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OCTAFORM TECHNICAL SUMMARY
PVC STAY-IN-PLACE FORMWORK + LINER
WATER & WASTEWATER CONTAINMENT

Ideal project fit matrix for consultants and specifiers:

- Application-specific performance requirements
- Service life
- O&M
- Installed cost comparisons
- Estimating guide

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PREPARED BY

JAMES CARTER

Global Practice Lead, Water & Environmental Solutions Octaform Systems Inc.

E: james.carter@octaform.com

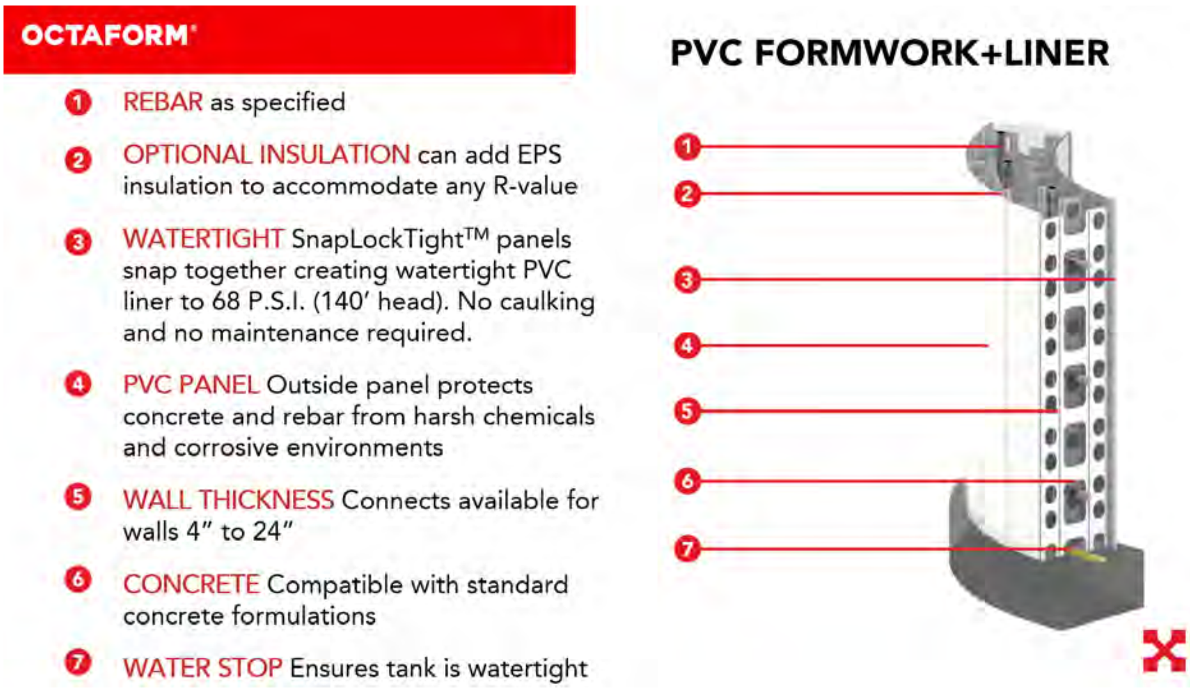
C: +1 (778) 997-3031

W: www.octaform.com

Technical Fit in Wastewater and Water Containment Applications

The following document offers a breakdown of ideal fit applications for Octaform PVC-lined concrete tanks. These tanks are built as a complete stay-in-place formwork system that includes a permanent water and gas-tight liner.

The system not only offers a liner but a composite effect, that provides additional structural protection on both the inside and outside of the structure, and improved curing, concrete hardness, compressive and flexural strength.



Octaform accommodates existing standard structural designs:

Octaform is regularly specified in place of traditional formwork with no design changes required and no negative impacts on the structural design. Any assumption – double-mats of re-bar, 3" spacing, various concrete mix designs, and keyways can all be accommodated. Similarly, for accommodating penetrations, anything designed with traditional formwork can be adapted with Octaform.

> **… but can offer opportunities for value engineering, adjustments to exposure classes, etc.:**
>
> Octaform is a permanent watertight liner that and offers several advantages structural engineers may want to account for. These are covered below with a summary table, following detailed applications and referenced studies.

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Technical Fit Evaluation Matrix for Octaform Stay-in-Place PVC Formwork + Liner

The following provides a high-level application/technical fit overview, with detailed descriptions and study documents referenced in the following pages for each application.

Application	Technical Fit	Installed Cost
Bare Concrete Containment. No chloride, H2S, or biofilm concern. No insulation	Octaform likely to extend service life, decrease the risk of leak and weather resistance ✓ Forming of certain designs can be less labor-intensive than traditional CIP forming and stripping ✓ Improved concrete performance due to complete concrete curing in a watertight permanent stay-in-place form. ✓ Added assurance - liner protects to 68 p.s.i. / 140' head. ✓ Additional assurance against leaks ✓ Improved seismic performance (increased hardness, flexural and compressive strength, and reduced spalling)	✓ Can be cost competitive on round tanks and often lowest total cost in rectangular tanks ✓ Value engineering consideration include possibility of removing admix in walls, reduced exposure class and possible reduction in steel density.
Any PU coated concrete. H2S, Chloride, or low pH issues.	Octaform offers improved service life, decreased maintenance versus CIP and precast concrete structures with polyurethane coatings. ✓ Proven low or no-maintenance service life ✓ PVC Liner is tested to 68 psi / 140' head pressure, inert to the majority of acids, salts, fats, bases and alcohols (i.e., H2S, chlorides). ✓ Resistant to corrosive sewage and waste.	✓ Most often lowest total cost solution. ✓ It is recommended for contractors engage directly with Octaform pre-estimation to ensure accurate takeoff assumptions and offer competitive bids.
Digesters – All Competitive Options **details in application overview section*	Octaform has proven out to be the best total solution in the majority of digester applications. ✓ Watertight, gas-tight PVC liner (Tested 68psi/140' head) ✓ Resistant to corrosive sewage and waste. ✓ Service life beyond 25 years with little maintenance ✓ Liner creates a watertight barrier protecting the tank from corrosion, cracking and leaks. ✓ PVC Liner is inert to the majority of acids, salts, fats, bases and alcohols (i.e., H2S, chlorides). ✓ Insulated digesters exceed performance expectations due to the thermal mass of concrete regulating temperatures + low thermal bridging.	✓ Lowest installed cost versus all other viable long-life, digester solutions. ✓ Lowest compare with PU+ Concrete, Lined Concrete, Glass-lined steel, Precast, etc. ✓ Lowest cost of rebar placement. ✓ Most often lowest finishing and sealing costs. ✓ Lowest cost of equipment rentals compared with all other solutions. ✓ Lowest overall shipping costs. (Ships flat and PVC is lightweight).
Potable Water Containment	Octaform is the best total solution in the **majority** of cases preferred by consultants and owners:	✓ Lowest total cost when any coating or membrane required

	✓ PVC has the lowest biofilm adhesion ✓ Watertight liner reduces the risk of leaks (140' head) ✓ Cracks, minor rock pockets, and cold joints will not lead to leakage ✓ Improved compressive & flexural strength of concrete from complete curing and composite effects with Octaform ✓ Significantly improves seismic performance. ✓ NSF Potable certified	✓ Lowest total cost compared to bare concrete with value engineering for liner and compressive strength
Aquaculture	Octaform is the best total solution in the majority of cases: ✓ PVC has the lowest biofilm adhesion. Biofilms and their propensity to transmit disease and off-flavor compounds are a major consideration in overall productivity, yields, and profits. ✓ Low porosity and abrasion, further reduce the risk of harm to fish and infection ✓ Acoustic dampening and reduction of fish stress (cortisol) have been indicated considerations compared to above-ground steel or fiberglass tanks ✓ Watertight liner reduces the risk of leaks (140' head) ✓ Cracks, minor rock pockets, and cold joints will not lead to leakage ✓ Improved compressive & flexural strength of concrete from complete curing and composite effects with Octaform ✓ Significantly improves seismic performance.	✓ Lowest total cost compared to fiberglass, glass-lined steel and PU lined concrete ✓ Reduced delivery times compared to fiberglass ✓ Reduced maintenance and risk compared to all formats

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Detailed Application Overviews

Bare Concrete Containment Vessels:

Octaform can offer owners a better total solution, which provides consultants and contractors peace of mind knowing they are providing a tank that will not leak and will require little to no maintenance.

Octaform can also be cost-competitive with bare concrete tanks provided some assumptions are applied in value engineering or the owner is willing to make a lifecycle evaluation. These must be done with a thorough review of studies and capabilities which are included in the appendices of this document.

Engineers' interpretations:

- ✓ Octaform offers a watertight stay-in-place liner and gas-tight to 68 p.s.i. or (140 feet of head) (Intertek 2008 study).
- ✓ This means reduced risk of leakage, even with a minor cracking event, inconsistencies, minor rock pockets, or cold joints. It also means many engineers choose not to use crystalline admix in the walls beyond the first lift. Others simply are looking for a longer-lasting tank with more assurance of leak protection.
- ✓ Octaform stay-in-place forms are watertight, increasing concrete hardness (up to 41%), eliminating drying shrinkage, cracking, and capillarization – all contributing factors to H_2S contamination, corrosion, and decreased service life.
- ✓ Octaform has a composite effect reducing spalling and failures. This further adds compressive, flexural strength and resistance to cyclic loads from seismic events.
- ✓ Reduction in exposure class as determined by an engineer.
- ✓ Other factors noted above can be considered for value engineering, or simply apply standard structural concrete assumptions.
- ✓ Octaform is regularly specified in place of traditional formwork with no design changes required and no negative impacts on the structural design.

Other Wastewater Considerations

In recent discussions, some owners and engineers have begun to consider the service life of equipment and possibility of detrimental impacts of erosion on introducing additional fines into the equipment leading to increased wear. To date, this is inconclusive but might be considered based on the specifics of your facility. We would like to hear more from consultants and owners on this.

Concrete + Membrane or Coating:

- ✓ Due to the permanent, zero-maintenance 68 PSI (140' head) liner, Octaform is not only often the lowest cost solution but offers owners the best overall performance.
- ✓ It is vital for Octaform to work with prospective contractors in the pre-bid phase to ensure they are confident in the system. Octaform offers extensive support to guarantee they understand how to estimate effectively, ensure reliable delivery on-time on budget and that they will have extensive on-site support. Octaform is designed and supported to safeguard contractors' success the first time they use it. In many cases, it can reduce project risk and timeline versus membrane applications.

Concrete + Insulation or Concrete + Coating + Insulation:

Octaform offers the lowest total cost of all available insulated and lined tanks, with equivalent or improved service life and performance.

- ✓ Permanent, zero-maintenance 68 PSI (140' head) liner
- ✓ Rapid and cost-effective incorporation of insulation within the formwork. Octaform is the best total solution at the lowest cost in the majority of insulated and lined tank scenarios, particularly digesters.
- ✓ High building efficiency due to low thermal bridging, increased temperature stability since the thermal mass of concrete is retained inside of the insulation which is ideal for optimal digester performance, and several other industrial and agricultural requirements.

Digesters and Other Scenarios with H2S

With tanks often requiring little or no maintenance beyond 20 years, Octaform is often not only the best total solution when compared to alternatives but it is the most cost-effective, often coming in at less total cost than concrete + coated tanks and significantly less than glass-lined steel and precast options.

When insulation is required, Octaform can be as much as 40% less total cost than other solutions. Owners have also reported that due to the thermal mass of concrete and on the interior of the insulation, Octaform maintains a level temperature and brings new feedstock up to temperature faster exceeding expected performance and profits.

- ✓ Octaform has over 250 digesters in service worldwide, several in the EU for over 20 years. These are regularly inspected with methane detection equipment; all are performing as new.

- ✓ PVC is inert to H2S and chlorides as well as most acids down to pH 2.7
- ✓ Octaform's stay-in-place liner watertight and gas-tight to 68 p.s.i. (140 feet of head)
- ✓ The majority of corrosion in digesters is in the gas space, Octaform lined tank walls address this. Standard polyurethane-coated floors, admixes, and water stops have proven effective for floor and floor joint connections
- ✓ Ceilings can be accommodated in flexible PVC roof systems or poured concrete with Octaform liner cast-in.
- ✓ Reduction in exposure class as determined by engineer.

Potable Water Containment

- ✓ With one, exception (copper), PVC has been found to have the lowest biofilm accumulation of all common containment surfaces. Several studies indicate PVC has the lowest adhesion of biofilms when compared to steel, stainless steel, glass-lined steel, fiberglass, polyurethane, or epoxy coatings and is second only to copper.
- ✓ Octaform reduces the risk of leakage due to cracking of concrete with 68 psi liner (140' head pressure)
- ✓ Octaform improves concrete curing and protects against corrosion or contamination
- ✓ Improved flexural and compressive strength.
- ✓ Reduces the effects of internal damage due to surface freeze-thaw adhesion and scour and reduce pressure on the tank from freezing

Aquaculture

- ✓ PVC has been shown to have the lowest rate of adhesion of biofilms and the easiest to ensure complete removal.
- ✓ Biofilm accumulations have a direct impact on disease fish mortality and ultimately overall annual yields in aquaculture. These factors need to be considered internally and may vary in each facility.
- ✓ The smooth fish-friendly PVC surface help prevent skin abrasions and infections to the fish which then further decreases the risk of disease and helps to increase stock mortality rates.
- ✓ Concrete is an effective noise barrier. Encasing porous concrete with a material like PVC effectively increases its sound insulating characteristics.
- ✓ Minimized downtime for cleaning and repairs.
- ✓ Liner unlikely to require any intervention in 20-25 years, but if required, would not be a significant event or even result in a leak.
- ✓ Reduced risk to flooding, floating, or seismic events compared to fiberglass or certain bolted steel designs.

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Value Engineering with Octaform

Octaform's tank technology is a robust solution that greatly increases the service life of concrete even in seismic zones. With added assurance of leak protection, corrosion resistance, and increased resiliency to the variability of quality adherence in the field.

Octaform offers a watertight membrane that is lab-tested to 68 PSI. This supports the opportunity for designers to apply reduced exposure classes. Some value engineering measures include:

- ✓ Reduced rebar area
- ✓ Elimination of crystalline waterproofing admixture within concrete
- ✓ Improved concrete performance due to prolonged curing time
- ✓ Reduced drying shrinkage, cracking, and capillarization
- ✓ No caulking, sealants, or cladding are required

Test Summary – Octaform Containment Tank Related Studies

Reduced Biofilm Adhesion (Appendix Q & R)
PVC is widely acknowledged in the water industry to have the lowest biofilm adhesion when compared to common alternatives – bare concrete, epoxy, and polyurethane coated concrete, fiberglass, glass-lined steel, and even stainless steel. In aquaculture applications, biofilms are a contributing factor to increased mortality and overall production yields not to mention occasional risks of catastrophic stock losses.

NSF certified for potable water (Appendix P: NSF Certification & Test Details)
Test detail shows no leaching and detectable amounts of all volatile organic compounds.

Certified food-grade CFIA approved (Appendix S: CFIA test)
Valid in USA & Canada food processing & aquaculture applications.

Improved sound attenuation in above-grade tanks versus fiberglass or steel alternatives.
Acoustic stress has shown in various practical studies to decrease production by up to 30%. (see Appendix I)

Seismic Performance (see Appendix A & G UBC Lab Tests)
Improved seismic performance versus cast-in-place concrete, tilt-up, and some precast options.
Seismic Testing of Reinforced Concrete squat wall with opening.
University of British Columbia (July 2007)

Watertight to 68 PSI or 140' head (see Appendix C – Intertek 2009 Test)
Octaform's permanent liner tested to 68 PSI / 140' of head pressure

Improved Concrete Hydration & Complete Curing (Appendix E)
Seattle University Effect of PVC Stay-In-Place Formwork on the Hydration of Concrete. Leaving watertight forms in place creates a **complete cure of concrete for improved compressive strength, fluid**

retention, and corrosion resistance. Completely cured concrete and stay-in-place watertight forms lead to reduced drying shrinkage, cracking, and capillarization further reducing risks of cracks or leaks, improving structural strength and service life of the tank. Cores often exceed a 40% increase in hardness.

Octaform Composite Behavior- Improved Compressive Strength (Appendix B)
BCIT 2009: Evaluation of the Compressive Strength Behaviour of the Octaform Concrete Forming System

Octaform Composite Behavior - Improved Compressive Strength (Appendix H)
University of British Columbia studies showed a compressive strength of on average of 31% with a minimum of 12%. This study was done with a short curing time. Field tests pulled after 3-6 months often show as much as a 60% increase due to prolonged curing.

Improved Seismic Performance (Appendix B)
University of British Columbia 2007: Seismic Testing of Concrete Squat Wall with Opening. The study showed Octaform composite behavior reduced cracking, spalling at joint, and failure when exposed to cyclic loading. Some cracking observed at 225% VERTEQ-II amplitude and significant structural cracking and spalling was observed at VERTEQ-II x 250%. By comparison, the CIP concrete control specimen completely collapsed at VERTEQ-II 200%.

Octaform Composite Behavior – Improved Flexural Strength (Appendix F)
University of Waterloo 2007: Flexural Behavior of Octaform Concrete Forming Systems. The report showed an increase in maximum load of 36%, ultimate load of 91%, and maximum deflection of 55% versus conventional cast in place stripped forms.

20 Year Limited Warranty
Octaform offers a 20-year limited warranty against leaks and corrosion of Octaform SLT tank liner panels and panel connections with no monitoring or maintenance requirements. Specific contract obligations are required including certification of installation by Octaform. Full details available upon request.

Additional Tests:

Resistance to Corrosion

Octaform protects reinforced concrete from corrosive environments; prevents re-bar corrosion and concrete deterioration. Tests performed at the University of Manitoba indicated that there was no reduction in flexural strength of reinforced concrete specimens when compared to control (unexposed) specimens even after exposure to a corrosive manure environment for more than 2 years.

Blast Loading

Reinforced concrete encased with Octaform's PVC forms is expected to significantly improve structural integrity under seismic loading and other extreme loading situations such as blast and impact. Preliminary blast studies by US DOD available upon request.

Fire Rating

Meets the 2-hour fire rating when tested on a pilot scale. Tested according to the following standards: UBC 7-1, ASTM E1 19-98, NFPA 251, and CAN/ULC S101-M89; Standard test methods for fire tests of building construction materials. *

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Flame Spread Test

Tested for flame spread according to ASTM E84-98 and CAN/ULC S102.2-M88; Standard for surface burning characteristics of flooring, floor covering, and miscellaneous materials and assemblies. *

Material	Standard	Flame Spread Classification	Smoke Developed Classification
Rigid PVC Concrete Wall Forming System	ASTM E84-90	35	120
	CAN/ULC S102.2-M88	20	175

Sound Transmission Test

An 8" thick Octaform wall has an STC of 54 when tested according to ASTM E90-2004, Standard Test Method for Laboratory Measurement of Airborne Sound Transmission Loss of Building Partitions" and classified in accordance with ASTM E413-2004, Classification for Rating Sound Insulation, and ASTM E 1332-90 (Reapproved 2003) entitled Standard Classification for Determination of Outdoor-Indoor Transmission Class.

Estimation Guide & Prices

The best way to determine total cost is to work with your Octaform rep. We offer complete Bill Of Quantities (BOQs) for your project. This includes a detailed, schedule-based labor break down with referenced efficiencies, time studies and videos to ensure you are confident in the efficiencies used.

These are helpful to estimators but also can be carried forward with our field service team and your project management team when completing the schedule. We offer full support in estimating, scheduling, and installation of your project.

Contact Your Sales Representative for Up-to-Date Pricing on Your Project

James Carter,
Director of Business Development, Global Practice Lead, Water & Environmental Solutions
Octaform
James.carter@octaform.com
Direct: 778-997-3031

Installation Costs

The following are based on several passed North American and European installations - Octaform round tanks install with productive, non-union crews. The ratio of skilled to unskilled labor is quite low, requiring about two senior formwork or framing specialists to ensure bracing is erected level, plumb, and to the correct radius. Follow-on labor, with supervision, can be low-skill.

Octaform supports projects worldwide with new crews and similar outcomes and offers extensive pre-design support for consultants, pre-bid support for contractors including detailed introductions and videos, pre-construction planning, on-site support, and certification of installations.

Estimation Guide:

Octaform preliminary estimates can be done with traditional structural design assumptions for cast-in-place concrete tanks. All standard rebar configurations, corners, gates, and weirs are easily accommodated. However as indicated, some value engineering is possible – review details below.

Rebar: Per standard structural design assumptions.

Concrete Mix Design: per standard structural design assumptions with consideration for permanent watertight gastight PVC liner. The following must be specified by the engineer:

Increase mix from 4” to minimum 6” slump with plasticizer. Pour within 40 minutes to ensure plasticizer is not setting up (add at the site if needed to ensure it is not in the truck too long). vibrate forms for tall tanks, and pencil vibration.
Maximum ½” diameter aggregate

Lifting Equipment

No cranes are required to lift Octaform forms into place.

Boom or scissor lifts are required for rebar placement utilization varies depending on the length and diameter of rebar being handled. One week per machine is usually sufficient for tanks less than 50’ diameter. Be cautious to estimate weather delays.

Table 1: Lifting Equipment

Tank Diameter	Days
< 50’	3-4
50-100’	5-8
101-200’	10-12 days
200’-260’	14-16 days
***Number of units and crews placing concurrently varies per project**	

Bracing Design:

Octaform is concrete formwork and is engineered to support concrete pour in 1-1.5-meter (4’-4.5’) lifts per hour requiring no additional forming.

Bracing is required to place the forms in the correct place and ensure that the forms are secured from wind loading and are only required on the inside of the structure. This allows for low clearance construction.

Stick-Framed Bracing & Catwalk to 20’ in Height

Octaform installation guide includes detailed bracing designs to 20 feet in height. Beyond 20’ in height, scaffolding should be estimated by a regional contractor. Be sure to ensure these designs are compliant with regional safety guidelines and fall arrest protection is used where required.

Table 2: Stick Framed Bracing - Unit Cost of Construction Materials

Item	Quantity Per 8’ Bracing Segment	Unit
2” x 4” x 8’	4 pcs	pcs
2” x 4” x wall height	4 pcs	pcs
2” x 12” x 8'	1 pc	pcs
½” x 4’ x 8’ plywood sheets (fashioning 6” bracing strips)	1/4 sheet	pcs

Screws 3" long enough shank to spin through bracing and pull form tight	8	pcs
Framing Nails	24	pcs

Erection timeline noted in the charts below.

ICF Bracing

ICF braces are easily utilized, refer to the installation guide for details. Total erection time including top bracing is approximately 8 linear feet per hour for tanks and 18 per hour for straight walls.

Scaffolding:

Scaffolding must be designed to accommodate connection to the formwork at the top. The bottom can be braced to the base or the slab. The scaffolding engineer must calculate for wind loading considerations and include tie-off details for the re-bar if this is required for regional compliance.

A deck can be placed 3' below the top of the tank for pouring and safe material handling, or flush to support the ceiling.

Octaform Installation – Labor:

Bracing

Octaform installation guide includes detailed designs for bracing formwork against scaffold, or very efficient 2x4 stick-framed brace plus pour deck or ICF designs up to 20' in height.

Complete Wall Erection:

Octaform complete wall erection scope includes:

- ✓ complete formwork erection
- ✓ typical penetrations for piping and mixers, door accommodations, etc.
- ✓ rebar placement and tie-offs
- ✓ pouring concrete
- ✓ cleanup forms
- ✓ remove bracing

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Productivity Illustrated: Based on primarily North American productive crews. Mostly non-union.

Table 3: Complete Wall Erection – Labor

	24' - 80' diameter		>80' diameter	
Bracing Set-up	**First Tank**	**Additional Tank(s)**	**First Tank**	**Additional Tank(s)**
Stick Framed Bracing & Catwalk	5.5 LF/hr	6.5 LF/hr	5.5 LF/hr	6.5 LF/hr
ICF Bracing	12 LF/hr	12 LF/hr	12 LF/hr	12 LF/hr
Bracing to Existing Scaffolding	15 LF/hr	17.5 LF/hr	17.5 LF/hr	17.5 LF/hr
Complete Wall Installation (SLT Watertight panel 1-side)	**First Tank**	**Additional Tank(s)**	**First Tank**	**Additional Tank(s)**
New Crew	8.5 sf/hr	9.25 sf/hr	9 sf/hr	11.5 sf/hr
Experienced Crew	9.25 sf/hr	11.25 sf/hr	9.75 sf/hr	12.25 sf/hr

Table 4: Complete Wall Erection – Same Size Tank Arrays Beyond 5 (for subsequent tanks)

	Tank Arrays Beyond 5
Bracing Set-up	**18'-60' diameter**
Stick Framed Bracing & Catwalk	8 LF/hr
ICF Bracing	12 LF/hr
Bracing to Existing Scaffolding	17.5 LF/hr
Complete Wall Installation (SLT Watertight panel 1-side)	**> 24' diameter**
New or Experienced Crew	12.25 sf/hr

Table 5: Placing EPS Insulation

	Tanks All Sizes
New or Experienced Crew (uniform productivity any size or volume)	80 sf/hr

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Appendix A

Seismic Upgrade Using Octaform Restoration and Repair System

University of British Columbia (June 2010)

Objective of Test

To test CMU walls retrofitted with Octaform under cyclic loading.

Significance and Main Findings

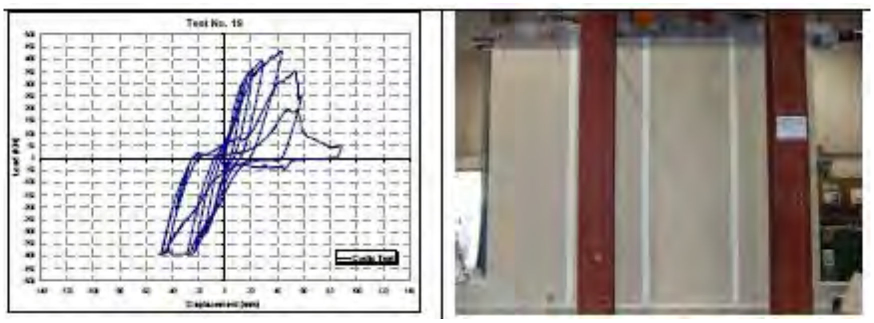
The Octaform System was used to seismically retrofit two concrete masonry unit (CMU) walls within the University of British Columbia's Innovative Retrofit Testing Program as a potential solution to the B.C. Seismic Mitigation Program. Retrofitted walls were subjected to cyclic loads applied through a lateral force along the top of the wall. The Octaform retrofitted wall reached a shear resistance of 450kN, well above all other retrofit strategies, and only experienced minimal hairline cracks.

Detailed Findings

A steel plate was anchored along the top of the wall which attached to the loading arm. Displacement and loads were recorded as shown in the figures below:

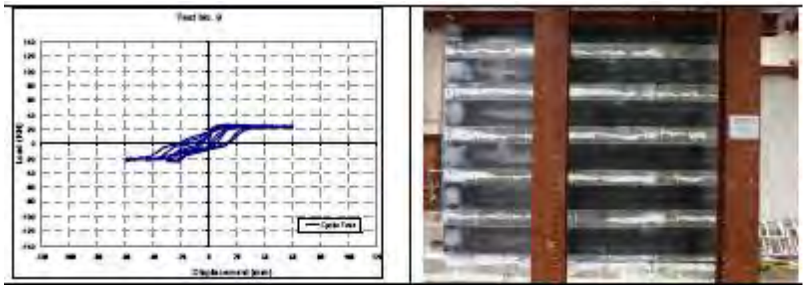
Load-Displacement Curve for Octaform Test Wall #1: Three anchor dowels at each edge

The first Octaform test wall lifted off the base due to insufficient anchorage between the Octaform wall and foundation, therefore the test was stopped before the capacity of the wall could be determined.



Load-Displacement Curve for Octaform Test Wall #2: Five anchor dowels at each edge

The second Octaform test wall contained additional anchors, and reached a maximum shear resistance of around 450kN, which was the maximum capacity the testing device could measure. The wall reached a ductility of about 3%, and showed only minimal hairline cracks along the mortar between the CMU blocks. In comparison, conventional unreinforced CMU walls typically only have a shear capacity of about 30kN, and a test wall retrofitted with Fibre-Reinforced Plastic (FRP) strips shown below only reached a shear capacity of about 20kN.



Load-Diplacement Curve for FRP Test Wall

Background of Test

- Two CMU block walls (stacked block pattern and running bond pattern) with dimension 3m x 3m (10 ft x 10 ft)

Method

The CMU blocks in the first wall were aligned using a stack pattern while the second had a running bond pattern. On both walls, PVC straps were attached to the CMU wall by metal fasteners and served as an attachment method for the Octaform connectors (2 inch) and panels. Steel reinforcing bars (10M) were placed, then grout was poured within the 2 inch wide space to bond the CMU wall to the Octaform System.

10 ft x 10 ft wall using grouted CMU construction block.

H-connectors were drilled into the wall with a 6" spacing between connectors.

2" connectors slid into H-connectors. Dowels were drilled into the concrete footing as anchors. Rebar was added.

Octaform Finished Panels were slid into the 2" connectors.

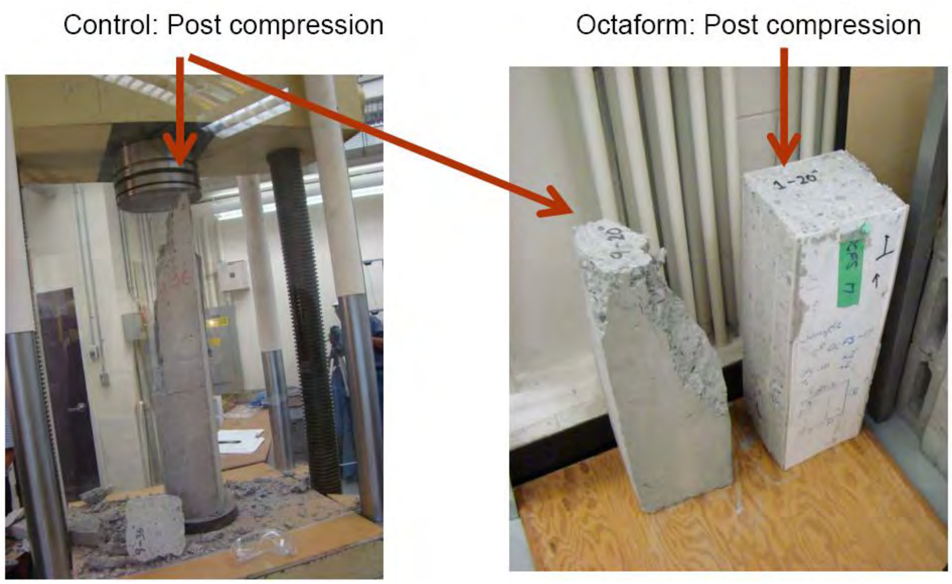
Custom grouting mixture supplied by Vector was placed into the form.

The wall was left to cure for a week prior to testing.

Appendix B

Evaluation of the Compressive Strength Behaviour of the Octaform Concrete Forming System

British Columbia Institute of Technology (April 2009)



Objective of Test

To investigate the compressive strength and the additional load carrying capacity of columns encased with Octaform Forming Systems.

Significance and Main Findings (Phase 1)

Phase 1 tested square columns of three varying heights. Octaform Systems PVC encasement increased the compressive strength of columns up to a maximum of 31%, and on average by about 12% depending on the configuration type. Tests showed that configuration I and II were the strongest in resisting compressive loads. Although control specimens failed in a brittle manner, Octaform columns experienced minimal spalling and were able to continue to carry the load after the peak load was reached, indicating an enhanced energy absorption capacity.

Significance and Main Findings (Phase 2)

Phase 2 tested rectangular columns of one height rather than square columns in order to force bending to occur. During testing, the Octaform column moved away from the actuator axis, therefore the column needed to be re-loaded several times. This resulted in the Octaform column having lower compressive strengths than the controls for Batch 1. Batch 2 had a lower concrete compressive strength, and in this case Octaform configuration II reached a higher compressive strength compared to the control.

However, the failure modes were similar to Phase I as the the control specimens failed suddenly in a brittle and sudden manner, while Octaform columns remained in one piece due to the confinement that the PVC panels provide to the concrete.

<u>Phase 1</u>

Background of Test

- 15 unreinforced square columns tested for compressive resistance
- Three column heights: 500mm (20 inch), 915mm (36 inch), 1.8m (72 inch)
- Cross sectional dimensions: 150mm x 150mm (6 inch x 6 inch)
- 4 column configurations using Octaform Systems PVC panels
- Control specimens contained only concrete

Size	Height	Configuration Type
6" x 6"	20", 36", 72"	Control
		Configuration I
		Configuration II
		Configuration III
		Configuration IV

Properties

Concrete slump: 180mm (7 inch)

Air content: 2.8%

Concrete compressive strength (28 day): 38MPa (5.5 ksi)

Method

- Specimens cast vertically in plywood forms
- Concrete poured, vibrated
- Cylinders cast for compressive strength tests

<u>Phase 2</u>

Background of Test

- 6 unreinforced rectangular columns tested for compressive resistance to analyze behavior and used to model the stress-strain and load capacity
- One column height: 915mm (36 inch)
- Cross sectional dimensions: 150mm x 100mm (6 inch x 4 inch)
- Unsymmetrical columns were tested to force bending about one plane
- Two column configurations using Octaform Systems PVC panels
- Two types of concrete mixes: Batch 1 with concrete compressive strength two times that of Batch 2
- Control specimens contained only concrete

Size	Height	Configuration Type
6" x 4"	36"	Control
		Configuration I
		Configuration II

Properties

Concrete slump: 30mm (1.2 inch) (Batch 2)

Concrete compressive strength (28 day): 18MPa (2.6 ksi) (Batch 1), 9MPa (1.3 ksi) (Batch 2)

Appendix C

ITS Intertek Testing Services
ETL SEMKO

Water Resistance of Panel Snap-Tight-Lock 3 inch Width System

Intertek Testing Services (October 2008)

Objective of Test
To test the water tightness of an insulated Octaform concrete wall system under a water resistance test.

Significance and Main Findings
The Octaform Panel Snap-Tight-Lock PVC system when sealed with Chem-Calk 2020 withstood a maximum water pressure of 6psi and 68psi after a curing period of 24 hours and 96 hours, respectively.

Background of Test
- 4 to 5 PVC Snap-Tight-Lock panels were connected together, using different sealants on the joints (Chem-Calk 2020, NuFlex Silicone, Rubber Gasket)
- Water resistance was tested in accordance with AATCC 127-1998, with a modified procedure to accommodate the sample

Appendix D

Determination of Physical Properties: PVC Interlocking Hollow Forming Elements for Concrete

Cambridge Materials Testing Limited, & Intertek (March 2008)

Objective of Test

To investigate the mechanical properties of the PVC used in Octaform Systems. Tests included impact resistance, tensile properties, modulus of elasticity, heat deflection temperature, coefficient of linear thermal expansion, weatherability, and durability.

Significance and Main Findings

The impact resistance results on PVC samples prior to weathering are as follows:

Drop Dart Procedure A (Mean Failure Energy)	**Room Temperature**	**-30 °C**
Nominal Specimen Thickness	47.8 mils (1.21 mm)	47.6 mils (1.21 mm)
Mean Failure Height	6 inch	5.7 inch
Mean Failure Energy	48 in-lbf (5.42 J)	45.6 in-lbf (5.15 J)
Normalized Mean Failure Energy	1 in-lbf/mil (4.5 x 10^3 J/m)	0.96 in-lbf/mil (4.3 x 10^3 J/m)

Drop Dart Procedure B (Mean Brittle Failure Energy)	**Room Temperature**	**-30 °C**
Nominal Specimen Thickness	47.8 mils (1.21 mm)	47.6 mils (1.21 mm)
Mean Brittle Failure Height	6.75 inch	5.7 inch
Mean Brittle Failure Energy	54 in-lbf (6.10 J)	45.6 in-lbf (5.15 J)
Normalized Mean Failure Energy	1.13 in-lbf/mil (5.0 x 10^3 J/m)	0.96 in-lbf/mil (4.3 x 10^3 J/m)

Percent retention of impact resistance after exposure to outdoor weathering:

	Exposure Duration		
	6 months	**12 months**	**24 months**
Ohio	102	107	100
Florida	101	93	89
Arizona	107	97	48

To quantify the durability of the PVC, the percent retention of impact resistance after exposure to 2000 hours of accelerated weathering was found to be 109%. The CCMC Technical Guide specifies an 80% minimum retention of the original impact resistance. The high percentages indicate PVC's ability to retain its resistance and percentages above 100% show that the resistance increased after exposure to weathering. As shown in the table above, the PVC met the criteria in all exposure situations except for the 24 month exposure in Arizona.

Other properties of PVC tested are compared to the CCMC criteria:

	Average	**Criteria**	**Criteria Met?**
Tensile Strength	46.1 MPa (6690 psi)	> 37.7 MPa (>5500 psi)	Yes
Modulus of Elasticity	2970 MPa (431,000 psi)	> 2800 MPa (>377,000 psi)	Yes
Deflection Temperature	71°C (160 °F)	> 70°C (158°F)	Yes
Coefficient of Linear Thermal Expansion	3.8×10^{-5} cm/cm/ °C	< 6×10^{-5} cm/cm/ °C	Yes

Background of Test

- 200 samples of PVC interlocking hollow forms of dimension 150mm x 150mm (6 inch x 6 inch) were tested
- Properties measured were impact resistance (Notched Izod and Drop Dart tests), tensile properties, modulus of elasticity, heat deflection temperature, coefficient of linear thermal expansion, weatherability, and durability

Method

- Testing was conducted according to the technical requirements found in "Physical Properties of PVC Elements" from the CCMC Technical Guide: PVC Interlocking Hollow Forming Elements for Concrete (Noncombustible Construction), Masterformat Section 03134 and ASTM methods

Appendix E

SEATTLE UNIVERSITY

Effect of PVC Stay-In-Place Formwork on the Hydration of Concrete

Seattle University (August 2007)

Formwork Bracing System

Objective of Test

To investigate the effects of the Octaform PVC panels on the hydration of concrete and strength development.

Significance and Main Findings

The Octaform Finished Forming System acts as an insulator, allowing moisture and heat generated during the hydration of cement to be contained. In addition, fly ash with insulation used in combination with Octaform produces hydration conditions which yield higher compressive strength than a conventional wood formed wall with normal concrete mix and no insulation. This would make Octaform attractive in terms of cost and environmental advantages by requiring less cement material.

Tests showed that the difference in temperature development between normal concrete and fly ash mixes using conventional wood formwork is 49%, while for an Octaform System it is only 31%. This may indicate that the Octaform system may contain more moisture and develop more heat relative to wood formwork during the hydration process when fly ash is used.

Finally, the addition of the Octaform System eliminates the absorption of water by the form, which is typically common with wooden formwork.

Background of Test

- Walls (formed with Octaform Systems or conventional wood formwork) were subjected to thermal and compression tests
- Variables adjusted were formwork material, wall thickness (100mm (4 inch), 200mm (8 inch), or 300mm (12 inch)), concrete composition (with or without fly ash) and insulation (with or without)
- 8 wall samples were tested for temperature and strength

Method

- Temperature of concrete was monitored to measure the extent of the hydration process
- Strength of concrete was determined by measuring the compressive strength

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Appendix F

University of Waterloo

Flexural Behavior of Octaform Concrete Forming System

University of Waterloo (July 2007)

Objective of Test

To investigate the flexural behavior of beams formed with Octaform Forming System in comparison to regular concrete beams.

Significance

Tests suggested that the Octaform System has properties which increase the ultimate load, cracking load, yield load and deflection. This allows structures produced with the Octaform System to carry more load and behave in a more flexible manner. Even Octaform beams without reinforcement showed greater load capacity in comparison to regular unreinforced beams, indicating that the PVC panels contribute to an increase in flexural strength.

Main Findings

The table below shows the percent increase in load and deflection for Octaform specimens with and without reinforcement and for varying beam depths in comparison to regular concrete beams:

	Increase in Cracking Load (%)	Increase in Ultimate Load (%)	Increase in Yield Load (%)	Increase in Maximum Deflection (%)
150mm (6 inch) without reinforcement	36	-	-	-
200mm (8 inch) without reinforcement	18	-	-	-
150mm (6 inch) with reinforcement	36	36	65	24
200mm (8 inch) with reinforcement	36	36	91	55

In terms of connector configurations, there was no difference in performance between the two types of connectors (middle connectors or 45 degree connectors) when used separately. However, Octaform specimens (without reinforcement) showed higher increases in maximum and yield loads when both types of connectors were used rather than just one type. The presence of both types of connectors increased the rigidity of the system.

Comparing the Octaform beams with and without reinforcement, the presence of steel reinforcement increased the number of cracks but decreased the width of the cracks, and increased the maximum load capacity by 197% (for specimens with both connectors or with inclined connectors).

Detailed Findings

Control specimens (concrete with reinforcement) had flexural cracks which appeared in the mid span of the specimen, load capacity increased steadily, followed by yielding of the steel reinforcement, and finally failure due to concrete crushing in compression.

Octaform specimens (without reinforcement) had flexural cracks which appeared in the mid span of the specimen, load capacity increased and dropped as new flexural cracks formed, followed by yielding of the tension PVC panel, and finally failure due to the tension panel rupturing.

Octaform specimens (with reinforcement) had flexural cracks which appeared in the mid span of the specimen, load capacity increased steadily, followed by yielding of the steel reinforcement, yielding of the tension PVC panel (at which point the load ceased to increase), and finally failure due to concrete crushing in compression and buckling of the compression PVC panel.

Typical Rupture of Octaform Panels

Background of Test

- 24 beam specimens (12 combinations with duplicate specimens of each) subjected to four point bending
- 305mm (12 inch) wide by 2500mm (96 inch) long beams
- Variables adjusted were beam depth 150mm or 200mm (6 inch or 8 inch), steel reinforcement (none or 2-10M bars (#3 size bar)), connectors (middle connectors or 45 degree connectors)
- All control specimens contained reinforcement (placed on the tension side)
- Four point bending spanning 2100mm (83 inch) with loads placed 700mm (28 inch) apart

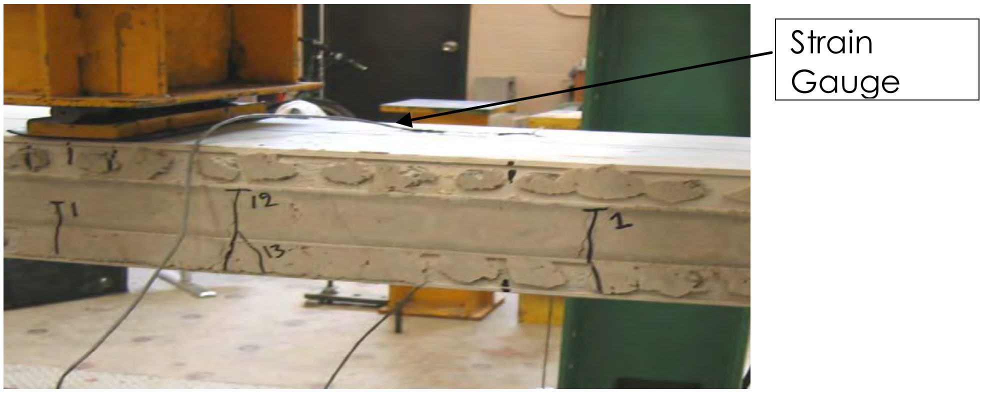
Properties

Concrete slump: 180mm (7 inch)
Concrete compressive strength (28 day): 25MPa (3.6 ksi)
Steel yield strength: 400MPa (58 ksi)

Method

- Specimens cast vertically in plywood forms
- Concrete poured, vibrated, then cured with wet burlap
- Load applied using a servo-hydraulic actuator, deflection measured with a Linear Variable Differential Transformer (LVDT), strain in panels measured using

electrical strain gauges
- Each specimen tested until failure (25% drop in load compared to maximum load achieved)



Strain gauge installed on the midspan section

Test Setup

Appendix G

Seismic Testing of Reinforced Concrete Squat Wall with Opening

University of British Columbia (July 2007)

Octaform System vs. Control Test Wall (painted white to view cracks)

Objective of Test

To investigate the behavior and seismic resistance of an Octaform System concrete wall under lateral loads.

Significance and Main Findings

Tests showed that the wall constructed with the Octaform System had a higher lateral load capacity, higher stiffness, less surface cracking, smaller crack widths, and resistance against spalling compared to a regular reinforced concrete wall. This makes the Octaform Finished Forming System a favorable choice for structures produced in high seismic.

Detailed Findings

The regular reinforced wall developed flexural cracks in the columns and beams at the location of the vertical reinforcements, surface spalling, and collapse occurred at 200% of the amplitude of the experimental earthquake due to a crack at the bottom of the clear length of a column. For the Octaform Wall System, the first flexural crack occurred at 225% of the experimental earthquake. Flexural cracks occurred at the location of the centre line of each Octaform panel and no cracks formed in the column.

Background of Test

- Two reinforced concrete squat walls of thickness 0.1m (3.9 inch)(one with and without Octaform System) were subjected to dynamic loads on a shake table test
- Wall dimensions: 2400mm x 2400mm (94 inch x 94 inch) with a centre opening of 1600mm x 1300mm (63 inch x 51 inch)
- 10M (#3 size bar) Horizontal and Vertical Reinforcement

Method

- Wall was bolted to the foundation with high strength threaded steel rods to produce a rigid connection
- Accelerometers and transducers measured the acceleration and displacements, respectively
- Walls subjected to a synthetically generated earthquake acceleration record and applied at increasing amplitudes

Properties

Concrete compressive strength (28 day): 32MPa (4.6 ksi)
Steel yield strength: 400MPa (58 ksi)

Appendix H

SEATTLE UNIVERSITY

Effect of PVC Stay-In-Place Formwork on the Mechanical Performance of Concrete

Seattle University (May 2006)

Octaform Cube Under Axial Load

Control Cube Under Axial Load

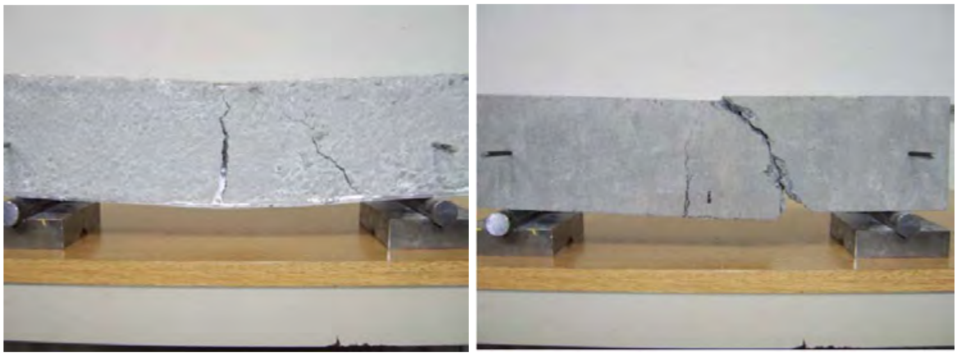
Objective of Test

To investigate the effect of the Octaform System on the mechanical properties of concrete (flexural, compression, hydration).

Significance and Main Findings

Tests showed that Octaform Systems enhance the mechanical properties of concrete due to the presence of the PVC panels and connectors. Results indicated an increase in the moment capacity and toughness by over 50%, and an increase in the compressive strength by 30% compared to systems without Octaform. The increase in compressive strength is likely due to the PVC panels acting to confine the concrete.

The results in this preliminary test did not show any enhancement in the hydration process with the use of Octaform (however further testing proves otherwise in Seattle University's research in 2007). The results did not differ significantly between different configurations.

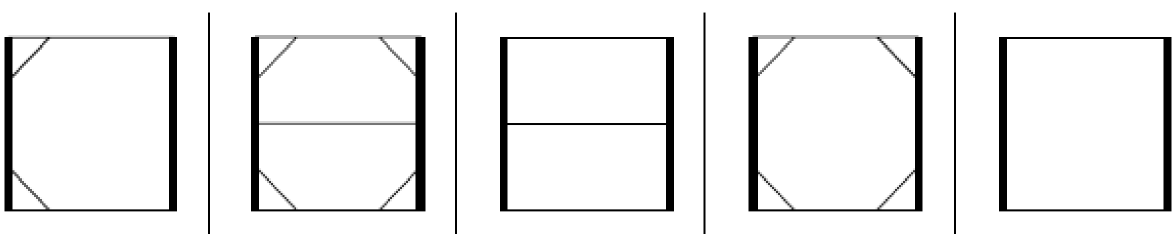


Octaform (left) vs. Control Beam in Flexure and Shear Cracking in Reinforced Specimens

Background of Test

- Tested for compression, flexure, thermal properties, and the influence of formwork on the hydration process
- 5 different Octaform configurations and a control specimen
- A typical test series contained 6 replications of each configuration
- 1 test series was for compression tests and 2 test series were for flexural tests (one series with reinforcement)
- Compression cubes of dimensions 150mm x 150mm x 150mm (6 inch x 6 inch x 6 inch)
- Flexural beams of dimensions 150mm x 150mm x 600mm (6 inch x 6 inch x 24 inch)
- 10M (#3 size bar) reinforcement used where applicable

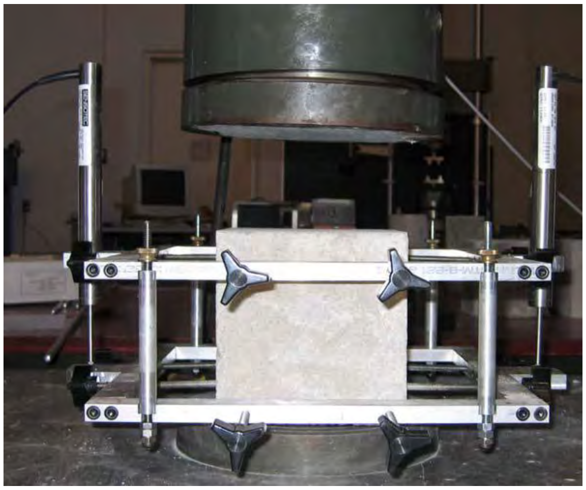
Configuration Types:



Method

- Compression tests were performed on concrete cubes
- Flexure tests were performed on concrete beams (with or without steel) under

3 point bending (load applied at mid span)
- Thermal tests were performed by monitoring temperature in concrete cubes during casting over a 72 hour period



Compression Test Fixture to Measure Modulus

Appendix I

ITS Intertek Testing Services
ETL SEMKO

Sound Transmission Loss Test and Classification of an 8 Inch Thick Concrete Filled Octaform Wall System

Intertek Testing Services (May 2006)

Objective of Test

To determine the sound-insulating property and to rate the ability of an Octaform wall system to reduce the overall loudness of ground and air transportation noise.

Significance and Main Findings

There is no pass-fail criteria for these tests and the values obtained for the Octaform wall system are as follows:

Sound Transmission Class (STC) = 54
Outdoor-Indoor Transmission Class (OITC) = 46

These values can be used in order to compare the sound and noise reducing properties with other materials and building elements. In general, higher values indicate higher sound insulating properties.

The STC value describes the decibel reduction in noise that a partition can provide. Typical interior walls in residential wood stud frame buildings using 25.4mm (1 inch) drywall have an STC of about 33. In comparison, concrete walls of thickness 100mm to 200mm (4 inch to 8 inch) have higher STC values ranging from 40 to 50. An STC value of 54 for the 200mm (8 inch) thick Octaform concrete wall indicates that the PVC contributes in attenuating sound. An STC value of 54 is equivalent to a partition constructed of a single layer of 12.7mm (½ inch) drywall glued to a 200mm (8 inch) thick concrete block wall and painted on both sides.

The OITC standard is used to rate the transmission of sound between outdoor and indoor spaces, and targets lower sound frequencies (down to 80 Hz) that capture ground and air transportation noise. It is a newer rating system used to assess exterior partitions that are exposed to traffic noise. For example, glass windows typically have an OITC range of 20 to 30. A typical 89mm (3.5 inch) steel stud wall with insulation and 12.7mm (½ inch) drywall has an OITC of about 40. In comparison, the 200mm (8 inch) thick Octaform concrete wall has an OITC of 46.

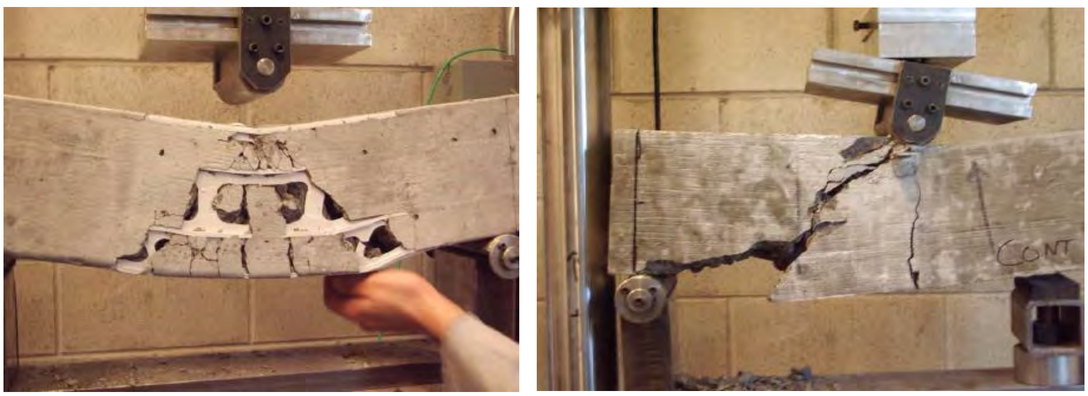
Background of Test

- Sample 200mm (8 inch) thick concrete filled Octaform wall system was constructed to be tested in accordance with ASTM E90-2004, ASTM E413-2004, and ASTM E1332-90 in order to determine the Sound Transmission Class (STC) and Outdoor-Indoor Transmission Class (OITC)
- Wall dimension 1140mm (45 inch) wide by 1650mm (65 inch) high
- Higher values of the STC indicate greater sound insulating properties
- Values of OITC are used as a rank ordering device

Appendix J

Evaluating the Performance of Octaform Concrete Forming Systems Under Cyclic Loading

University of British Columbia (April 2006)



Octaform Beam vs. Control Beam Under Point Load

Objective of Test

To investigate how Octaform System beams perform under flexural cyclic and quasi-static loading.

Significance and Main Findings

Tests showed that specimens containing PVC configurations exhibited higher values of strength under quasi-static loading compared to cyclic loading. This is explained due to a slower load application under quasi-static conditions, therefore allowing the beam to adjust to the conditions. There is evidence that the addition of PVC can add to the overall bending strength of the system. Different configurations of the PVC panels were found to have varying effects on the flexural strength.

Detailed Findings

Results showed that beams with only 45 degree corner sections had a greater resistance to quasi-static loads compared to cyclic loading but were more susceptible to shear failure rather than flexural failure. On the other hand, beams with midpoint connectors had a greater resistance to cyclic loading rather than quasi-static loads, and kept their structural integrity.

Background of Test

- 22 beam specimens constructed with 5 different PVC configurations and a control specimen (using conventional wood forms) for cyclic loading and quasi-static loading tests in order to determine the strength of each configuration and the flexural behavior under such conditions
- 3 identical beams for each of the 5 configurations plus 7 control beams
- Beam dimensions 150mm x 150mm x 600mm (6 inch x 6 inch x 24 inch)
- Beams reinforced with 10M (#3 size bar) main reinforcement bars and 4M bar stirrups
- 3 point loading

Properties

Concrete compressive strength (28 day): 40MPa (5.8 ksi)
Steel yield strength: 400MPa (58 ksi)

Appendix K

Cambridge materials testing limited

Finished Product Testing: PVC Interlocking Hollow Forming Parts

Cambridge Materials Testing Limited, & Intertek (April 2006)

Objective of Test

To investigate the properties of the PVC used in Octaform Systems, namely the wall thickness, colour match, hardness (Shore D), ash content, shrinkage, rate of burning, and impact resistance.

Significance and Main Findings

The properties of the PVC tested are shown below:

	Value	ASTM Standard
Wall Thickness	1.232mm (0.0485 in)	N/A
Hardness (Shore D)	80	D2240-04
Ash Content	14.70%	D229-01
Shrinkage	2.70%	D3679-04a
Rate of Burning	---	D635-03

A durometer was used to determine the hardness of PVC by measuring the depth of indentation created by a standardized pressure. Shore D corresponds to the D Scale for harder plastics while the A Scale is for softer plastics. The D Scale has a range of values from 0 to 100, with higher values indicating a harder material. The PVC hardness value of 80 indicates the material is relatively hard.

The ash content of a plastic is found by burning the sample to determine the amount of filler left after the polymer has burned off. The ash that is left is weighed and divided by the weight of the original sample to obtain the ash content.

The shrinkage test determined by ASTM D3679-04a states that the maximum shrinkage allowed is 3%, therefore a 2.7% shrinkage of the PVC is allowable.

During the rate of burning test, the material did not burn to the first reference mark, so the rate of burning according to ASTM d635-03 could not be determined.

Background of Test

- Samples of PVC interlocking hollow forms - dimensions 150mm x 300mm (6 inch x 12 inch), 150mm x 610mm (6 inch x 24 inch),150mm x 915mm (6 inch x 36 inch) were tested
- Properties measured were the wall thickness, colour match, hardness, ash content, shrinkage, rate of burning, and impact resistance

Method

- Testing was conducted according to the technical requirements found in "Physical Properties of PVC Elements" from the Canadian Construction Materials Centre (CCMC) Technical Guide: PVC Interlocking Hollow Forming Elements for Concrete (Noncombustible Construction), Masterformat Section 03134 and ASTM methods

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Appendix L

ITS Intertek Testing Services ETL SEMKO

Pilot Scale Fire Test Program Conducted on Vinyl Encompassed Concrete Wall System

Intertek Testing Services (July 2002)

Exposed Octaform Wall After Fire and Hose Stream Tests

Objective of Test

To see if the Octaform wall system meets a 2 hour fire rating.

Significance and Main Findings

The Octaform wall system met the standards for a 2 hour fire rating.

Detailed Findings

During the fire endurance test, the vinyl on the exposed side was consumed in flames and burned away completely, leaving the concrete exposed. The concrete however did not crack or spall. No burn through occurred to the unexposed side of the wall.

During the hose stream test, the test assembly met the required standards and no openings developed.

Background of Test

- Fire endurance and hose stream tests were conducted on an Octaform concrete wall system in order to determine eligibility for a 2 hour fire resistance rating
- Tests were in accordance with UBC 7-1, ASTM E119-98, NEPA 251, CAN/ULC S101-M89
- 100mm (4 inch) wall thickness used

Appendix M

Thermal Analysis – EPS Insulation

Intertek Testing Services (August 2000)

Objective of Test

To measure the U-Value and R-Value of an Octaform wall system insulated with expanded polystyrene insulation blocks and a regular built-up wood stud wall system.

Significance and Main Findings

The following results were obtained from the centre of an Octaform wall insulated with expanded polystyrene insulation blocks and a regular built-up wood stud wall system.

	Octaform Wall System	**Built-up Wood Stud Wall System**
U-value	0.066 Btu/hr/ft2/°F (0.37 m2 °K/W)	0.050 Btu/hr/ft^2/°F (0.28 m^2 °K/W)
R-value	15.2 hr-ft^2 °F/Btu (2.7 m^2 °K/W)	20.2 Btu/hr/ft2/°F (3.56 m2 °K/W)

Expanded polystyrene insulation blocks have an R-Value of about 4.5 hr-ft^2 °F/Btu (0.79 m^2 °K/W) per inch of thickness, which is lower than the R-Value for polyisio foam used in the test done in 1997. In addition, the insulation thickness was reduced from 89mm (3.5 inch) to 76mm (3 inch), which explains why the R-Value for the entire wall has decreased for this test in comparison to the 1997 test.

Background of Test

- Sample insulated Octaform wall system of low density concrete was modeled using Frame 4.0 computer software under ASHRAE winter conditions (0°F outside

temperature and 70°F indoor temperature)
- 76mm (3 inch) thick expanded polystyrene insulation blocks were placed on the exterior side of the concrete wall
- Wood wall system consisted of 3/8" thick fir plywood sheathing, 6 mil poly vapour barrier, 2"x6" spruce studs @ 24" o/c, R-20 fibreglass insulation, 1"x4" spruce strapping @ 24" o/c and 30 ga high tensile painted steel siding
- Wall systems were modeled only for the central wall area

Appendix N

ITS Intertek Testing Services
ETL SEMKO

Flame Spread Test Program Conducted on Extruded PVC Concrete Wall Forming System

Intertek Testing Services (February 2000)

Objective of Test

To observe the rate of progression of a flame along a sample of the PVC Octaform panels in a 7.6m (25 foot) long tunnel.

Significance and Main Findings

The flame spread classification for the PVC panels was found to be 35 and 20 (for ASTM and CAN/ULC standards, respectively). This value is relative to the flame spread classification of red oak flooring and asbestos-cement board which have values of 100 and 0, respectively.

The smoke development classification for the PVC panels was found to be 120 and 175 (for ASTM and CAN/ULC standards, respectively). This value is relative to the smoke classification of red oak flooring, which has a value of 100.

Background of Test

- Surface burning characteristics of extruded PVC Octaform panels were tested in accordance with ASTM E84-98 and CAN/ULC S102.2-M88 “Standard for Surface Burning Characteristics of Flooring, Floor Covering and Miscellaneous Materials and Assemblies”
- In total, 4 runs were conducted
- PVC sample lengths of 3.66m (12 feet), width 152mm (5.97 inches)

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Appendix O

ITS Intertek Testing Services
ETL SEMKO

Product Evaluation Conducted on Vinyl Panels

Intertek Testing Services (July 1998)

Objective of Test

To measure the exact thickness of the PVC panels.

Significance and Main Findings

The vinyl panels have an average thickness of 1.224mm (0.0482 inches).

Background of Test

- Thickness measurements were made on twenty samples of vinyl extruded panels

NSF International
789 N. Dixboro Rd. Ann Arbor, MI 48105, USA
1-800.NSF.MARK | +1-734.769.8010 | www.nsf.org
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EVALUATION REPORT

Send To: C0021751
Zi Li Fang
Octaform Systems Inc.
520-885 Dunsmuir Street
Vancouver, British Columbia V6C 1N5
Canada

Facility: C0043589
Poly-Chlor Plastic
44 Leeder Street
Coquitlam BC V3K 3V5
Canada

Result	**PASS**	Report Date	12-MAR-2020
Customer Name	Octaform Systems Inc.		
Tested To	NSF/ANSI/CAN 61		
Description	Octaform PVC Stay-in-Place Concrete Formwork | White formwork panels		
Trade Designation	Octaform PVC Stay-in-Place Concrete Formwork		
Test Type	Annual Collection		
Job Number	A-00348595		
Project Number	W0590686		
Project Manager	Jenae Yono		

Thank you for having your product tested by NSF International.

Please contact your Project Manager if you have any questions or concerns pertaining to this report.

Report Authorization Kathryn Foster **Date** 12-MAR-2020

Kathryn Foster - Technical Operations Manager, Water

General Information

Standard: NSF/ANSI/CAN 61

Monitor Code: A

Physical Description of Sample: White formwork panels

Tested DCC Number: PM08812

Trade Designation/Model Number: Octaform PVC Stay-in-Place Concrete Formwork

---

Sample Id: **S-0001677700**
Description: Sample exposed at 23C and pH 5
Sampled Date: 02/18/2020
Received Date: 01/27/2020

Normalization Information:

Date exposure completed:	18-FEB-2020	Calculated N1:	0.085	Field Exposure Time:	24 hours	Lab Exposure Time	24 hours
Field Surface Area:	2.2 in2	Lab Surface Area:	12.9 in2	Constant N2:	1	Misc. Factor:	1
Field Static Volume:	1 L	Lab Static Volume:	0.500 L				
				Calculated NFm:	1.00		
Compound Reference Key:	SPAC						

Testing Parameter	Sample	Control	Result	Normalized Result	Units
Chemistry Lab					
Metals I in water by ICPMS (Ref: EPA 200.8)					
Aluminum	ND(10)	ND(10)	ND(10)	ND(0.85)	ug/L
Arsenic	ND(1)	ND(1)	ND(1)	ND(0.09)	ug/L
Barium	3	3	ND(1)	ND(0.09)	ug/L
Beryllium	ND(0.5)	ND(0.5)	ND(0.5)	ND(0.04)	ug/L
Bismuth	ND(1)	ND(1)	ND(1)	ND(0.09)	ug/L
Cadmium	ND(0.2)	ND(0.2)	ND(0.2)	ND(0.02)	ug/L
Chromium	ND(1)	ND(1)	ND(1)	ND(0.09)	ug/L
Copper	ND(1)	ND(1)	ND(1)	ND(0.09)	ug/L
Mercury	ND(0.2)	ND(0.2)	ND(0.2)	ND(0.02)	ug/L
Nickel	ND(1)	ND(1)	ND(1)	ND(0.09)	ug/L
Lead	ND(0.5)	ND(0.5)	ND(0.5)	ND(0.04)	ug/L
Antimony	ND(0.5)	ND(0.5)	ND(0.5)	ND(0.04)	ug/L
Selenium	ND(1)	ND(1)	ND(1)	ND(0.09)	ug/L
Tin	ND(0.5)	ND(0.5)	ND(0.5)	ND(0.04)	ug/L
Strontium	ND(1)	ND(1)	ND(1)	ND(0.09)	ug/L
Thallium	ND(0.2)	ND(0.2)	ND(0.2)	ND(0.02)	ug/L
Zinc	ND(10)	ND(10)	ND(10)	ND(0.85)	ug/L
Silver	ND(1)	ND(1)	ND(1)	ND(0.09)	ug/L

Sample Id: **S-0001677701**
Description: Sample exposed at 23C and pH 10
Sampled Date: 02/18/2020
Received Date: 01/27/2020

Normalization Information:

Date exposure completed:	18-FEB-2020	Calculated N1:	0.085	Field Exposure Time:	24 hours	Lab Exposure Time	24 hours
Field Surface Area:	2.2 in2	Lab Surface Area:	12.9 in2				

Sample Id: **S-0001677701**

Normalization Information:

				Constant N2:	1	Misc. Factor:	1
Field Static Volume:	1 L	Lab Static Volume:	0.500 L				
				Calculated NFm:	1.00		
Compound Reference Key:	SPAC						

Testing Parameter	Sample	Control	Result	Normalized Result	Units
Chemistry Lab					
Metals I in water by ICPMS (Ref: EPA 200.8)					
Aluminum	11	11	ND(10)	ND(0.85)	ug/L
Arsenic	ND(1)	ND(1)	ND(1)	ND(0.09)	ug/L
Barium	ND(1)	ND(1)	ND(1)	ND(0.09)	ug/L
Beryllium	ND(0.5)	ND(0.5)	ND(0.5)	ND(0.04)	ug/L
Bismuth	ND(1)	ND(1)	ND(1)	ND(0.09)	ug/L
Cadmium	ND(0.2)	ND(0.2)	ND(0.2)	ND(0.02)	ug/L
Chromium	ND(1)	ND(1)	ND(1)	ND(0.09)	ug/L
Copper	ND(1)	ND(1)	ND(1)	ND(0.09)	ug/L
Mercury	ND(0.2)	ND(0.2)	ND(0.2)	ND(0.02)	ug/L
Nickel	ND(1)	ND(1)	ND(1)	ND(0.09)	ug/L
Lead	ND(0.5)	ND(0.5)	ND(0.5)	ND(0.04)	ug/L
Antimony	ND(0.5)	ND(0.5)	ND(0.5)	ND(0.04)	ug/L
Selenium	ND(1)	ND(1)	ND(1)	ND(0.09)	ug/L
Tin	ND(0.5)	ND(0.5)	ND(0.5)	ND(0.04)	ug/L
Strontium	ND(1)	ND(1)	ND(1)	ND(0.09)	ug/L
Thallium	ND(0.2)	ND(0.2)	ND(0.2)	ND(0.02)	ug/L
Zinc	ND(10)	ND(10)	ND(10)	ND(0.85)	ug/L
Silver	ND(1)	ND(1)	ND(1)	ND(0.09)	ug/L

Sample Id: **S-0001677702**
Description: Sample exposed at 23C and pH 8
Sampled Date: 02/18/2020
Received Date: 01/27/2020

Normalization Information:

Date exposure completed:	18-FEB-2020	Calculated N1:	0.083	Field Exposure Time:	24 hours	Lab Exposure Time	24 hours
Field Surface Area:	2.2 in2	Lab Surface Area:	25.8 in2	Constant N2:	1	Misc. Factor:	1
Field Static Volume:	1 L	Lab Static Volume:	0.970 L				
				Calculated NFm:	1.00		
Compound Reference Key:	SPAC						

Testing Parameter	Sample	Control	Result	Normalized Result	Units
Chemistry Lab					
* Acrylonitrile, Acetates and Acrylates by VOC GCMS					
Acrylonitrile	ND(0.2)	ND(0.2)	ND(0.2)	ND(0.02)	ug/L
Ethyl acetate	ND(1)	ND(1)	ND(1)	ND(0.08)	ug/L
Methyl acrylate	ND(1)	ND(1)	ND(1)	ND(0.08)	ug/L

Sample Id: **S-0001677702**

Testing Parameter	Sample	Control	Result	Normalized Result	Units
Chemistry Lab (Continued)					
Ethyl acrylate	ND(1)	ND(1)	ND(1)	ND(0.08)	ug/L
tert-Butyl Acetate	ND(1)	ND(1)	ND(1)	ND(0.08)	ug/L
Methyl methacrylate	ND(1)	ND(1)	ND(1)	ND(0.08)	ug/L
Isobutyl acetate	ND(1)	ND(1)	ND(1)	ND(0.08)	ug/L
n-Butyl acetate	ND(1)	ND(1)	ND(1)	ND(0.08)	ug/L
Butyl acrylate	ND(1)	ND(1)	ND(1)	ND(0.08)	ug/L
Butyl methacrylate	ND(1)	ND(1)	ND(1)	ND(0.08)	ug/L
Methyl Acetate	ND(1)	ND(1)	ND(1)	ND(0.08)	ug/L
Metals I in water by ICPMS (Ref: EPA 200.8)					
Aluminum	ND(10)	ND(10)	ND(10)	ND(0.83)	ug/L
Arsenic	ND(1)	ND(1)	ND(1)	ND(0.08)	ug/L
Barium	ND(1)	ND(1)	ND(1)	ND(0.08)	ug/L
Beryllium	ND(0.5)	ND(0.5)	ND(0.5)	ND(0.04)	ug/L
Bismuth	ND(1)	ND(1)	ND(1)	ND(0.08)	ug/L
Cadmium	ND(0.2)	ND(0.2)	ND(0.2)	ND(0.02)	ug/L
Chromium	ND(1)	ND(1)	ND(1)	ND(0.08)	ug/L
Copper	ND(1)	ND(1)	ND(1)	ND(0.08)	ug/L
Mercury	ND(0.2)	ND(0.2)	ND(0.2)	ND(0.02)	ug/L
Nickel	ND(1)	ND(1)	ND(1)	ND(0.08)	ug/L
Lead	ND(0.5)	ND(0.5)	ND(0.5)	ND(0.04)	ug/L
Antimony	ND(0.5)	ND(0.5)	ND(0.5)	ND(0.04)	ug/L
Selenium	ND(1)	ND(1)	ND(1)	ND(0.08)	ug/L
Tin	ND(0.5)	ND(0.5)	ND(0.5)	ND(0.04)	ug/L
Strontium	ND(1)	ND(1)	ND(1)	ND(0.08)	ug/L
Thallium	ND(0.2)	ND(0.2)	ND(0.2)	ND(0.02)	ug/L
Zinc	ND(10)	ND(10)	ND(10)	ND(0.83)	ug/L
Silver	ND(1)	ND(1)	ND(1)	ND(0.08)	ug/L
BASE/NEUTRAL/ACID EPA METHOD 625 Scan for Tentatively Identified Compoun					
No Compounds Detected	ND(4)	Complete	ND(4)	ND(0.3)	ug/L
Scan Control Complete	TRUE				
Semivolatile Compounds, Base/Neutral/Acid Target 625, Data Workup					
Pyridine	ND(2)	ND(2)	ND(2)	ND(0.2)	ug/L
Nitrosodimethylamine (N-)	ND(2)	ND(2)	ND(2)	ND(0.2)	ug/L
N-Nitrosomethylethylamine	ND(2)	ND(2)	ND(2)	ND(0.2)	ug/L
5-Methyl-2-hexanone (MIAK)	ND(2)	ND(2)	ND(2)	ND(0.2)	ug/L
1-Methoxy-2-propanol acetate	ND(2)	ND(2)	ND(2)	ND(0.2)	ug/L
2-Heptanone	ND(2)	ND(2)	ND(2)	ND(0.2)	ug/L
Cyclohexanone	ND(2)	ND(2)	ND(2)	ND(0.2)	ug/L
Nitrosodiethylamine (N-)	ND(2)	ND(2)	ND(2)	ND(0.2)	ug/L
Isobutylisobutyrate	ND(2)	ND(2)	ND(2)	ND(0.2)	ug/L
Aniline	ND(2)	ND(2)	ND(2)	ND(0.2)	ug/L
Phenol	ND(2)	ND(2)	ND(2)	ND(0.2)	ug/L
Di(chloroethyl) ether	ND(2)	ND(2)	ND(2)	ND(0.2)	ug/L
2-Chlorophenol	ND(2)	ND(2)	ND(2)	ND(0.2)	ug/L

Sample Id: **S-0001677702**

Testing Parameter	Sample	Control	Result	Normalized Result	Units
Chemistry Lab (Continued)					
2,3-Benzofuran	ND(2)	ND(2)	ND(2)	ND(0.2)	ug/L
1,3-Dichlorobenzene	ND(2)	ND(2)	ND(2)	ND(0.2)	ug/L
1,4-Dichlorobenzene	ND(2)	ND(2)	ND(2)	ND(0.2)	ug/L
3-Cyclohexene-1-carbonitrile	ND(2)	ND(2)	ND(2)	ND(0.2)	ug/L
2-Ethylhexanol	ND(2)	ND(2)	ND(2)	ND(0.2)	ug/L
Benzyl alcohol	ND(2)	ND(2)	ND(2)	ND(0.2)	ug/L
1,2-Dichlorobenzene	ND(2)	ND(2)	ND(2)	ND(0.2)	ug/L
bis(2-Chloroisopropyl)ether	ND(2)	ND(2)	ND(2)	ND(0.2)	ug/L
2-Methylphenol (o-Cresol)	ND(2)	ND(2)	ND(2)	ND(0.2)	ug/L
N-Methylaniline	ND(2)	ND(2)	ND(2)	ND(0.2)	ug/L
Acetophenone	ND(2)	ND(2)	ND(2)	ND(0.2)	ug/L
N-Nitrosodi-n-propylamine	ND(2)	ND(2)	ND(2)	ND(0.2)	ug/L
N-Nitrosopyrrolidine	ND(2)	ND(2)	ND(2)	ND(0.2)	ug/L
3- and 4-Methylphenol (m&p-Cresol)	ND(2)	ND(2)	ND(2)	ND(0.2)	ug/L
Hexachloroethane	ND(2)	ND(2)	ND(2)	ND(0.2)	ug/L
2-Phenyl-2-propanol	ND(2)	ND(2)	ND(2)	ND(0.2)	ug/L
N-Nitrosomorpholine	ND(2)	ND(2)	ND(2)	ND(0.2)	ug/L
Nitrobenzene	ND(2)	ND(2)	ND(2)	ND(0.2)	ug/L
2,6-Dimethylphenol	ND(2)	ND(2)	ND(2)	ND(0.2)	ug/L
N-Vinylpyrrolidinone	ND(2)	ND(2)	ND(2)	ND(0.2)	ug/L
N-Nitrosopiperidine	ND(2)	ND(2)	ND(2)	ND(0.2)	ug/L
Triethylphosphate	ND(2)	ND(2)	ND(2)	ND(0.2)	ug/L
Isophorone	ND(2)	ND(2)	ND(2)	ND(0.2)	ug/L
2-Nitrophenol	ND(2)	ND(2)	ND(2)	ND(0.2)	ug/L
2,4-Dimethylphenol	ND(2)	ND(2)	ND(2)	ND(0.2)	ug/L
bis(2-Chloroethoxy)methane	ND(2)	ND(2)	ND(2)	ND(0.2)	ug/L
2,4-Dichlorophenol	ND(2)	ND(2)	ND(2)	ND(0.2)	ug/L
Trichlorobenzene (1,2,4-)	ND(2)	ND(2)	ND(2)	ND(0.2)	ug/L
Naphthalene	ND(2)	ND(2)	ND(2)	ND(0.2)	ug/L
4-Chloroaniline	ND(2)	ND(2)	ND(2)	ND(0.2)	ug/L
1,1,3,3,-Tetramethyl-2-thiourea	ND(4)	ND(4)	ND(4)	ND(0.3)	ug/L
Hexachlorobutadiene	ND(2)	ND(2)	ND(2)	ND(0.2)	ug/L
Benzothiazole	ND(2)	ND(2)	ND(2)	ND(0.2)	ug/L
N-Nitrosodi-n-butylamine	ND(2)	ND(2)	ND(2)	ND(0.2)	ug/L
4-Chloro-3-methylphenol	ND(2)	ND(2)	ND(2)	ND(0.2)	ug/L
p-tert-Butylphenol	ND(2)	ND(2)	ND(2)	ND(0.2)	ug/L
2-Ethylhexyl glycidyl ether	ND(2)	ND(2)	ND(2)	ND(0.2)	ug/L
2,6-Di-t-butyl-4-methylphenol(BHT)	ND(2)	ND(2)	ND(2)	ND(0.2)	ug/L
Methylnaphthalene, 2-	ND(2)	ND(2)	ND(2)	ND(0.2)	ug/L
Cyclododecane	ND(2)	ND(2)	ND(2)	ND(0.2)	ug/L
2,4,5-Trichlorophenol	ND(2)	ND(2)	ND(2)	ND(0.2)	ug/L
2,4,6-trichlorophenol	ND(2)	ND(2)	ND(2)	ND(0.2)	ug/L
1(3H)-Isobenzofuranone	ND(2)	ND(2)	ND(2)	ND(0.2)	ug/L
2-Chloronaphthalene	ND(2)	ND(2)	ND(2)	ND(0.2)	ug/L

Sample Id: **S-0001677702**

Testing Parameter	Sample	Control	Result	Normalized Result	Units
Chemistry Lab (Continued)					
2-Nitroaniline	ND(2)	ND(2)	ND(2)	ND(0.2)	ug/L
1,1'-(1,3-Phenylene)bis ethanone	ND(2)	ND(2)	ND(2)	ND(0.2)	ug/L
2,6-Di-tert-butylphenol	ND(2)	ND(2)	ND(2)	ND(0.2)	ug/L
Dimethylphthalate	ND(2)	ND(2)	ND(2)	ND(0.2)	ug/L
1,1'-(1,4-Phenylene)bis ethanone	ND(2)	ND(2)	ND(2)	ND(0.2)	ug/L
Acenaphthylene	ND(2)	ND(2)	ND(2)	ND(0.2)	ug/L
Benzenedimethanol, a,a,a',a'-tetramethyl-1,3-	ND(2)	ND(2)	ND(2)	ND(0.2)	ug/L
2,6-Dinitrotoluene	ND(2)	ND(2)	ND(2)	ND(0.2)	ug/L
2,4-Dinitrotoluene	ND(2)	ND(2)	ND(2)	ND(0.2)	ug/L
Benzenedimethanol, a,a,a',a'-Tetramethyl-1,4-	ND(2)	ND(2)	ND(2)	ND(0.2)	ug/L
2,4-Di-tert-butylphenol	ND(2)	ND(2)	ND(2)	ND(0.2)	ug/L
Dimethyl terephthalate	ND(2)	ND(2)	ND(2)	ND(0.2)	ug/L
Acenaphthene	ND(2)	ND(2)	ND(2)	ND(0.2)	ug/L
Dibenzofuran	ND(2)	ND(2)	ND(2)	ND(0.2)	ug/L
Ethyl-4-ethoxybenzoate	ND(2)	ND(2)	ND(2)	ND(0.2)	ug/L
4-Nitrophenol	ND(2)	ND(2)	ND(2)	ND(0.2)	ug/L
Cyclododecanone	ND(2)	ND(2)	ND(2)	ND(0.2)	ug/L
Diethyl Phthalate	ND(2)	ND(2)	ND(2)	ND(0.2)	ug/L
p-tert-Octylphenol	ND(2)	ND(2)	ND(2)	ND(0.2)	ug/L
Fluorene	ND(2)	ND(2)	ND(2)	ND(0.2)	ug/L
4-Chlorophenylphenylether	ND(2)	ND(2)	ND(2)	ND(0.2)	ug/L
3-Nitroaniline	ND(2)	ND(2)	ND(2)	ND(0.2)	ug/L
4-Nitroaniline	ND(2)	ND(2)	ND(2)	ND(0.2)	ug/L
Nitrosodiphenylamine (N-)	ND(2)	ND(2)	ND(2)	ND(0.2)	ug/L
Azobenzene	ND(2)	ND(2)	ND(2)	ND(0.2)	ug/L
4-Bromophenylphenylether	ND(2)	ND(2)	ND(2)	ND(0.2)	ug/L
Hexachlorobenzene	ND(2)	ND(2)	ND(2)	ND(0.2)	ug/L
Pentachlorophenol	ND(2)	ND(2)	ND(2)	ND(0.2)	ug/L
Phenanthrene	ND(2)	ND(2)	ND(2)	ND(0.2)	ug/L
Anthracene	ND(2)	ND(2)	ND(2)	ND(0.2)	ug/L
Diisobutyl phthalate	ND(2)	ND(2)	ND(2)	ND(0.2)	ug/L
Dibutyl phthalate	ND(2)	ND(2)	ND(2)	ND(0.2)	ug/L
Diphenyl sulfone	ND(2)	ND(2)	ND(2)	ND(0.2)	ug/L
Hydroxymethylphenylbenzotriazole	ND(2)	ND(2)	ND(2)	ND(0.2)	ug/L
Fluoranthene	ND(2)	ND(2)	ND(2)	ND(0.2)	ug/L
Pyrene	ND(2)	ND(2)	ND(2)	ND(0.2)	ug/L
Butyl benzyl phthalate	ND(2)	ND(2)	ND(2)	ND(0.2)	ug/L
Di(2-ethylhexyl)adipate	ND(2)	ND(2)	ND(2)	ND(0.2)	ug/L
3,3-Dichlorobenzidine	ND(2)	ND(2)	ND(2)	ND(0.2)	ug/L
Benzo(a)anthracene	ND(2)	ND(2)	ND(2)	ND(0.2)	ug/L
Di(2-ethylhexyl)phthalate	ND(2)	ND(2)	ND(2)	ND(0.2)	ug/L
Chrysene	ND(2)	ND(2)	ND(2)	ND(0.2)	ug/L
Di-n-octylphthalate	ND(2)	ND(2)	ND(2)	ND(0.2)	ug/L
Benzo(b)fluoranthene	ND(2)	ND(2)	ND(2)	ND(0.2)	ug/L

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Testing Parameter	Sample	Control	Result	Normalized Result	Units
Chemistry Lab (Continued)					
Benzo(k)fluoranthene	ND(2)	ND(2)	ND(2)	ND(0.2)	ug/L
Benzo(a)Pyrene (PAH)	ND(2)	ND(2)	ND(2)	ND(0.2)	ug/L
Dibenzo(a,h)anthracene	ND(2)	ND(2)	ND(2)	ND(0.2)	ug/L
Indeno(1,2,3-cd)pyrene	ND(2)	ND(2)	ND(2)	ND(0.2)	ug/L
Benzo(g,h,i)perylene	ND(2)	ND(2)	ND(2)	ND(0.2)	ug/L
* 1,3-Butadiene (Modified EPA 524.2)					
1,3-Butadiene	ND(0.5)	ND(0.5)	ND(0.5)	ND(0.04)	ug/L
* Acrylic Acid, LC/UV					
Acrylic acid	ND(10)	ND(10)	ND(10)	ND(0.83)	ug/L
* Methacrylic Acid, LC/UV					
Methacrylic Acid	ND(10)	ND(10)	ND(10)	ND(0.83)	ug/L
Volatile Organic Compounds (Ref: EPA 524.2)					
Dichlorodifluoromethane	ND(0.5)	ND(0.5)	ND(0.5)	ND(0.04)	ug/L
Chloromethane	ND(0.5)	ND(0.5)	ND(0.5)	ND(0.04)	ug/L
Vinyl Chloride	ND(0.5)	ND(0.5)	ND(0.5)	ND(0.04)	ug/L
Bromomethane	ND(0.5)	ND(0.5)	ND(0.5)	ND(0.04)	ug/L
Chloroethane	ND(0.5)	ND(0.5)	ND(0.5)	ND(0.04)	ug/L
Trichlorofluoromethane	ND(0.5)	ND(0.5)	ND(0.5)	ND(0.04)	ug/L
Trichlorotrifluoroethane	ND(0.5)	ND(0.5)	ND(0.5)	ND(0.04)	ug/L
Methylene Chloride	ND(0.5)	ND(0.5)	ND(0.5)	ND(0.04)	ug/L
1,1-Dichloroethylene	ND(0.5)	ND(0.5)	ND(0.5)	ND(0.04)	ug/L
trans-1,2-Dichloroethylene	ND(0.5)	ND(0.5)	ND(0.5)	ND(0.04)	ug/L
1,1-Dichloroethane	ND(0.5)	ND(0.5)	ND(0.5)	ND(0.04)	ug/L
2,2-Dichloropropane	ND(0.5)	ND(0.5)	ND(0.5)	ND(0.04)	ug/L
cis-1,2-Dichloroethylene	ND(0.5)	ND(0.5)	ND(0.5)	ND(0.04)	ug/L
Chloroform	ND(0.5)	ND(0.5)	ND(0.5)	ND(0.04)	ug/L
Bromochloromethane	ND(0.5)	ND(0.5)	ND(0.5)	ND(0.04)	ug/L
1,1,1-Trichloroethane	ND(0.5)	ND(0.5)	ND(0.5)	ND(0.04)	ug/L
1,1-Dichloropropene	ND(0.5)	ND(0.5)	ND(0.5)	ND(0.04)	ug/L
Carbon Tetrachloride	ND(0.5)	ND(0.5)	ND(0.5)	ND(0.04)	ug/L
1,2-Dichloroethane	ND(0.5)	ND(0.5)	ND(0.5)	ND(0.04)	ug/L
Trichloroethylene	ND(0.5)	ND(0.5)	ND(0.5)	ND(0.04)	ug/L
1,2-Dichloropropane	ND(0.5)	ND(0.5)	ND(0.5)	ND(0.04)	ug/L
Bromodichloromethane	ND(0.5)	ND(0.5)	ND(0.5)	ND(0.04)	ug/L
Dibromomethane	ND(0.5)	ND(0.5)	ND(0.5)	ND(0.04)	ug/L
cis-1,3-Dichloropropene	ND(0.5)	ND(0.5)	ND(0.5)	ND(0.04)	ug/L
trans-1,3-Dichloropropene	ND(0.5)	ND(0.5)	ND(0.5)	ND(0.04)	ug/L
1,1,2-Trichloroethane	ND(0.5)	ND(0.5)	ND(0.5)	ND(0.04)	ug/L
1,3-Dichloropropane	ND(0.5)	ND(0.5)	ND(0.5)	ND(0.04)	ug/L
Tetrachloroethylene	ND(0.5)	ND(0.5)	ND(0.5)	ND(0.04)	ug/L
Chlorodibromomethane	ND(0.5)	ND(0.5)	ND(0.5)	ND(0.04)	ug/L
Chlorobenzene	ND(0.5)	ND(0.5)	ND(0.5)	ND(0.04)	ug/L
1,1,1,2-Tetrachloroethane	ND(0.5)	ND(0.5)	ND(0.5)	ND(0.04)	ug/L
Bromoform	ND(0.5)	ND(0.5)	ND(0.5)	ND(0.04)	ug/L

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Testing Parameter	Sample	Control	Result	Normalized Result	Units
Chemistry Lab (Continued)					
1,1,2,2-Tetrachloroethane	ND(0.5)	ND(0.5)	ND(0.5)	ND(0.04)	ug/L
1,2,3-Trichloropropane	ND(0.5)	ND(0.5)	ND(0.5)	ND(0.04)	ug/L
1,3-Dichlorobenzene	ND(0.5)	ND(0.5)	ND(0.5)	ND(0.04)	ug/L
1,4-Dichlorobenzene	ND(0.5)	ND(0.5)	ND(0.5)	ND(0.04)	ug/L
1,2-Dichlorobenzene	ND(0.5)	ND(0.5)	ND(0.5)	ND(0.04)	ug/L
Carbon Disulfide	ND(1)	ND(1)	ND(1)	ND(0.08)	ug/L
Methyl-tert-Butyl Ether (MTBE)	ND(0.5)	ND(0.5)	ND(0.5)	ND(0.04)	ug/L
tert-Butyl ethyl ether	ND(0.5)	ND(0.5)	ND(0.5)	ND(0.04)	ug/L
Methyl Ethyl Ketone	ND(5)	ND(5)	ND(5)	ND(0.4)	ug/L
Methyl Isobutyl Ketone	ND(5)	ND(5)	ND(5)	ND(0.4)	ug/L
Toluene	ND(0.5)	ND(0.5)	ND(0.5)	ND(0.04)	ug/L
Ethyl Benzene	ND(0.5)	ND(0.5)	ND(0.5)	ND(0.04)	ug/L
m+p-Xylenes	ND(1)	ND(1)	ND(1)	ND(0.08)	ug/L
o-Xylene	ND(0.5)	ND(0.5)	ND(0.5)	ND(0.04)	ug/L
Styrene	ND(0.5)	ND(0.5)	ND(0.5)	ND(0.04)	ug/L
Isopropylbenzene (Cumene)	ND(0.5)	ND(0.5)	ND(0.5)	ND(0.04)	ug/L
n-Propylbenzene	ND(0.5)	ND(0.5)	ND(0.5)	ND(0.04)	ug/L
Bromobenzene	ND(0.5)	ND(0.5)	ND(0.5)	ND(0.04)	ug/L
2-Chlorotoluene	ND(0.5)	ND(0.5)	ND(0.5)	ND(0.04)	ug/L
4-Chlorotoluene	ND(0.5)	ND(0.5)	ND(0.5)	ND(0.04)	ug/L
1,3,5-Trimethylbenzene	ND(0.5)	ND(0.5)	ND(0.5)	ND(0.04)	ug/L
tert-Butylbenzene	ND(0.5)	ND(0.5)	ND(0.5)	ND(0.04)	ug/L
1,2,4-Trimethylbenzene	ND(0.5)	ND(0.5)	ND(0.5)	ND(0.04)	ug/L
sec-Butylbenzene	ND(0.5)	ND(0.5)	ND(0.5)	ND(0.04)	ug/L
p-Isopropyltoluene (Cymene)	ND(0.5)	ND(0.5)	ND(0.5)	ND(0.04)	ug/L
1,2,3-Trimethylbenzene	ND(0.5)	ND(0.5)	ND(0.5)	ND(0.04)	ug/L
n-Butylbenzene	ND(0.5)	ND(0.5)	ND(0.5)	ND(0.04)	ug/L
1,2,4-Trichlorobenzene	ND(0.5)	ND(0.5)	ND(0.5)	ND(0.04)	ug/L
Hexachlorobutadiene	ND(0.5)	ND(0.5)	ND(0.5)	ND(0.04)	ug/L
1,2,3-Trichlorobenzene	ND(0.5)	ND(0.5)	ND(0.5)	ND(0.04)	ug/L
Naphthalene	ND(0.5)	ND(0.5)	ND(0.5)	ND(0.04)	ug/L
Benzene	ND(0.5)	ND(0.5)	ND(0.5)	ND(0.04)	ug/L
Total Trihalomethanes	ND(0.5)	ND(0.5)	ND(0.5)	ND(0.04)	ug/L
Total Xylenes	ND(0.5)	ND(0.5)	ND(0.5)	ND(0.04)	ug/L

Sample Id: **S-0001677704**
Description: Octaform PVC Stay-in-Place Concrete Formwork | White formwork panels
Sampled Date: 01/27/2020
Received Date: 01/27/2020

Normalization Information:

Testing Parameter	Sample	Control	Result	Normalized Result	Units
Chemistry Lab					
Material Screening for Lead by XRF					

Sample Id: **S-0001677704**

Testing Parameter	Sample	Control	Result	Normalized Result	Units
Chemistry Lab (Continued)					
Lead content verification	Pass				

Sample Id: **S-0001677710**
Description: White formwork panels
Sampled Date: 01/27/2020
Received Date: 01/27/2020

Normalization Information:

Testing Parameter	Sample	Control	Result	Normalized Result	Units
Chemistry Lab					
Vinyl chloride, Residual, NSF					
Residual Vinyl Chloride	ND(0.5)		ND(0.5)		mg/kg
Residual Vinyl Chloride P/F	PASS		PASS		

Testing Laboratories:

	Id	Address
All work performed at: →	NSF_AA	NSF International 789 N. Dixboro Road Ann Arbor MI 48105

References to Testing Procedures:

NSF Reference	Parameter / Test Description
C0513	Material Screening for Lead by XRF
C0743	* Acrylonitrile, Acetates and Acrylates by VOC GCMS
C1182	Metals I in water by ICPMS (Ref: EPA 200.8)
C2023	BASE/NEUTRAL/ACID EPA METHOD 625 Scan for Tentatively Identified Compounds (TICs)
C2024	Semivolatile Compounds, Base/Neutral/Acid Target 625, Data Workup
C3369	* 1,3-Butadiene (Modified EPA 524.2)
C4022	* Acrylic Acid, LC/UV
C4267	* Methacrylic Acid, LC/UV
C4400	Vinyl chloride, Residual, NSF
C4662	Volatile Organic Compounds (Ref: EPA 524.2)

Test descriptions preceded by an asterisk "*" indicate that testing has been performed per NSF International requirements but is not within its scope of accreditation.

Unless otherwise indicated, method uncertainties are not applied in any determinations of conformity. Testing utilizes the requested sections of any referenced standards, which may not be the entire standard.

Appendix Q

Adhesion of Yersinia Ruckeri to fish farm materials:

Table 3
Adhesion kinetics of *Y. ruckeri* strains ATCC 29473 and PBM1 on the tested materials [(cell number × 10^{-3}) cm^{-2} support]

Material	Time (h)					
	3		6		9	
	ATCC 29473	PBM1	ATCC 29473	PBM1	ATCC 29473	PBM1
PVC	0.08 ± 0.01[a]	21.56 ± 11.56	1.09 ± 0.09	8.17 ± 5.01	2.75 ± 1.22	40.5 ± 0.94
Fibreglass	0.34 ± 0.06	8.44 ± 2.27	2.25 ± 0.51	6.24 ± 1.34	16.65 ± 3.77	44.96 ± 5.15
Concrete	0.27 ± 0.02	9.75 ± 3.43	5.59 ± 1.02	29.46 ± 8.56	33.28 ± 10.37	354.14 ± 102.95
Wood	1.83 ± 0.41	196.92 ± 93.7	18.65 ± 4.49	68.62 ± 11.95	81.55 ± 13.94	720.09 ± 303.21

[a] SD, standard deviation ($n = 3$).

Detailed Findings

- PVC has 0.082.
- Fibreglass is 11 times higher at 0.925.
- Concrete at 3.070.

Smoother materials will wash easier and water flows smoothly over the surface in the RAS system reducing small eddies etc. Where there is more adhesion there is a higher risk of biofilm and algae accumulation.

Table 4
Average roughness amplitude (RA) values and advancing contact angles for water, DIM and GLY on the different tested supports

Material	RA (μm)	Contact angles, θ (°)			Surface energy (mJ m^{-2})		
		H_2O	DIM	GLY	γ_S	γ_S^{LW}	γ_S^{AB}
PVC	0.082 ± 0.109[a]	76 ± 3[b]	30 ± 4	70 ± 2	42	39	3
Glassfibre	0.925 ± 0.229	56 ± 2	43 ± 2	73 ± 2	40	29	11
Concrete	3.070 ± 1.010	ND	ND	ND	ND	ND	ND
Wood	5.030 ± 0.970	ND	ND	ND	ND	ND	ND

ND, not determined.
[a] SD, standard deviation ($n = 3$).
[b] $n = 10$.

Appendix R

Response of Bacterial Biofilms in Recirculating Aquaculture Systems to Various Sanitizers:

FIGURE 2a. Percentage reduction of total plate count on various substances found in recirculating aquaculture systems. The number is the average of three observations with three replications for each sanitizer treatment.

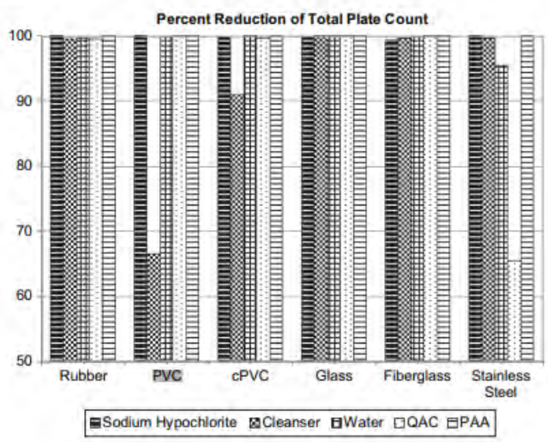
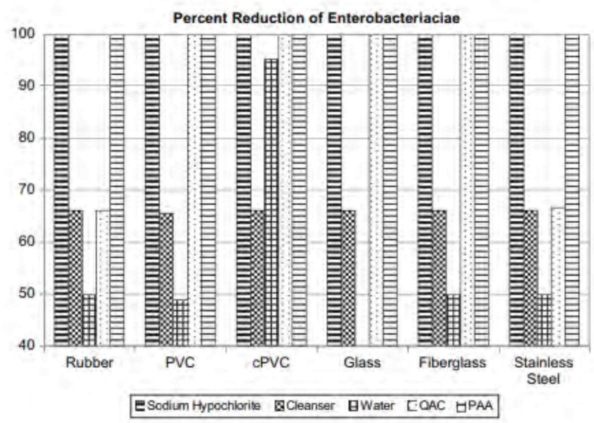


FIGURE 2b. Percentage reduction of Enterobacteriaceae on various substances found in recirculating aquaculture systems. The number is the average of three observations with three replications for each sanitizer treatment.



Appendix R-2: Biofilm Accumulation on PVC - Combined Studies from Potable Water Containment, Water Distribution Systems and Aquaculture

Biofilm Accumulation and PVC

PVC has been found to have the lowest biofilm accumulation of all surfaces used for fluid containment:

- fiberglass & epoxy
- concrete + PU coatings
- bare concrete
- stainless steel
- glass lined steel

Several studies from potable water and aquaculture industry highlight the reduced adhesion and improved cleanability.

Adhesion of Yersinia ruckeri to fish farm materials:

This causes redmouth disease on rainbow trout.

Table 3
Adhesion kinetics of *Y. ruckeri* strains ATCC 29473 and PBM1 on the tested materials [(cell number $\times 10^{-3}$) cm^{-2} support]

Material	Time (h)					
	3		6		9	
	ATCC 29473	PBM1	ATCC 29473	PBM1	ATCC 29473	PBM1
PVC	0.08 ± 0.01[a]	21.56 ± 11.56	1.09 ± 0.09	8.17 ± 5.01	2.75 ± 1.22	40.5 ± 0.94
Fibreglass	0.34 ± 0.06	8.44 ± 2.27	2.25 ± 0.51	6.24 ± 1.34	16.65 ± 3.77	44.96 ± 5.15
Concrete	0.27 ± 0.02	9.75 ± 3.43	5.59 ± 1.02	29.46 ± 8.56	33.28 ± 10.37	354.14 ± 102.95
Wood	1.83 ± 0.41	196.92 ± 93.7	18.65 ± 4.49	68.62 ± 11.95	81.55 ± 13.94	720.09 ± 303.21

Note first column shows:

- PVC has 0.082
- Glassfibre 11x higher at 0.925
- Concrete at 3.070

Smoother materials wash easier and water flows smoothly over the surface in the RAS system reducing small eddies etc where more adhesion of biofilms and algaes might be possible.

Table 4
Average roughness amplitude (RA) values and advancing contact angles for water, DIM and GLY on the different tested supports

Material	RA (μm)	Contact angles, θ (°)			Surface energy (mJ m^{-2})		
		H_2O	DIM	GLY	γ_S	γ_S^{LW}	γ_S^{AB}
PVC	0.082 ± 0.109^a	76 ± 3^b	30 ± 4	70 ± 2	42	39	3
Glassfibre	0.925 ± 0.229	56 ± 2	43 ± 2	73 ± 2	40	29	11
Concrete	3.070 ± 1.010	ND	ND	ND	ND	ND	ND
Wood	5.030 ± 0.970	ND	ND	ND	ND	ND	ND

ND, not determined.
[a] SD, standard deviation ($n = 3$).
[b] $n = 10$.

https://www.sciencedirect.com/science/article/abs/pii/S0927776502000231

Why PVC pipes have become preferable for potable:

Table 1 Comparison of 21 d and 10 months (42 weeks) biofilm heterotroph populations (c.f.u. cm^{-2}) in four materials ranked in order of greatest to lowest numbers recovered

	Run 1 (21 d)	Relative adhesion (%)	Run 2 (21 d)	Relative adhesion (%)	Mean relative (%)	Run 3 (10 m)	Relative adhesion (%)
Cast iron	$3{\cdot}2 \times 10^6$	100	$2{\cdot}5 \times 10^6$	100	100	$4{\cdot}0 \times 10^7$	100
Thermanox™	$1{\cdot}0 \times 10^6$	32	$9{\cdot}3 \times 10^5$	38	34·5	$2{\cdot}8 \times 10^6$	7
MDPE	$2{\cdot}4 \times 10^5$	7	$2{\cdot}1 \times 10^5$	9	8	$3{\cdot}9 \times 10^5$	1
uPVC	$6{\cdot}6 \times 10^4$	2	$1{\cdot}2 \times 10^5$	5	3	$3{\cdot}0 \times 10^5$	1

* Values are the mean of five replicate discs each serially diluted and plated in triplicate on R^2A.

https://sfamjournals.onlinelibrary.wiley.com/doi/pdf/10.1111/j.1365-2672.1998.tb05280.x

Structure and microbial diversity of biofilms on different pipe materials of a model drinking water distribution systems

Table 1

Characteristics of deposits on the inner surface of the pipes

	HDPE	PEX	PVC
Percentage of surface covered by mineral deposits (%)	47.52	21.64	0
Size of mineral deposits (μm^2)			
Mean value	3.82	0.08	0
Median	0.19	0.03	0
Standard deviation	26.40	0.24	0
Total number of bacteria (cells cm^{-2})			
Mean value	1.59×10^6	1.24×10^7	1.59×10^5
Standard deviation	9.30×10^5	7.94×10^6	1.59×10^5

https://www.ncbi.nlm.nih.gov/pmc/articles/PMC4282696/

Biofilm formation on materials commonly used in household drinking water systems

Experimental day		Average microscopic cell count (log/cm²) 4	8	12	16	20	24	28	30
Copper		6.43 ± 0.01	6.76 ± 0.01	6.86 ± 0.03	6.68 ± 0.02	6.73 ± 0.01	6.76 ± 0.01	6.78 ± 0.01	6.82 ± 0.02
	cv (%)	0.88	0.39	1.45	1.12	0.40	0.48	0.85	1.30
Stainless steel		6.58 ± 0.02	6.87 ± 0.02	6.90 ± 0.01	6.75 ± 0.01	6.78 ± 0.01	6.92 ± 0.01	7.00 ± 0.01	7.08 ± 0.01
	cv (%)	1.46	1.14	0.51	0.63	0.38	0.34	0.45	0.53
PVC		6.80 ± 0.01	6.90 ± 0.02	6.89 ± 0.01	6.94 ± 0.01	6.92 ± 0.01	6.94 ± 0.01	6.93 ± 0.00	6.96 ± 0.01
	cv (%)	0.46	0.88	0.31	0.61	0.36	0.33	0.26	0.29

Note, repeated decreases throughout the cycle on Copper & PVC with SS having continual increase.

CONCLUSIONS

Biofilm formation on materials commonly used in household plumbing systems is very fast, reaching 106 cells/cm2 within 4 days, and more than 107/cm2 cells after 30 days, having chlorinated water as the only source of nutrients. Considering the number of attached cells, biofilm thickness and average colony size, copper is the best choice of material for a household plumbing system, followed by

PVC and stainless steel.

Stainless steel taps, which almost exclusively dominate
the market, pose the greatest risk for water consumers' health.

https://www.researchgate.net/publication/274678708_Biofilm_formation_on_materials_commonly_used_in_household_drinking_water_systems/link/5c2981c7299bf12be3a3536b/download

Canadian Food Inspection Agency
Agence canadienne d'inspection des aliments

Food Safety Directorate
3851 Fallowfield Road
Ottawa, Ontario, Canada
K2H 8P9

Tel: (613) 228-6698
Fax: (613) 228-6675

Appendix S

Direction de la sécurité alimentaire
3851, chemin Fallowfield
Ottawa (Ontario) Canada
K2H 8P9

Tél: (613) 228-6698
Télécopieur: (613) 228-6675

Date: 2008/10/31

File/Dossier: # O075

Mr. David Richardson
President
Octaform Systems Inc.
885 Dunsmuir Street, Suite 520
Vancouver, British Columbia
V6C 1N5

RE: O075 Octaform Systems Inc.
Vancouver, British Columbia V6C 1N5
08/10/31 el Octaform Stay-In-Place PVC Framework - Snap Lock Panel

This will acknowledge your submission concerning the above wall systems for which you are requesting acceptance for use in food plants.

Based on the present available information no objection will be taken to the installation of said walls systems in food plants provided that:

All corners and wall-floor junctions shall be coved, the coving to have a radius of at least 2.5 cm.

Should any changes occur in the composition or intended use of the aforementioned wall systems, then this acceptance will be considered **null and void.**

La présente fait suite à votre demande d'acceptation concernant le système de murs ci-haut mentionné, destiné à être utiliser dans des établissements alimentaires.

Sur la base des informations présentées, nous n'avons aucune objection quant à l'installation et l'utilisation des murs ci-haut mentionnés dans les établissements alimentaires pourvu que:

Tous les coins et les joints des murs et des planchers soient arrondis, et la courbure doit correspondre à celle d'un cercle d'un rayon minimum de 2,5 cm.

Cette acceptation sera considérée comme **NULLE et SANS EFFET** si l'on procède à une modification quelconque dans la formulation chimique ou de l'usage proposée du système de murets ci-haut mentionné.

Canada

This acceptance should not be misconstrued as an endorsement for these or similar wall systems and their use in food plants will depend upon their continued acceptability to all concerned.

Cette acceptation ne doit pas être interprétée comme un endossement pour ce système de muret ou un système similaire et son usage dans les établissements alimentaires et son acceptabilité sera conditionnelle à la satisfaction de toutes les parties intéressées.

Should any unacceptable sanitary maintenance problems occur as a result of improper installation or maintenance, the inspection service may request corrective action to be taken.

Si des conditions d'entretien sanitaire inacceptable survenaient à la suite d'un usage ou d'une installation inapproprié, le service d'inspection pourrait demander que des mesures correctives soient prises dans les plus brefs délais.

Yours truly.

Je vous prie d'agréer l'expression de nos sentiments les meilleurs.

Agent intérimaire de programmes
Évaluation chimique
Division de la salubrité des aliments
Direction de la salubrité des aliments

Bernard Dallaire
Acting Program Officer
Chemical Evaluation
Food Safety Division
Food Safety Directorate

BD/jc

RDIMS# 1715747