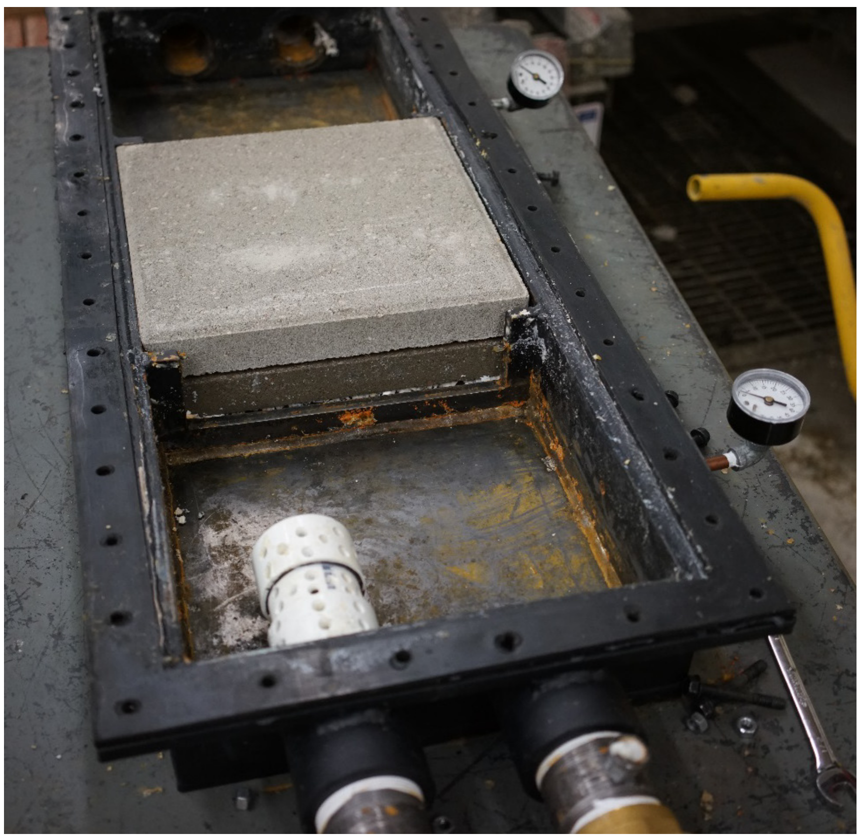
RECLAMATION

Managing Water in the West

Evaluating Methods to Seal Leaking Contraction Joints in Dams

Research and Development Office
Science and Technology Program
(Final Report) ST-2016-7688-01



U.S. Department of the Interior
Bureau of Reclamation
Research and Development Office

August 2016

Mission Statements

The U.S. Department of the Interior protects America's natural resources and heritage, honors our cultures and tribal communities, and supplies the energy to power our future.

The mission of the Bureau of Reclamation is to manage, develop, and protect water and related resources in an environmentally and economically sound manner in the interest of the American public.

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All Reclamation concrete dams have joints which experience pressure caused by the reservoir water elevation. These joints have waterstops to prevent water leakage through the joint. Over time, the waterstops can begin to leak.
These leaks can lead to millions of dollars of increased maintenance costs across numerous facilities.
Conventional leaking contraction joint repair methods are either very expensive or do not last long. We developed an inexpensive method to deliver repair materials deep under water (Travel Report 2013).
To test those methods, we built a laboratory fixture to simulate a leaking contraction joint in a dam under pressure. With this fixture we tested different repair options. These options included sawdust, hydrophilic waterstop chips, chemical grouts used for sealing water leakage through concrete, and combinations of the chips and grouts.
In this testing we found that sawdust didn't slow the water flowing through the test fixture joint. Hydrophilic chips slowed the water by as much as 65%, and Hydrophilic chips combined with some chemical grouts completely stopped the water flow through the test fixture joint.
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Executive Summary

All Reclamation concrete dams have joints which experience pressure caused by the reservoir water elevation. These joints have waterstops between the formed drain and the upstream face of the dam to prevent water leakage through the joint. Over time, the waterstops can begin to leak which can become a significant maintenance issue.

These leaks can lead to millions of dollars of increased maintenance costs across numerous facilities, since they corrode metalwork, increase operation costs through increased pumping to remove excess water, and reduce worker productivity as they work around the leaks, etc. In some cases, the water leaks can threaten or damage expensive equipment.

Conventional leaking contraction joint repair methods are either very expensive or do not last long. Based on work from previous years looking into cheaper repair options, where we developed an inexpensive method to deliver repair materials to a specific location deep under water (Travel Report 2013), several prototype repair methods were developed.

To test those methods, we built a laboratory fixture to simulate a leaking contraction joint in a dam under pressures as high as 35 psi. With this fixture we tested different repair options. These options included sawdust, hydrophilic waterstop chips, chemical grouts used for sealing water leakage through concrete, and combinations of the chips and grouts.

In this testing we found that sawdust didn't slow the water flowing through the test fixture joint. Hydrophilic chips slowed the water by as much as 65%, and Hydrophilic chips combined with some chemical grouts completely stopped the water flow through the test fixture joint.

These results could have substantial implications at Reclamation facilities with leaking contraction joints. These methods can be implemented to significantly reduce or completely stop the infiltration of water and are much cheaper than many alternatives.

We recommend that the combination method be evaluated further and that a field test be performed at a facility with leaking contraction joints.

Contents

Introduction

Background

Many Reclamation structures are being used past their design life. Some of the dams have damaged and worn out waterstops between blocks. The waterstops are used to keep water out of the structure. Once they are damaged, water infiltrates the structure which can corrode metalwork, and increase operating costs through increased pumping. This water can also infiltrate lift lines which can increase uplift pressures and contribute to structure instability. In addition, this water can also be a nuisance, which can reduce worker productivity as they have to manage their work around these leaks.

Previous work has attempted to stop these leaks using chemical grouts. Traditional methods require divers and specialized equipment to get the grout injected at the correct location. In addition, in many cases, these grouts are unsuccessful since water leaking through contraction joints flows at such a high velocity that the grout does not have time to set up.

From a previous S&T project, a novel, inexpensive method was used to deliver a ground up hydrophilic waterstop in close proximity to a leaking contraction joint (Travel Report 2013). That work was very promising and improvements were suggested for further study, including using combinations of materials that might improve service life of the repair. While the leaks were reduced significantly, they eventually increased since the ground up waterstop is not sticky and fell off or was sucked into the joint.

Objective

This research included looking into currently used practices for this repair, such as the use of sawdust, and also evaluating new methods. Specifically, we wanted to compare current practices to the proposed new materials and delivery method. We felt that a combination of the chips and chemical grout could work better than the individual components themselves. As described above, the grout was sucked through the joint so quickly it didn’t have time to cure. Also, the chips aren’t sticky, so they don’t stick to themselves or the joint faces and fell off or eventually got sucked through. We wanted to see if the chips would slow down the flow enough so the grout would have time to react. If so, the grout would hold the chips in place so the resultant product would be very strong and durable and would stay in place for a long time.

A fixture was built in the laboratory to recreate this type of leak so that different repair methods could be tested and evaluated. The specific aspects of this project were to:

- Determine the best way to model a leaking contraction joint. The model should simulate reservoir water pressure on one side of the joint and atmospheric pressure on the other.
- Design and build a physical model to perform testing that can be used multiple times under identical conditions.
- Perform tests using different repair materials and compare their joint sealing capabilities.

Previous Work

Currently some Reclamation facilities use sawdust to reduce this type of leakage. The sawdust is placed in the reservoir upstream of the leak using a cage with a remote release mechanism. This is accomplished by placing the sawdust in a wire cage and lowering the cage from the top of the dam down the upstream face by a cable. Once the cage is at the desired elevation a cord is pulled from above that releases a door on the cage which releases the sawdust. The sawdust is then sucked into the leaking joint by the flowing water. We observed this process at Pueblo dam. According to Pueblo personnel, this method slows the flow down for a period of time. Once the sawdust begins to decompose it is washed through the joint and the leakage returns, making it necessary to repeat the process.

Grand Coulee Testing (Travel Report 2013)

Attempts had been made at Grand Coulee Dam to stop leakage through a contraction joint between blocks 81 and 82. Grand Coulee personnel ran a video camera down the upstream face of the dam and observed where water was infiltrating the 81/82 block joint. They could see small particles flowing into the contraction joint between the 1060 and 1030 elevations. The bottom of the joint was at the 1018 foot elevation, which was about 200 feet below the water surface.

A dye test was also performed on the upstream face. Dye was injected into the reservoir on the upstream face while personnel were inside galleries watching to see where and how quickly it was penetrating. The dye took between 3 and 5 seconds to travel from the reservoir into the galleries. Additional dye was injected along the entire face to get a better idea of where the water was entering the dam. They found water entering between the 1060 and 1030 elevations. Dye injected below the 1020 elevation just pooled on the bottom of the reservoir.

Since water flowed from the reservoir into the galleries so quickly, we determined that chemical grout was not a suitable repair method since the type of grout needed would not cure fast enough. Most flexible chemical grouts have a set time of over 20 seconds. There are some chemical grouts that could react within the 5 second window; however, they are rigid foams and would not provide a long lasting repair in moving joints.

Grand Coulee personnel had tried a few different methods to seal the joint with limited success. In one attempt, they placed a small diameter flexible hose in the reservoir over the section of joint between the 1060 and 1030 elevations and allowed it to be sucked into the joint with the flowing water. Due to the roughness of the joint there was only minimal reduction in flow as measured by a weir placed in the drainage ditch in the 1000 elevation gallery (Figure 1). They also placed a plastic membrane over the upstream face on the same section of joint and allowed it to be sucked over the contraction joint. This membrane pressed onto the face well; however the flow did not decrease. A likely explanation for this was that water flowed into the joint from above and below the membrane, since the membrane did not seal the joint at its ends.

Figure 1 – Weir placed in the 1000 gallery drainage ditch measuring inflow from the 81/82 joint.

Because of the unique circumstances involved with attempting this repair, a modified version of a product called Cylutions, manufactured by Emagineered Solutions Incorporated, was used. This product is normally used to repair leaks resulting from damaged waterstops in contraction joints. Normally, a core hole is drilled along the leaking contraction joint, and the product is dropped into the core hole in the form of solid cylinders a few feet long. It is a solid urethane that reacts with water and expands to seal the hole and leaking joint. This product reacts with water and swells 300% in size.

Using the product in that form was not practical here. We worked with the manufacturer to develop a ground up version (Figure 2). One important aspect of the ground up particles is that they swell but do not stick to each other or anything else.

The ground up waterstop was placed in a 55 gallon barrel with water, and an agitator was used to keep the particles suspended (Figure 3). This slurry was then pumped from the top of the dam through a one inch plastic tube using a screw type progressive cavity pump (Figure 4). The distribution of the slurry was monitored by Grand Coulee's remotely operated vehicle (R.O.V) and a downhole inspection camera. The hose location was controlled from the top of the dam. It was raised and lowered so the outlet was close to the joint and in a place where water was actively infiltrating. A section of steel pipe was attached to the underwater end of the hose to increase its weight to make it easier to control the location of the end.

Figure 2 – Ground up waterstop. Left side before water and right side right after water was added. The cups contained the same volume of waterstop.

Figure 3 – Ground up waterstop suspended in water.

Figure 4 – Progressive cavity screw pump used to deliver water/waterstop solution.

Throughout the course of three days the slurry was placed along the contraction joint. Upon arrival, the leakage measured by the flume was 145 gallons per minute (gpm). After placing a total of 100 pounds of ground up waterstop the flow was reduced to 63 gpm. The smaller waterstop particles entered the joint while the larger waterstop particles packed on the front of the joint (Figure 5). During this process the face of the joint was almost completely full, to the point where the particles were beginning to create a mound at the joint (Figure 6). A small amount of waterstop particles traveled completely through the joint and were seen in the drainage ditch at the 1000 gallery. A large amount of particles that did not enter the joint settled to the bottom of the reservoir in a pile. While these particles slowed the inflow of water they didn't completely stop it. Water continued to infiltrate between the particles and into the dam.

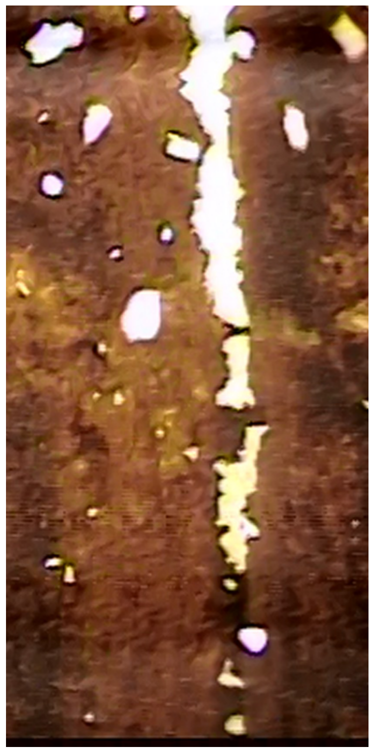


Figure 5 – Waterstop material packing on the front and entering the joint.

Figure 6 – Waterstop material creating a mound on the face of the joint.

Once the flow rate was reduced, a chemical grout was injected into the joints from inside the dam and the water leakage was further reduced to 10 gpm. The flow in this joint eventually increased but not to its original rate. This was most likely caused by some of the waterstop material either getting sucked into and through the joint or falling off the upstream surface of the dam since they do not stick to the concrete surfaces or each other. There is a hydro power generator near this joint which could have caused enough vibration to dislodge some of these particles.

Evaluation

Testing Method

In order for the fixture to accurately represent a leaking joint there was some fine tuning to get all the parameters correct. Our approach was to adjust the components in a way that they would mimic the efforts that took place at Grand Coulee. Since this is our only known real world representation we felt comfortable with this approach. There were two main aspects of the model that required adjustment to achieve these conditions: the joint width and the flow rate. We adjusted these until we saw the chips and the flow behaving in a similar manner to Grand Coulee. Tests 1 though 4 were used to achieve these conditions.

Fixture Description

This testing fixture is composed of four main components: the joint fixture, a pumping system to provide the water flowing through the joint, a method to provide the hydrophilic waterstop (chips), and a pump to provide the chemical grout. The fixture and flow diagram are shown in Figure 7. The “supply water” pump and tank provide the reservoir water that is flowing through the joint throughout the test. The “chips with water” pump is a low flow pump providing just enough water to deliver the chips. All the products that flow through the joint flow to the discharge tank. A flow meter measures the amount of water leaking through the joint which decreases as the chips and grout plug up the joint. The pressure gauges measure the upstream and downstream pressures. P_1 measured the upstream pressure, which increased as the chips and grout plugged up the joint. P_2 measured the downstream pressure, which remained constant at 0 throughout the testing.

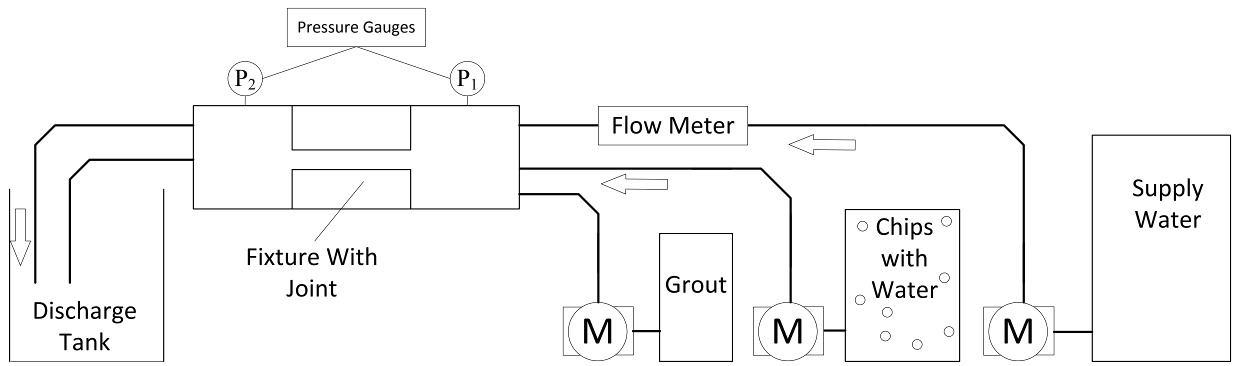


Figure 7 – Fixture flow diagram.

The internal dimensions of the testing fixture were L 36 inches X W 12 inches X H 3.75 inches. The layout is shown in Figure 8 and 9. The entrance section is 12 inches X 12 inches. The concrete pavers in the center section are 12 inches X 12 inches X 2 inches each, and the outlet section is 12 inches X 12 inches. Drawings with dimensions are in appendix 1. The joint to be tested was between the pavers. The pavers were spaced apart by acrylic spacers (Figure 10). A PVC diffuser was used to even out the flow of the supply water. Figure 11 shows the layout of all components including the pumps and tanks. Figure 12 shows the supply water flow meter, and the “chips with water” pump.

Figure 8 – Fixture internal view.

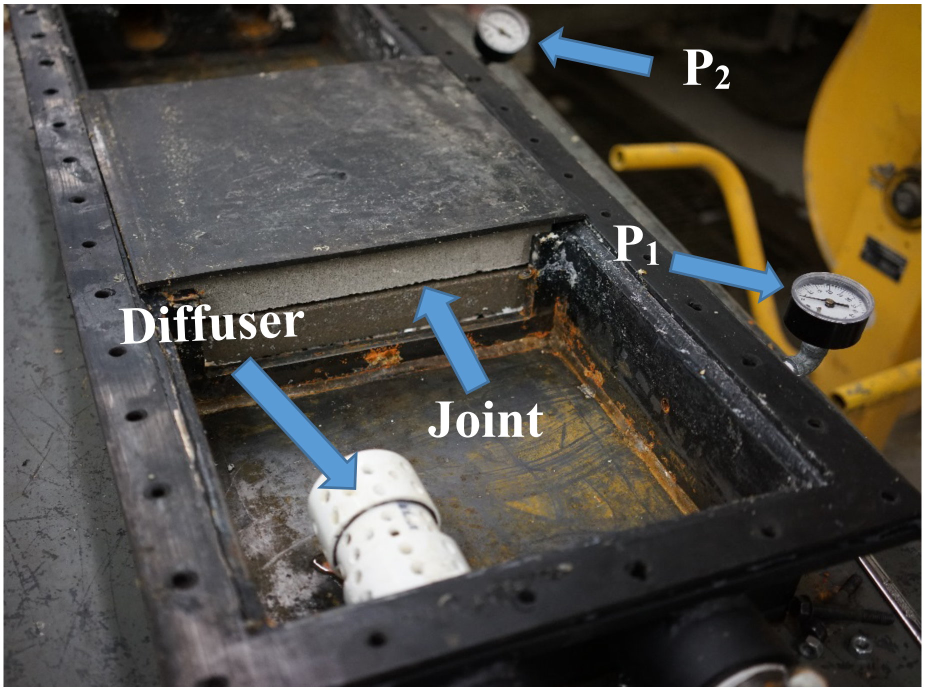


Figure 9 – Fixture internal view.

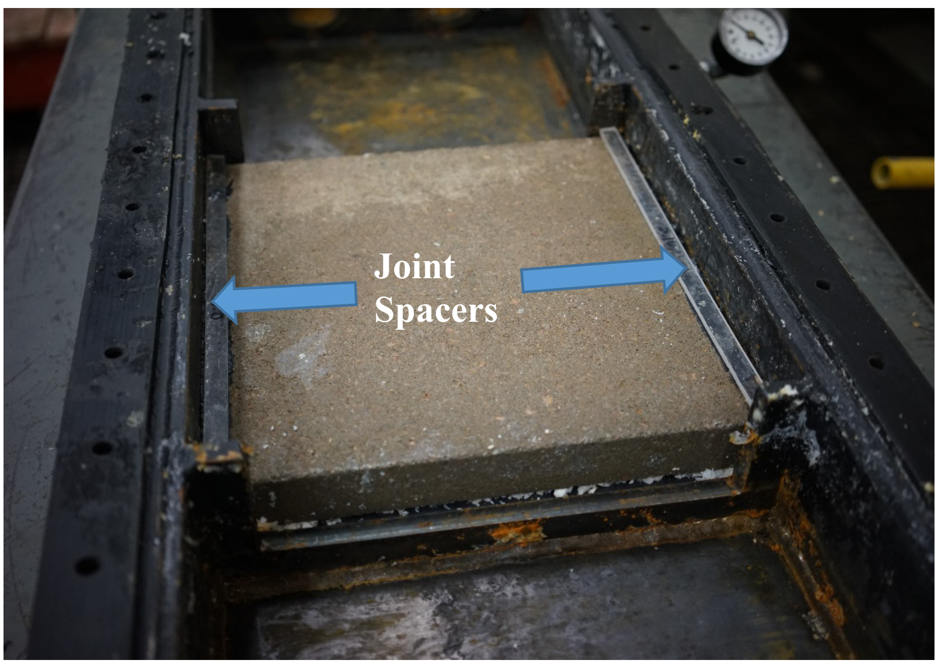


Figure 10 – Fixture internal view showing joint spacers.

Figure 11 – Testing components layout.

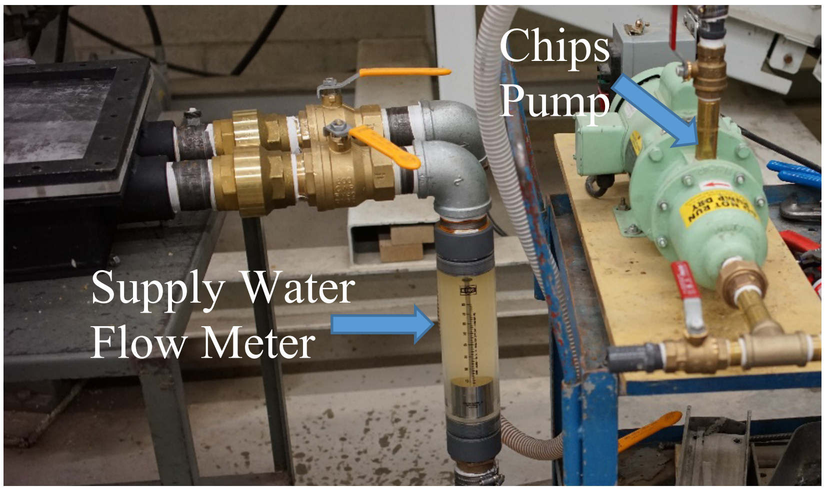


Figure 12 – Flow meter and chips pump.

Test Procedure

For the tests conducted with chemical grout and chips, each type of grout was tested in a cup with the hydrophilic chips to ensure there were no adverse reactions between the two. Water was also mixed with these grouts and chips to see how they behaved when reacting with water.

Once we made all the necessary adjustments to the fixture to mimic the Grand Coulee joint, the testing began. The joint dimensions were set at 0.11 inch think, 11 inches wide and 12 inches long. The initial flow rate was set at 40 gpm. This translated to a water velocity in the joint of 10.6 feet per second. These conditions were met and a steady state was achieved prior to beginning each test. Once testing began we recorded P_1, and flowrate. In each test we injected 48 ounces of chips or sawdust. For each grout tested two gallons of grout was injected (Table 1).

Table 1. Materials tested.

Test Number	Items Tested	Volume of Chips or Sawdust (ounces)	Volume of Grout (gallons)
1	Chips	48	0
2	Chips	48	0
3	Chips	48	0
4	Chips	48	0
5	Sawdust	48	0
6	Chips With 248/249	48	2
7	Chips with ST-504	48	2
8	Chips with PU F400	48	2

Hydrophilic chips

The hydrophilic waterstop material used in this testing was already in a chip form. The chips provided by the manufacturer were too large for our pump so we ground them to a smaller size. The chips were sent through a meat grinder to decrease their size. There was a medium size that went through the grinder once and a fine grind that went through the meat grinder twice. Gradations were completed for these three different sizes (Table 2, and Figure 13). The small grind was used in all lab testing.

Table 2. Gradation of Hydrophilic chips.

	From Manufacturer	Medium Grind	Small Grind
Sieve Size (inches)	Percent Retained	Percent Retained	Percent Retained
3/8	5%	0%	0%
1/4	57%	0%	0%
#4 (0.187")	26%	14%	9%
#8 (0.0937")	11%	58%	46%
#16 (0.0469")	1%	23%	36%
#30 (0.0234")	0%	5%	9%
pan	0%	0%	0%

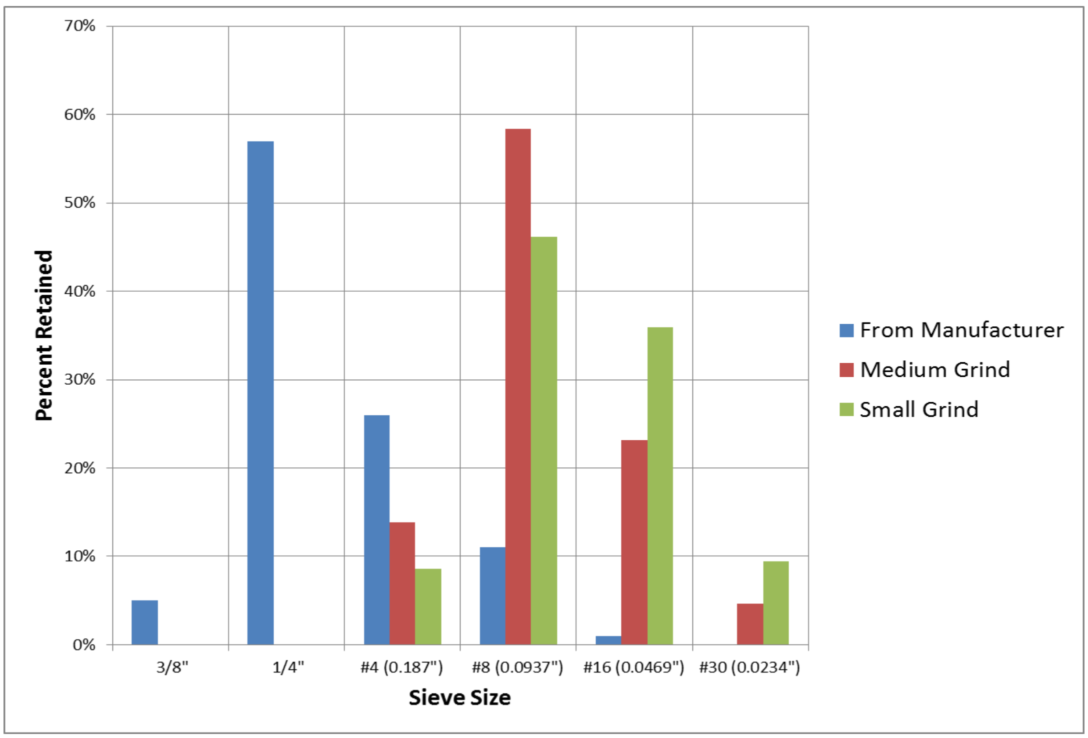


Figure 13 – Gradation Chart.

Test Results

Cup Tests

None of the grouts had an adverse reaction with the chips (Figure 14). Additionally the chips didn't react with the grouts when mixed with water. When the chips and grout were mixed the end products was a grout/chips matrix. Since most of the water was taken up by the grout reaction the chips only hydrated and expanded a small amount. When the chips react with water they change from their light brown color to white. In the reacted cup test we could see that the chips were still mostly light brown (Figure 15).

This cup test was only used to see how the chips and grout react with each other. The end product is not what we would expect to see in a joint when they react together. In the joint test there was an ample amount of water available for the chips to completely react and allow them to grow to their maximum size prior to the introduction of chemical grout.

Three different types of grout were used for this research. These grouts were chosen because they are some of the most commonly used grouts for water control, and each has been used by the TSC grouting crew with good success. They are all good at sealing water leaks in cracked concrete or contraction joints with low flows. They are seldom successful at stopping water leaks in high flow situations. Technical data sheets for each product are in the appendix 3.

The first grout used was AV 248/249 manufactured by Avanti Int. It is a hydrophobic polyurethane resin that only needs a small amount of water to react and cure. AV 248 is a single component resin, catalyzed with AV-249, and is a moisture-activated MDI-based polyurethane resin. It is pumped as one catalyzed component and reacts with water in the substrate to form a water tight, closed cell foam. The second grout tested was ST-504, manufactured by Strata-Tech. ST-504 is an MDI-based hydrophilic gel that is used for water control and soil stabilization. It is most commonly pumped at a 1:1 ratio with water. The third grout tested was PU F400, manufactured by Spetec. PU F400 is similar to 248/249 in its makeup. It is a one component catalyzed hydrophobic closed cell injection resin designed to shut off water leaks.

Figure 14 – Cup tests with grout and chips.

Figure 15 – Cup tests after reacting with water.

Testing Results

The hydrophilic chips successfully slowed down the water flow. They slowed the water in the 0.11 inch joint by 65% (Table 3). Not all the grouts worked equally. Two of the grouts with chips completely stopped the flow while the third wasn't any better than chips alone. The AV 248/249 didn't show any improvement over chips only. This could be attributed to the gel time which was twice that of the other grouts. The gel time for 248/248 was two minutes, 504 was one minute and PU F400 was 50 seconds.

Table 3. Testing data.

Test Number	Items Tested	Joint Spacing (inches)	Initial Pressure P_1 (psi)	Initial Flow (GPM)	Final Pressure P_1 (psi)	Final Flow (GPM)	% Flow Reduction
1	Chips	0.16	2	80	30	25	69%
2	Chips	0.16	2	80	18	54	33%
3	Chips	0.16	2	40	25	30	25%
4	Chips	0.11	3	40	30	14	65%
5	Sawdust	0.11	3	40	3	40	0%
6	Chips With 248/249	0.11	3	40	30	16	60%
7	Chips with ST-504	0.11	3	40	30	0	100%
8	Chips with PU F400	0.11	3	40	30	0	100%

Tests 1 through 3 were performed to adjust the fixture to match results observed at Grand Coulee. These tests showed that the fixture was operating as designed and that it was a good representation of a contraction joint in a concrete dam. After each test, the fixture was disassembled, examined and photos were taken (Figures 16-18). For tests 1 through 4, once the supply pump and flow of water was stopped some chips fell off the front of the joint since there was no longer any water pressure to hold them in place.

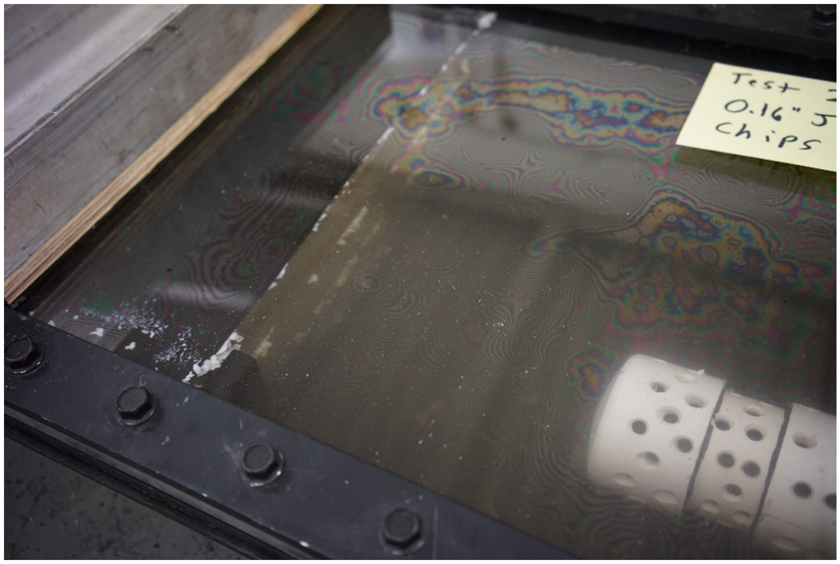


Figure 16. Test 2 chips catching in joint during test.

Figure 17. Test 2 chips caught in joint after test.

Figure 18. Test 2 view of inside the joint after testing completed.

Test 4 was a good representation of the contraction joint at Grand Coulee. The chips clogged the joint and began to mound on the upstream face (Figure 19). The chips slowed the flow by 65% (Figure 20). This was a good starting point for additional testing since there was room for improvement.

A total of 48 ounces of chips were used in each test. As seen in figure 19 and others, there was a small amount of water leaking between the upper paver and the acrylic fixture cover. This was a result of the rising pressure on the inlet side of the fixture. The increasing pressure caused the acrylic to slightly flex upward. An aluminum support channel was placed above the paver and acrylic to limit this movement, but it wasn't entirely effective. During testing, the chips and grout plugged up this area as they did the concrete joint.

Figure 19. Test 4 view during testing.

Figure 20. Test 4 view of inside the joint after testing completed.

Test 5 with the sawdust showed a 0% reduction in flow. Two different types of sawdust were used (Figure 21). The larger sawdust plugged the pump and didn't flow into the joint. The finer sawdust was too small to get caught in the joint and simply flowed through it. We did not conclude that sawdust doesn't work to slow the flow of water in a contraction joint, but that it didn't work in this test set-up.

Figure 21. Larger sawdust on left and finer sawdust on right.

Test 6 used chips and AV 248/249. The introduction of grout did not reduce the flow in the joint (Figure 22). The AV 248/249 is very similar to the PU F400 and it should have slowed the flow considerably. The 248 was catalyzed at the standard rate which produced a gel time of two minutes. Since this set time was significantly longer than the other grouts, most of the grout washed through the joint before it had a chance to react and set up (Figure 23). We feel it would have worked similar to the PU F400 if a higher amount of catalyst was used and the gel time was reduced to the 1 minute time frame. After disassembling the fixture we found that some of the chips had attached to the reacted grout on the upstream side of the joint. (Figure 24).

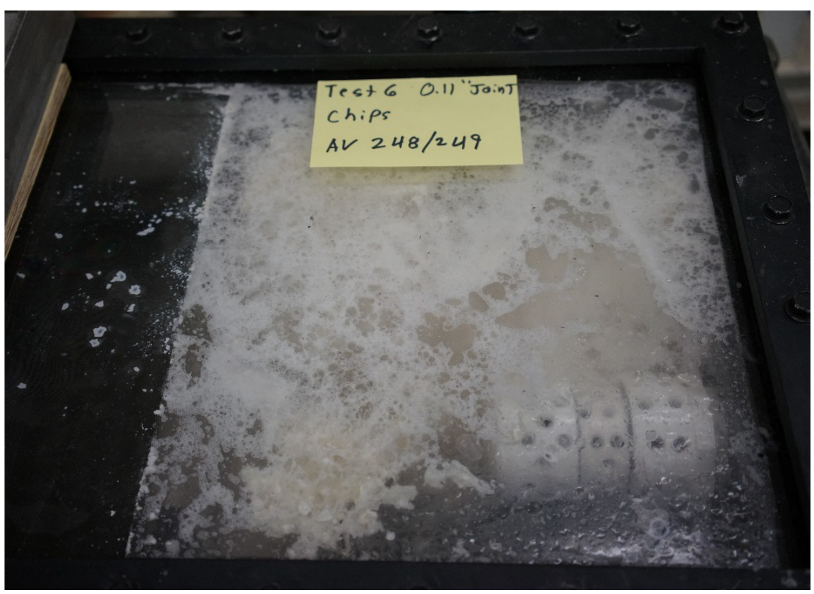


Figure 22. Test 6 reacted grout in fixture after test.

Figure 23. Test 6 inside of joint after test.

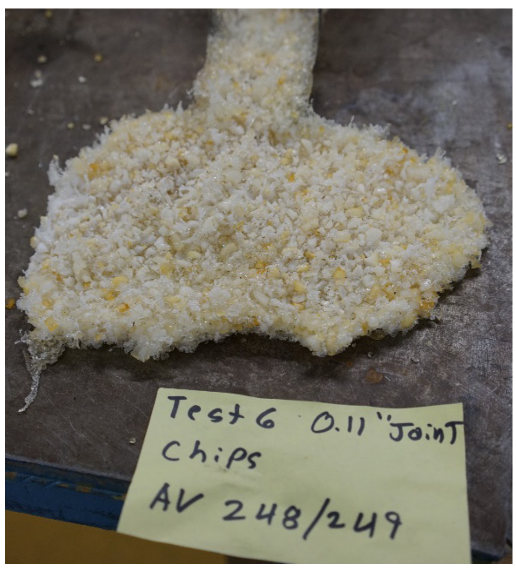


Figure 24. Test 6 reacted grout with chips attached.

Test 7 was with chips and ST-504. The chips slowed down the flow rate, which gave the ST-504 time to react, attach to existing chips and collect more chips (Figure 25). The flow rate was reduced to 0 gpm (Figure 26). After disassembling the fixture we found a matrix of grout and chips in the joint (Figure 27).

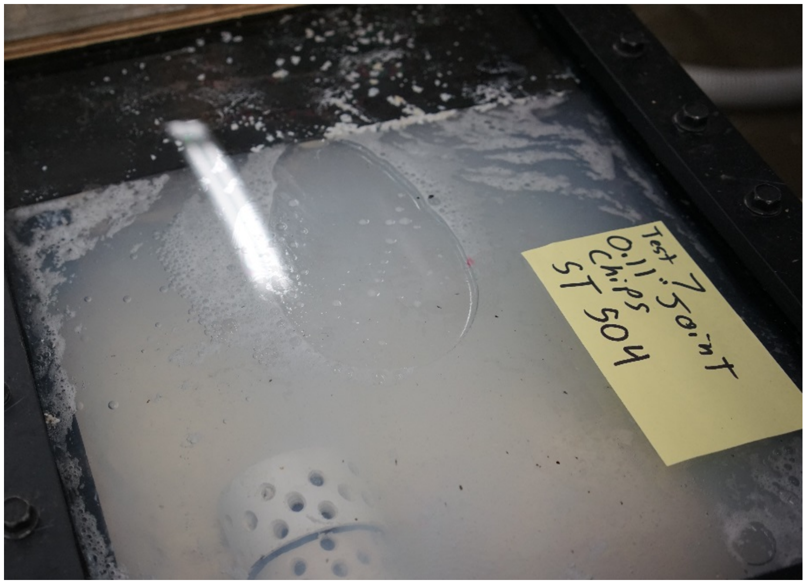


Figure 25. Test 7 ST-504 reacting with chips during test.

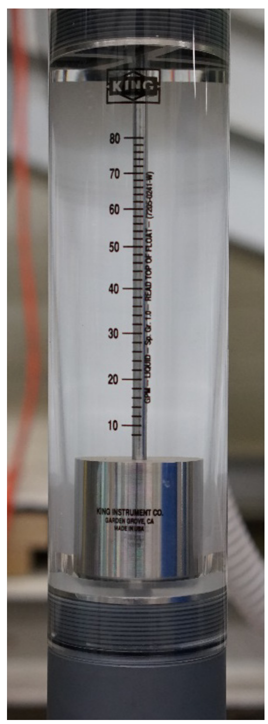


Figure 26. Test 7 flow rate of supply water reduced to 0 gpm during test.

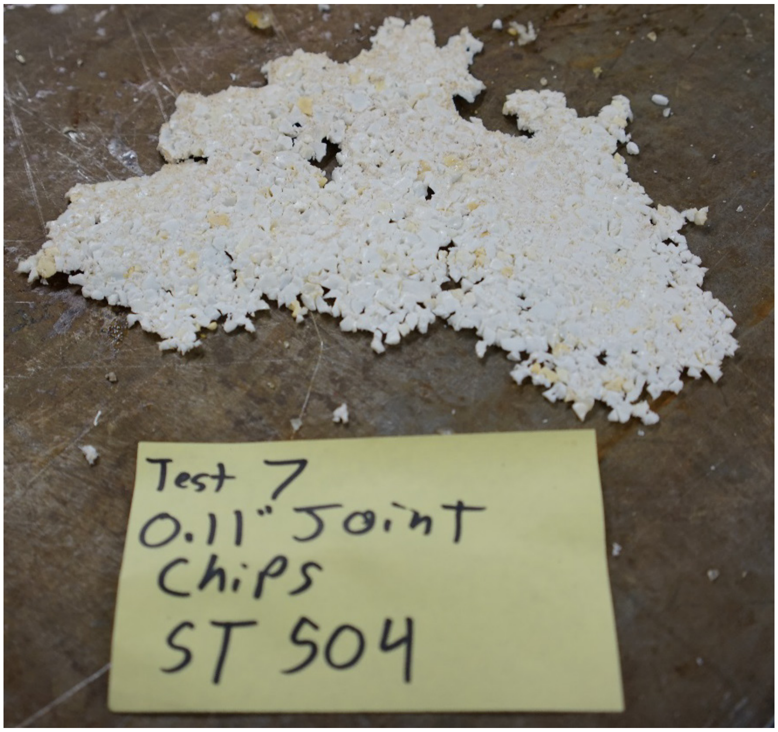


Figure 26. Test 7 mesh of grout and chips.

Test 8 was chips and PU F400. The results were similar to those of ST-504 (Figure 27). The grout worked to reduce the flow to 0 gpm by bonding the chips together and collecting additional chips (Figure 28). When the fixture was disassembled and the upstream pressure was released most of the chips stayed where they were as opposed to falling off the joint, indicating they were held in place by the grout. Since the flow rate was reduced to 0 gpm, most of the chips and some of the grout used never made it through the joint. Instead, they simply stayed and reacted in the upstream area of the fixture (Figure 29).

Figure 27. Test 8 PU F400 reacting during testing.

Figure 28. Test 8 inside joint after testing.

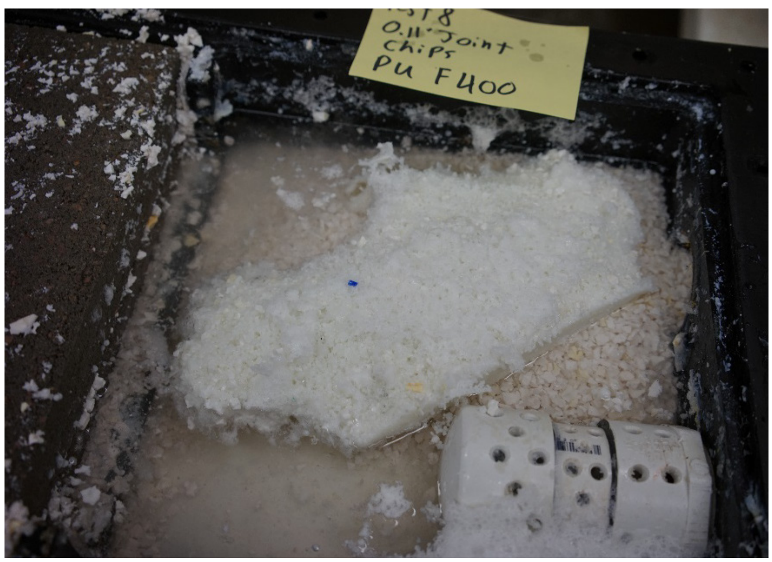


Figure 29. Test 8 reacted grout and chips in fixture after testing.

Conclusions and Recommendations

Testing in the laboratory and at Grand Coulee shows that the use of this ground up waterstop material is a viable, low cost repair solution for sealing leaking contraction joints with large flows.

1. The chips became lodged in the joint and expanded. This significantly slowed the water flow.
2. The lab research showed that chips alone are incapable of completely stopping the flow of water in a joint.

3. The addition of chemical grout can be useful in completely stopping the flow.
4. The addition of chemical grout is successful in bonding the chips together.
5. This addition of chemical grout allows the chips to stay in place once the water pressure is reduced, and it could possibly hold the chips in place in dams that experience vibrations like that from power generation.

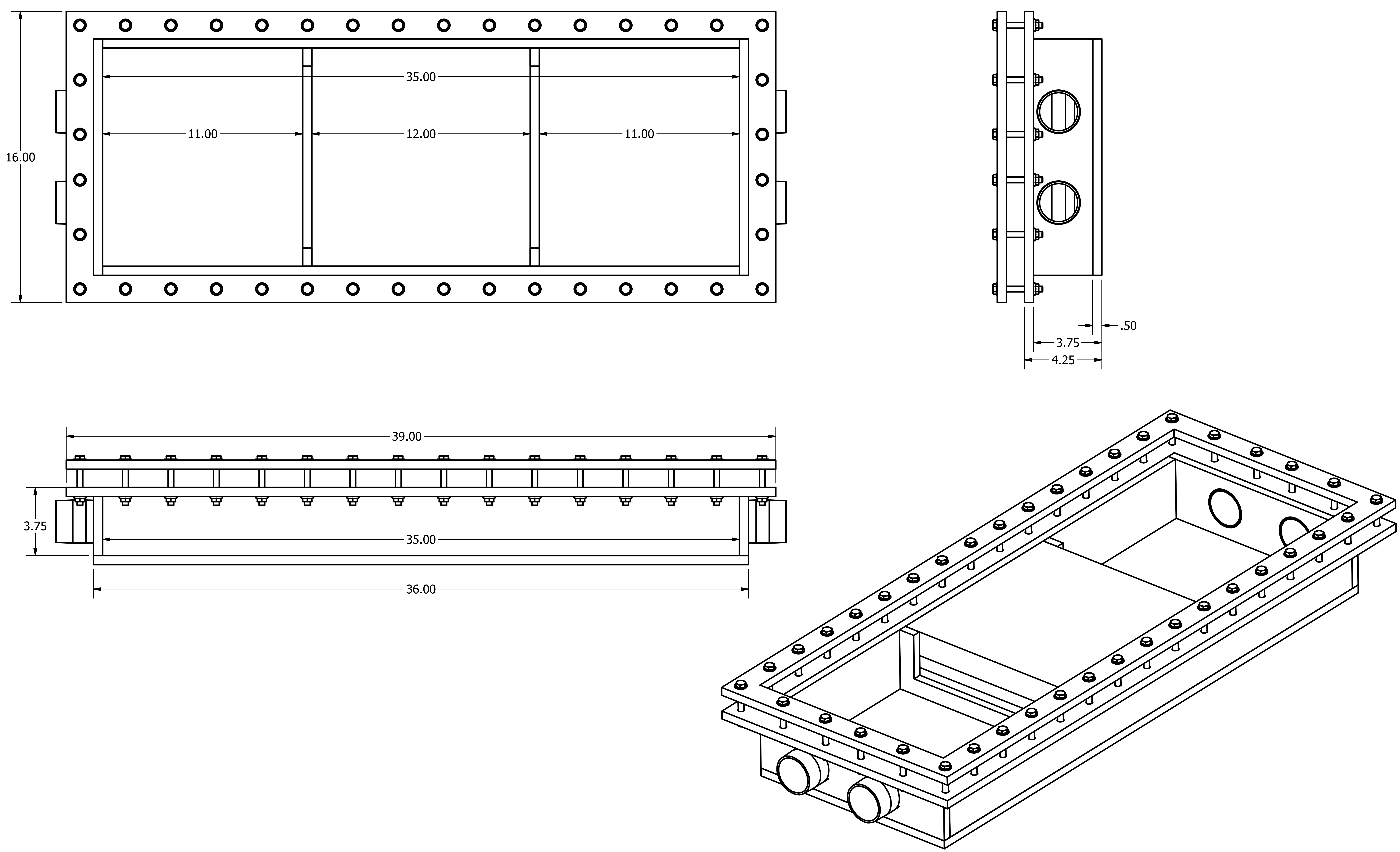
A field trial is recommended to test this approach on a leaking contraction joint. There are a few additional items to consider for a field trial. Grout that flows through the joint and doesn't react until it reaches the gutters in the galleries will need to be collected. Filters will be needed in the drainage gutters to collect this grout once it reacts and before it reaches sump pumps. Additionally, some of the grout will not flow into the joint and will instead react in the reservoir. This grout will float to the top of the reservoir and should be collected.

References

(Starbuck, Grand Coulee Dam Ground up Urethane and Grouting Travel Report, 2013)

Appendices

1. Fixture Drawings
2. Pump Specs
3. Grout Data Sheets



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CHECKED		TITLE		
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MFG				
APPROVED				
		SIZE C	DWG NO Plates Assembly	REV
		SCALE	SHEET 1 OF 1	

Bottom Plate 1/2" Steel
Qty 1

DRAWN DStarbuck	7/27/2016			
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MFG				
APPROVED				
		SIZE C	DWG NO	REV
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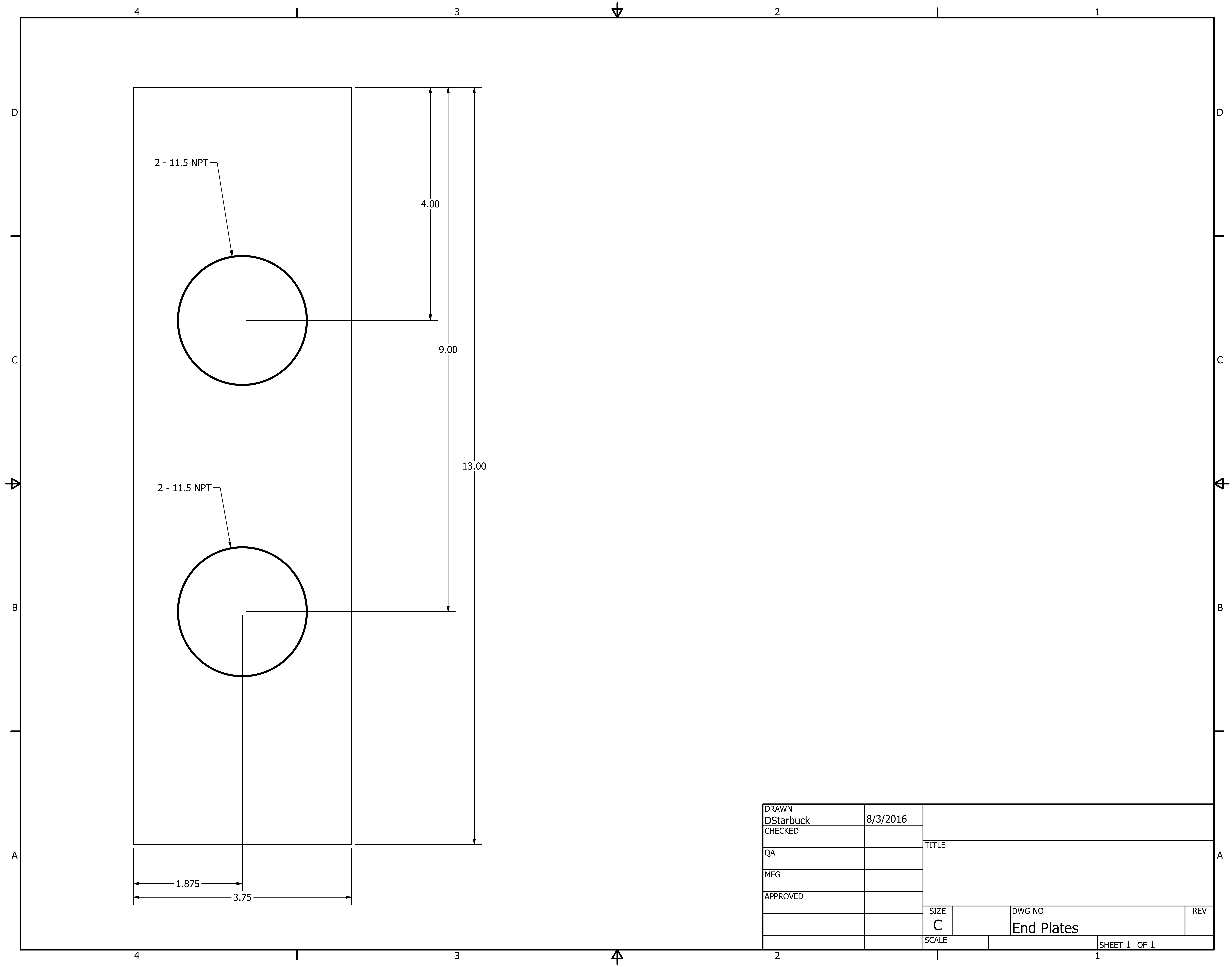
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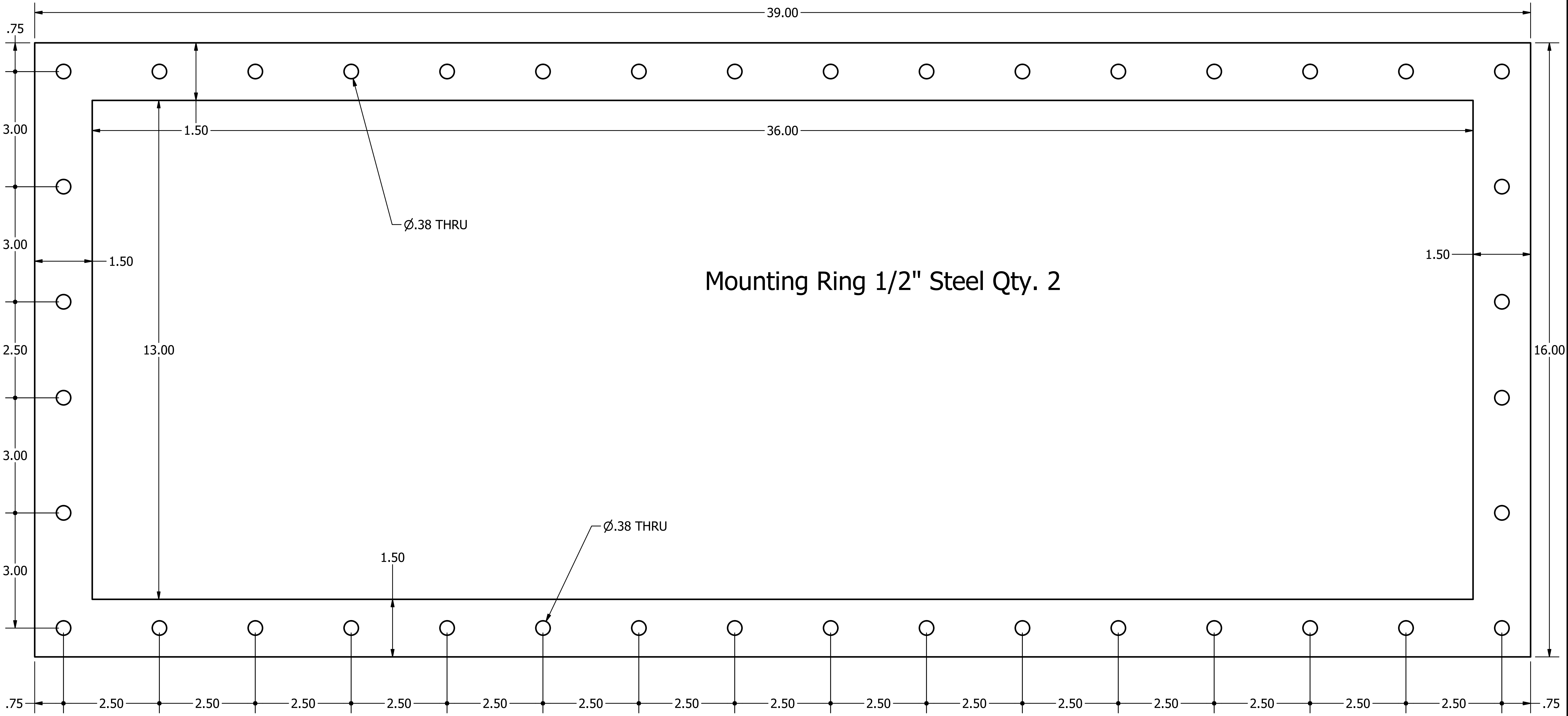

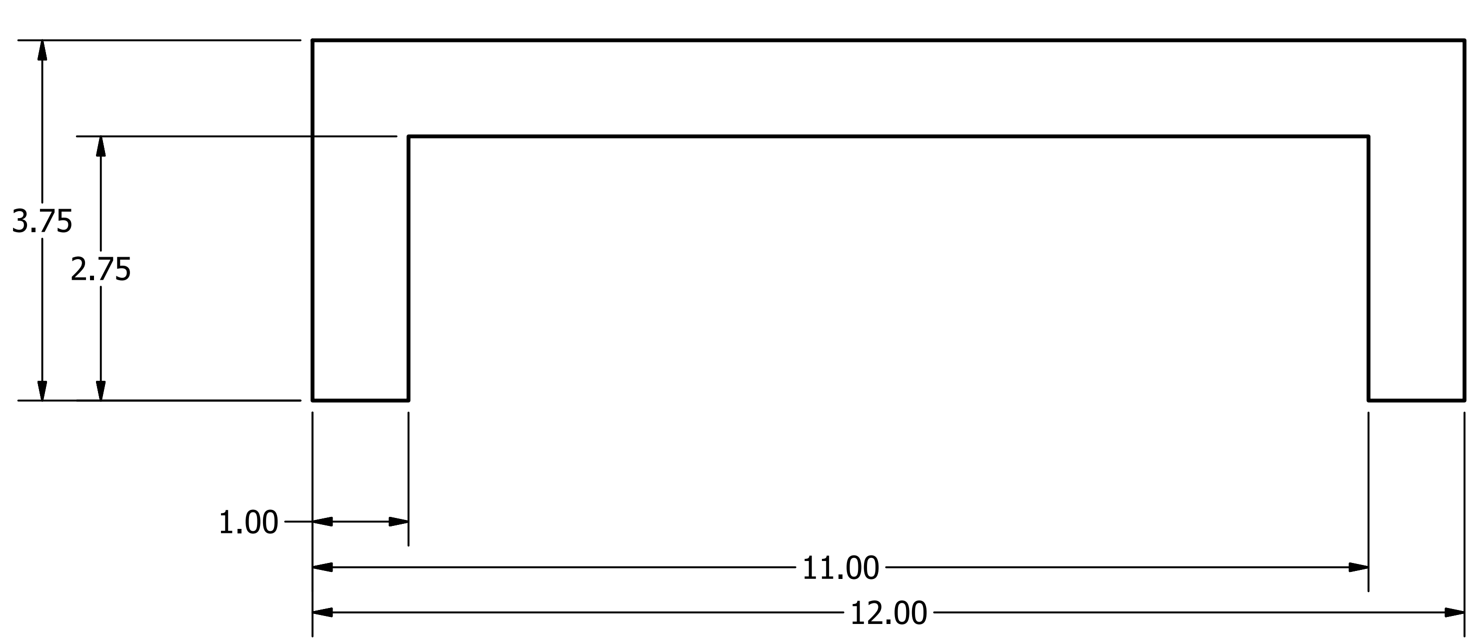

Retainer Plates
1/2" Steel Qty. 2

DRAWN DStarbuck	7/27/2016	
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MFG		
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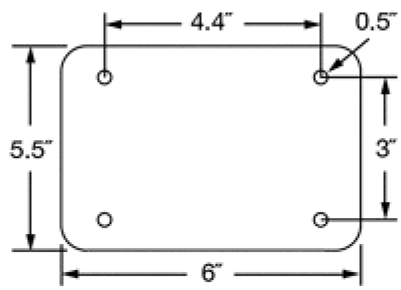
		SCALE · SHEET 1 OF 1

Self-Priming Pump for Water and Coolants

Heavy Duty, 2 hp, 240/460V AC, 2 Intake Pipe Size



Mounting Plate

Priming	Self-priming up to 20 ft.
Maximum Flow, gpm @ 30 Feet of Head @ 60 Feet of Head @ 90 Feet of Head	 90 50 28
Maximum Feet of Head	82
Maximum Solid Diameter	3/8"
Motor Enclosure Type	Totally Enclosed Fan Cooled (TEFC)
hp	2
Volts AC @ 60 Hz (phase)	240/460 (3)
Amps	6/3
Temperature Range	40° to 180° F
Connections	NPT Female
Pipe Size Intake Discharge	 2 2
Maximum Viscosity	1 cp
Height	11 1/8"
Width	9 1/8"
Depth	19 7/8"

Chemical Resistance	
No Effect (no performance degradation)	Deionized Water, Ethylene Glycol, Sodium Hydroxide (20%) at Max. temperature of 120° F, Water
Moderate Effect (may shorten product life or degrade performance)	Hydraulic Oil
Not Recommended	Acetone, Ammonium Hydroxide (100%), Diesel Fuel, Ethanol, Gasoline, Hydrochloric Acid (100%), Hydrochloric Acid (20%), Hydrochloric Acid (37%), Isopropyl Alcohol (100%), Kerosene, Lacquer Thinner, Methanol, Methyl Chloride, Methyl Ethyl Ketone, Mineral Spirits, Motor Oil, Nitric Acid (100%), Nitric Acid (20%), Nitric Acid (50%), Paint, Phosphoric Acid (<40%), Phosphoric Acid (Greater Than or Equal to 40%), Salt Water, Sodium Hydroxide (50%), Sodium Hydroxide (80%), Sodium Hypochlorite (Bleach), Sulfuric Acid (<10%), Sulfuric Acid (10-75%), Sulfuric Acid (>75%), Xylene
Note	Chemical compatibility must be determined by the customer based on the conditions in which the product is being used, including the presence of other chemicals, temperature, and consistency.
Wetted Parts	Buna-N, Carbon, Cast Iron, Ceramic, Type 304 Stainless Steel

Drain underground tanks and process wastewater with these pumps that can be installed up to 20 feet above your liquid source. Housing is cast iron. Do not run dry. Maximum viscosity is 1 centipoise, and temperature range is 40° to 180° F. Connections are NPT female.

Motor is continuous duty. Three-phase motors have wire leads for electrical connection.

Heavy duty and heavy duty high-flow pumps provide protection in dusty and dirtyenvironments. Heavy duty pumps have a cast iron impeller.

CONTINENTAL PROGRESSING CAVITY ULTRAPUMP

PERFORMANCE DATA

MODEL CP

REVISED 4/2012

PERFORMANCE DATA							
MODEL NO	DISCHARGE PRESSURE	CAPACITY- Gallons per Minute (Water at 70°F)					MOTOR HORSE POWER
		PUMP SPEED					
		1750 RPM	1150 RPM	870 RPM	580 RPM	430 RPM	
CP-15	0	1.9	1.3	1.0	0.7	0.5	1/2
	25	1.7	1.0	0.5	0.2	0.1	
	50	1.5	0.9	0.2			
	75	1.2	0.8				
	100	1.0	0.7				
	125	0.8	0.5				
	150	0.6	0.4				
CP-22	0	4.9	3.2	2.0	1.6	1.2	1/2
	25	4.1	2.7	2.0	1.3	0.9	
	50	3.4	2.2	1.6	1.0	0.7	
	75	2.6	1.7	1.3	0.8	0.6	
	100	2.0	1.5	1.0	0.6	0.4	
CP-33	0	9.4	6.0	4.6	3.1	2.3	1/2
	25	7.0	4.5	3.4	2.3	1.7	
	50	4.2	2.7	2.0	1.3	0.9	
CP-44	0	15.0	9.7	7.3	4.9	3.6	3/4
	25	12.0	7.8	5.9	4.0	3.0	
	50	9.4	6.1	4.6	3.1	2.3	3/4
CP-56	0	24.0	15.6	11.7	7.9	5.8	1 1/2
	25	22.0	14.3	10.7	7.2	5.3	
	35	20.5	13.3	10.0	6.7	4.9	
	50	19.5	12.7	9.5	6.4	4.1	
CP-67	0	53.0	34.5	26.0	17.5	13.0	2
	10	48.0	31.0	23.4	15.8	11.7	
	20	43.0	28.0	21.0	14.0	10.3	
	35	34.0	22.0	16.5	11.0	8.1	2
	50	25.0	16.3	12.3	8.3	6.1	2

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AURORA, CO 80011-1242

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1	10/07/13	071597 01

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TD continental cp-15 bureau of

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321-000500	VERBAL	010-DAVID HUDSON	Stock	NEXT DAY	10/07/13

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Units Ordered	U/M	Item Description	Units Shipped	B/C	Price	Per	Discount	Extended	Tax
1	EA	CPM-15-CSQ CLOSED COUPLED PUMP AND MOTOR 1.5GMP 1/2 HP BACKORDERED FROM INV#071597-00	1		995.8600		.00	995.86	T
1	EA	SHIPPING AND HANDLING	1		236.8700		.00	236.87	T

Terms: Monthly Service Charge May Be Applied To Past Due Accounts.
COD

Tax Area ID: CO - 060590300		Net Sales	1,232.73
		Freight	.00
State Tax %	2.900	State Tax	35.75
Local Tax %	4.100	Local Tax	50.54
		Invoice Amount	**1,319.02**

DENVER Winpump COMPANY

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T&C: You agree that the sale of these products/services is subject to all of our standard terms and conditions of sale located at www.winwholesale.com/tcsale.

INVOICELP : Laser Invoice

Stop leaks. Stabilize soil.
Control groundwater. Permanently.

Rev03.2016

TECHNICAL DATA SHEET

AV-248 FLEXSEAL

HYDROPHOBIC POLYURETHANE FOAM

DESCRIPTION
Injected as a single component, catalyzed **AV-248** Flexseal is a moisture activated MDI-based polyurethane resin. The chemical reaction is catalyzed by using **AV-249** Flexseal AC and uses moisture as an initiator. Like other hydrophobics, **AV-248** Flexseal withstands wet/dry cycles and reacts with moisture; but unlike other hydrophobics, it forms a resilient, impermeable *flexible* foam. This high quality resin is designed for sealing active and potential water leaks in various cracks, and annular spaces where flexibility is needed but is susceptible to wet/dry cycles. Avanti's **AV-248** is one of the most versatile products on the market.

APPLICATION
- For use above or below grade in humid or arid atmospheres
- Fills various cracks and pipe penetrations
- Stops leaks in concrete structures
- Designed for tunnels, mines, dams, reservoirs, block walls and structures that may shift

FEATURES AND BENEFITS
- Expands 400% – 600%
- Solvent-free system
- Controllable reaction time by adjusting **AV-249** Flexseal AC volume
- Withstands wet/dry cycles
- Unique hydrophobic that cures into a flexible, closed-cell foam

GROUTING TECHNIQUES
- Expanded Gasket Placement Technique (EGP)
- Variable Pressure Application Technique (V-PAT) – Crack Injection

HOW IT WORKS
AV-248 is a moisture-activated reaction. When injected into a concrete structure, the low viscosity resin will react with moisture and begin to expand. The final product is a very dense, closed cell foam impermeable to water yet flexible in nature.

ADDITIVES
- **AV-249** Flexseal AC – catalyst, 16 oz. (0.5 L) container

PACKAGING
Product packaged by weight based on specific gravity.
- Drum = Net Wt. 435 lbs. / Volume 48 – 49.36 gal.
- Pail = Net Wt. 44 lbs. / Volume 4.85 – 5 gal.
- Gallon = Net Wt. 8 lbs. / Volume ~1 gal.

SHIPPING
- Motor Class 55
- Non-Hazardous
- Air freight available

CLEANING PRODUCTS
- **AV-208** Acetone, Technical Grade (CAS# 67-64-1) – removes moisture from equipment
- **AV-284** Pump Wash (Proprietary Blend) – removes uncured resin from pump and hose
- **AV-222** Cleaner (Proprietary Blend) – removes cured resin from equipment

STORAGE
Store in temperatures within or near 60°F – 100°F (16°C – 38°C) in a dry atmosphere.

PROPERTIES*

AV-248 – UNCURED

Appearance:	Milky white to clear liquid
Viscosity:	550 – 830 cP @ 72°F (22°C)
Flash Point:	>200°F (>93°C)
Specific Gravity:	1.056 @ 72°F (22°C) ±3%
Weight:	8.8 lbs./gal ± 3% (1.054 kg/L ± 3%)

AV-248 – CURED

Appearance:	Milky white flexible foam
Tensile Strength:	TBD
Toxicity:	Non-toxic

AV-249 Flexseal AC

Appearance:	Light yellow to white, clear liquid
Viscosity:	5 cP @ 72°F (22°C)
Flash Point:	>200°F (>93°C)
Specific Gravity:	1.02 @ 72°F (22°C) ±3%
Weight:	8.5 lbs./gal ± 3% (1.018 kg/L ± 3%)

*Laboratory Results

MIX PROCEDURE
Typically, one container of **AV-249** Flexseal AC is used per 5-gallon container of **AV-248** Flexseal. Depending on the desired reaction time, **AV-249** may be doubled. Mix thoroughly, but slowly, to avoid creating bubbles in the solution. Perform the standard cup test with site water to determine the desired reaction time.

PERFORMANCE
Flush equipment with **AV-208** before and after use to remove moisture and clean equipment. Performance will be influenced by site conditions. If site temperatures are low, heat the product to recommended operating temperatures of 60°F – 90°F (16°C – 32°C) and/or increase catalyst amount by 1% – 2%. Do not exceed more than 32 oz. (1 L) of **AV-249** Flexseal AC per 5-gallon container of the **AV-248** Flexseal resin. Do not use open flame as a heat source. Excess amounts of **AV-249** may adversely affect performance. Because catalyzed resin will react to moisture from the air, use product soon after mixing for best results.

SAFETY
Always use OSHA-approved personal protective equipment (PPE). Refer to the SDS for complete safety precautions. The SDS is available by request or via download at www.AvantiGrout.com.

NOTICE

Gel (Cure) Times for AV-248 Flexseal (Min:Sec)

Temperature (°F)	Half Catalyst	Full Catalyst	Double Catalyst
40°F	14:30	9:15	6:43
50°F	12:10	7:15	5:34
60°F	10:54	6:15	3:12
70°F	9:04	4:40	2:30

Return to ST-504

ST-504

VARI-GEL INJECTION RESIN

INTRODUCTION

Stratathane ST-504 Vari-Gel Injection Resin is a solvent-free, MDI-based water control and soil stabilization system. ST-504 is hydrophilic and reacts with water to form either a flexible gel or an elastomeric foam depending on the amount of reaction water added to the mix.

Stratathane ST-504 contains no measurable amount of TDI as performed by the Modified Analysis for Diisocyanates. ST-504 is non-flammable, non-carcinogenic, and non-corrosive as defined by 40 CFR and as described in the *NIOSH Pocket Guide for Hazardous Materials.*

ST-504 has NSF 61 approval for potable water contact and carries the Underwriters Laboratories UL seal.

Stratathane ST-504 is mixed with water at the work site to form a single injection material. The inert end product forms a water barrier which is essentially unaffected by acids, gasses, and organisms usually found in soil. A minimum of water (around 5% by volume) is needed for a reaction to occur, but large amounts can be accommodated through reaction or displacement.

Stratathane ST-504 is useful for a wide range of water control and soil stabilization applications, including grout curtains, stabilizing water-bearing soils, and sealing cracks or joints in concrete walls, buildings, dams and utility vaults.

Stratathane ST-504 may be placed by hand pumps or multi- ratio power pumps. Stainless steel fittings are recommended but not strictly required because ST-504 is no more corrosive than water. Cleanup of solidified material in the system, however, is often accomplished with caustic cleaning compounds, making stainless steel advisable.

The low viscosity of ST-504 makes it easy to inject. Once cured, its impermeability makes it an effective water shut-off system. The permeability of soil grouted with ST-504 depends on how well its voids are filled with grout. Values in the 10-7 cm/sec range should be obtained using *ASTM Constant Head Permeability Test Method D-2434.*

A three stage reaction takes place when ST-504 mixes with an equal volume of water and foams. The mixture first thickens and becomes creamy. Then, carbon dioxide gas evolves rapidly and the mixture expands as it cures. The expanded ST-504 volume then sets into a strong impermeable water barrier. Unrestrained ST-504 foam may expand up to 10 times its starting volume depending upon the degree of confinement applied to the expanding mass.

When ST-504 mixes with a large volume of water (i.e. 10:1 or greater), the three stages of the foam reaction cycle are not visible in the reacting mass. Instead, a marked viscosity increase will be seen just before the mass solidifies.

The reaction sequence with water takes place continuously during injection as product exits the packer. Initial penetration of the ST-504 grout mixture is facilitated by its low viscosity. After setting (in the case of the foam sequence), the expansive mixture pressure induces further filling of the grout zone. An ST-504 seal will tolerate freeze-thaw, wet-dry cycling, extrusion, and compression to a substantial degree.

DESCRIPTION

Uncured ST-504 is a dark brown liquid with a viscosity of about 700 cps at 25 C (77 F). This low viscosity is reduced even further after water is added. ST-504 contains non-volatile materials making up almost 100% of its total weight. Cured ST-504 is very firm and flexible. Its solid is a three dimensional cross-linked molecular structure which is insoluble in water.

PHYSICAL PROPERTIES

Color	Dark brown	
Viscosity	700 cps at 25 C	ASTM D1838
Specific Gravity	1.1 g/cc	9.25 lbs/gal
Flash Point	>220 F	ASTM D-93
Solids Content	>85%	ASTM D2832
Tensile Strength	>250 psi	ASTM 3574
Elongation	>400%	ASTM 3574
Shrinkage	<11%	ASTM D-1042
Vapor Pressure	0.0000002 psi	
Vapor Density	8.5 (Air = 1.0)	
Solubility	Insoluble; Reacts with water	

3601 104th Street Des Moines, Iowa 50322 PHONE 515/251.7770 FAX 515/251.7705
WEB SITE www.strata-tech.com EMAIL Info@strata-tech.com

Set time is the period from first contact of ST-504 with water to the point where the mix becomes too thick for gravity flow. The set time (sometimes called foam time) is influenced primarily by the mix temperature and the ratio of ST-504 to water. Set times are longest at low temperatures and ST-504 ratios, and vary a little with the age of the resin and mineral content of the water. The viscosity of mixed ST-504 is lowest for the first 40% to 50% of the set time and increases rapidly as the mix approaches set.

SET TIME
Seconds at 20 Degrees C

WATER : RESIN	GEL	RISE	TACK FREE
9:1	150	-	-
4:1	95		110
2:1	85	95	100
1:1	95	110	160
1:2	100	120	170
1:3	100	120	180

CLEANUP

ST-504 should not stand in equipment more than 12 hours without precautions because the possibility of moisture contamination is high. Flush equipment with ST-590 purging fluid and ST-522 Cleaner soon after use. The most common solvent for removal of liquid ST-504 is methylene chloride. Check solvents for water content prior to use.

When using solvents during cleanup, extinguish all ignition sources and observe proper precautions for handling such materials. For cleanup of cured ST-504, soak in a 100% solution of ST-522 Veri-Kleen Grout Cleaner using a covered polyethylene container. Grout spills on clothing are permanent, so disposable coveralls are recommended.

HANDLING AND STORAGE

Use reasonable care in handling and storing ST-504. The material is moderately sensitive to high storage temperatures. Under optimum storage of 40 - 60 F in dry conditions, the material should have a useful shelf life of one year. Storage temperature should not exceed 80 F. Once a container has been opened, the life of the material is reduced. Let container stand and adjust to ambient temperature before opening to prevent contamination by condensation. Test a resealed container to assure that moisture contamination has not occurred. Before handling this product, read and understand the Material Safety Data Sheet (MSDS). Instruction in sound safety practices is beyond the scope of this publication.

Direct contact of ST-504 liquid may cause skin and eye irritation. If ST-504 comes in contact with skin, wash with soap and water. For eye contact, flush immediately with water and consult a physician. ST-504 must not be ingested. Before eating, smoking or drinking, remove protective clothing, wash with soap and water, and stand away from the immediate work site. Do not smoke while working with ST-504. If respiratory difficulties occur, seek medical attention. Avoid exposure to vapors created from this product when it is heated. Gloves, goggles, respirator and protective clothing are recommended. Ventilate the work area as a matter of good practice, although hazardous levels of toxic vapors are not generally given off of the bulk product below 90 degrees F. Small amounts of MDI may be present and some users may be sensitive to MDI.

Summary of Handling Precautions:

1. Wear goggles and rubber gloves.
2. Wash any body contact area throughly with water.
3. In case of eye contact, wash immediately with water and seek medical attention.
4. Keep material away from heat and flame.
5. Ventilate and use respirator in hot or closed spaces.

Back to ST-504 Urethane Grout

STATEMENT

TDS

ONE-COMPONENT RESIN

SPETEC® PU F400

DESCRIPTION

Solvent and phthalate free, water reactive, hydrophobic, closed cell, low viscosity, shrink-free, flexible, one-component polyurethane injection resin designed to shut off water leaks

APPLICATIONS

- Shut off water leaks in concrete, brickwork and sewers where movement and settlement may occur
- Water cut-off of water leaks in foundations such as diaphragm walls, piling sheets and secant piles
- Sealing water-carrying cracks and joints in tunnel segments
- Curtain grouting behind tunnel, concrete, brickwork and sewer walls
- Injection of water cut-off membranes and liners in tunnels

ADVANTAGES

- One component
- Different reaction times are possible by adjusting the percentage of SPETEC® PU F400 ACC
- The closed-cell structure of cured polyurethane ensures permanent flexible sealing of cracks and joints.
- Cured polyurethane is flexible, shrink-free and exhibits good chemical resistance (contact our Technical Service for chemical resistance)
- Cured polyurethane is harmless for the environment and resistant to biological attacks.
- WQA drinking water certificate

PROCEDURE

Read the technical and safety data sheets prior to commencement of the injection works.
Vigorously shake the SPETEC® PU F400 ACC before use and pour the required quantity (2-10%) into the SPETEC® PU F400 resin. Mix the accelerator homogeneously into the resin and protect against moisture and rain to prevent premature reaction.
Depending on the application, injection can be carried out using a hand pump, pneumatic pump or electric pump.
Preferably use a separate pump for injection of water and PU resin.
Prior to injection, the pump must be flushed with Spetec PU Pump Flush and be completely free of water to prevent pump blockage.

PACKAGING AND STORAGE

SPETEC® PU F400 is moisture sensitive and should be stored in a dry area between 5°C and 30°C.
Shelf life: 24 months in original packaging.
Once opened, containers should be used as soon as possible.
SPETEC® PU F400 is packaged in 1000kg IBC containers, 200kg steel drums, 20kg and 5kg metal cans.
SPETEC® PU F400 ACC is packaged in 20kg metal cans, 2kg and 0.5kg bottles.

SAFETY INSTRUCTIONS

Avoid contact with eyes and skin, always use personal protective equipment in compliance with local regulations.
Read the relevant safety data sheets before use. When in doubt contact Resiplast Technical Service.

PROPERTIES

SPETEC® PU F400, uncured *(appearance: white liquid)*		
Viscosity at 25°C	EN ISO 3219	±340mPa.s
Flash point	EN ISO 2719	>150°C
Density	EN ISO 2811	±1.04kg/dm³

SPETEC® PU F400 ACC, Accelerator for SPETEC® PU F400 *(appearance: blue liquid)*		
Viscosity at 25°C	EN ISO 3219	±15mPa.s
Flash point	EN ISO 2719	>150°C
Density	EN ISO 2811	±0.9kg/dm³

SPETEC® PU F400 + Accelerator cured		
Tensile strength	EN 527	>1MPa
Elongation at break	EN 527	±100%
Density	EN ISO 1183	±1kg/dm³

REACTION RATE

SPETEC® PU F400 ACC	5°C		15°C		25°C		
%	Start	End	Start	End	Start	End	
2	145″	320″	120″	300″	60″	170″	4V
6	65″	110″	50″	95″	35″	80″	4V
10	45″	70″	30″	65″	25″	58″	4V

Resiplast NV/SA • Gulkenrodestraat 3 • B-2160 Wommelgem • info@spetec.com • www.spetec.com
Tel. +32 3 320 02 11 • Fax +32 3 322 63 80

Data Sets that support the final report

- Share Drive folder name and path where data are stored: H:\D8180\Science and Technology\FY16\Starbuck\Sealing Contraction Joints

- Point of Contact name, email and phone: D. Warren Starbuck dstarbuck@usbr.gov 303-445-2317

- Short description of the data: Drawings, Testing Photos and Videos

- Keywords: contraction joints, waterstop, grout

- Approximate total size of all files: 52.9 GB