fluids. The separation process shall be enhanced through the use of proprietary VortClarex coalescing media. The separator shall be designed to receive non-emulsified oily water by gravity or pumped flow and shall process it on a once-through basis. The system shall be a single wall, rectangular tank installed below grade.

1.2 DESCRIPTION

The VortClarex system shall be housed within a rectangular, precast reinforced concrete tank. Within the precast concrete vault, parallel-corrugated plate coalescing media shall be utilized to provide enhanced gravity separation of oil and water mixtures. The separator shall include a baffled inlet compartment, separation chamber, and clean water outlet chamber.

A. INLET COMPARTMENT
The inlet compartment shall be of sufficient volume to effectively reduce influent suspended solids, dissipate energy and begin separation. The inlet shall be comprised of a non-clog diffuser to distribute the flow across the width of the separation chamber. A sediment baffle will be provided to retain settleable solids and prevent sediment from entering the separation chamber.

B. SEPARATION CHAMBER
The oil separation chamber shall contain VortClarex coalescing media. The parallel corrugated plates shall be at a 45° angle with respect to longitudinal axis of the plate corrugations, and spaced ½-inch (13 mm) apart for removal of free oil 60 microns in size or greater, and settleable solids. System configuration shall not promote solids buildup on the plates, which may increase velocities and result in the discharge of an effluent of unacceptable quality.

Laminar flow with a Reynolds Number of less than 500 shall be maintained throughout the coalescing media over the range of operating flow rates (treatment through maximum conveyance flow), to prevent re-entrainment of oils with water. Flow through the coalescing media shall be cross-flow perpendicular to plate corrugations so that the oil collects and coalesces at the high point of corrugations and rises to the top of the media pack without clogging.

C. CLEAN WATER OUTLET CHAMBER
An oil retention baffle or inverted T-pipe section shall be provided to prevent free-floating oil from exiting the system.

D. PIPE CONNECTIONS
Internal SDR 35 piping shall extend through the external precast concrete wall of the vault. Influent and effluent pipes shall be connected to the VortClarex® pipe system by means of a Fernco type coupling.

1.3 QUALITY CONTROL INSPECTION

A. The quality of materials, the process of manufacture, and the finished sections shall be subject to inspection by the Engineer. Such inspection may be made at the place of manufacture, or on the work site after delivery, or at both places, and the sections shall be subject to rejection at any time if material conditions fail to meet any of the specification requirements, even though sample sections may have been accepted as satisfactory at the place of manufacture. Sections rejected after delivery to the site shall be marked for identification and shall be removed from the site at once. All sections that have been damaged beyond repair during delivery will be rejected and, if already installed, shall be repaired to the Engineer's acceptance level, if permitted, or removed and replaced, entirely at the manufacturer's expense.

B. All sections shall be inspected for general appearance, dimensions, soundness, etc. The surface shall be dense, close-textured and free of blisters, cracks, roughness and exposure of reinforcement.

C. Imperfections may be repaired, subject to the acceptance of the Engineer, after demonstration by the manufacturer that strong and permanent repairs result. Repairs shall be carefully inspected before final acceptance. Cement mortar used for repairs shall have a minimum compressive strength of 4,000 psi (28 MPa) at the end of 7 days and 5,000 psi (34 MPa) at the end of 28 days when tested in 3-inch (76 mm) by 6-inch (152 mm) cylinders stored in the standard manner. Epoxy mortar may be utilized for repairs.

1.4 SUBMITTALS

A. The Contractor shall be provided with dimensional drawings and, when specified, utilize these drawings as the basis for preparation of shop drawings showing details for construction, reinforcing, joints and any cast-in-place appurtenances. Shop drawings shall be annotated to indicate all materials to be used and all applicable standards for materials, required tests of materials and design assumptions for structural analysis. Shop drawings shall be prepared at a scale of not less than 3/16-inches per foot (1:75).

PART 2.00 PRODUCTS

2.1 MATERIALS AND DESIGN

A. Concrete for the precast VortClarex system shall conform to ASTM C 857 and C 858 and meet the following additional requirements:

1. The exterior wall thickness shall not be less than 6-inches (152 mm) or as shown on the dimensional drawings prepared by CONTECH Stormwater Solutions Inc. In all cases the wall thickness shall be no less than the minimum thickness necessary to sustain HS20 (MS18) loading requirements as determined by a Licensed Professional Engineer.
2. Sections shall have tongue-and-groove joints or shiplap joints and be sealed with a butyl mastic sealant designed to be resistant to fuel and oil such as ConSeal™ Brand CS-440 or approved equal. All joints will be above the resting water level.
3. Cement shall be Type II Portland cement, or approved equal, conforming to ASTM C 150.
4. All precast concrete sections shall be cured by an approved method. Sections shall not be shipped until the concrete has attained a compressive strength of 4,000 psi (28 MPa) or until 5 days after fabrication and/or repair, whichever is longer.

B. Coalescing media shall be manufactured by Facet International and be made of calcium carbonate filled polypropylene corrugated plates, with corrugation angles no less than 45° with respect to longitudinal axis of the plate corrugations. Plates shall be spaced at ½-inch (13 mm) intervals and be stacked and bound together with sturdy rods and supports to form modular plate packs.

C. Polyurethane elastomeric sealant shall comply with ASTM D-412 and GSA Specification TT-S-00230C, Type II, Class A and ASTM C-920, Type S, Grade NS.

D. Manhole frames and covers shall be provided by the manufacturer in the numbers and configurations as shown on the dimensional drawings prepared by CONTECH Stormwater Solutions. Casting for manhole frames and covers shall be in accordance with ASTM A48, CL.35B and AASHTO M105 and shall be Campbell Foundry Company, or approved equal, casting No. 1009A or No. 1012D custom forged with the CONTECH Stormwater Solutions logo and the words “Committed to Clean Water™”, unless specified otherwise on the shop drawings.

E. Hatchways shall be provided by the manufacturer in the numbers and configurations as shown on the dimensional drawings prepared by CONTECH Stormwater Solutions. Hatchways shall be made of steel or aluminum, and shall meet HS20-44 (MS18) loading requirements.

F. Brick or masonry used to build the casting and hatchway frames to grade shall conform to ASTM C 32 or ASTM C 139 and shall be installed in conformance with all local requirements.

2.2 PERFORMANCE

The VortClarex system shall remove essentially all free and dispersed non-emulsified oil from the water stream and produce a desired effluent based on an oil droplet typical of the site.

System Specifications

VortClarex Model	
Treatment Flow Rate	
Peak Flow Rate	
Effluent Target (for example, 10 ppm)	
Rim Elevation	
Invert Elevation	
Pipe Size/Material	

2.3 MANUFACTURER

The manufacturer of said VortClarex system shall have been regularly engaged in the engineering design and production of systems for the physical treatment of stormwater runoff for a minimum of 5 years.

Each VortClarex system shall be manufactured by Contech Engineered Solutions, or approved equal.

PART 3.00 EXECUTION

3.1 INSTALLATION

A. Each VortClarex system shall be constructed according to the sizes shown on the drawings and as specified herein. Install at elevations and locations shown on the drawings or as otherwise directed by the engineer.

B. Place the precast base unit on a granular subbase of minimum thickness of 6 inches (152 mm) after compaction or of greater thickness and compaction if specified elsewhere. The granular subbase shall be checked for level prior to setting and the precast base section of the vault shall be checked for level at all four corners after it is set. If the slope from any corner to any other corner exceeds 0.5% the base section shall be removed and the granular subbase material re-leveled.

C. Prior to setting subsequent sections place ConSeal™ brand CS-440 butyl mastic sealant, or approved equal in conformance with ASTM C 990-91, along the construction joint in the section that is already in place.

D. After setting the precast roof section of the VortClarex system, set riser sections to the height required to bring the cast iron manhole covers or hatches to grade, so that the sections are vertical and in true alignment with a ¼-inch (6 mm) maximum tolerance allowed. Backfill in a careful manner, bringing the fill up in 6-inch (152 mm) lifts on all sides. If leaks appear, clean the inside joints and caulk with lead wool to the satisfaction of the Engineer. Precast sections shall be set in a manner that will result in a watertight joint. In all instances, installation of the VortClarex system shall conform to ASTM specification C 891 “Standard Practice for Installation of Underground Precast Utility Structures”.

E. Holes made in the concrete sections for handling or other purposes shall be plugged with a non-shrink grout or by using grout in combination with concrete plugs.