THE LITTLE BOOK OF

WATERSTOP

VERSION 2.0

David R. Poole

The Little Book of Waterstop

About the Author

Water is our most valuable commodity. It is important to protect it, either from loss or pollution. Properly installed waterstop achieves both goals.

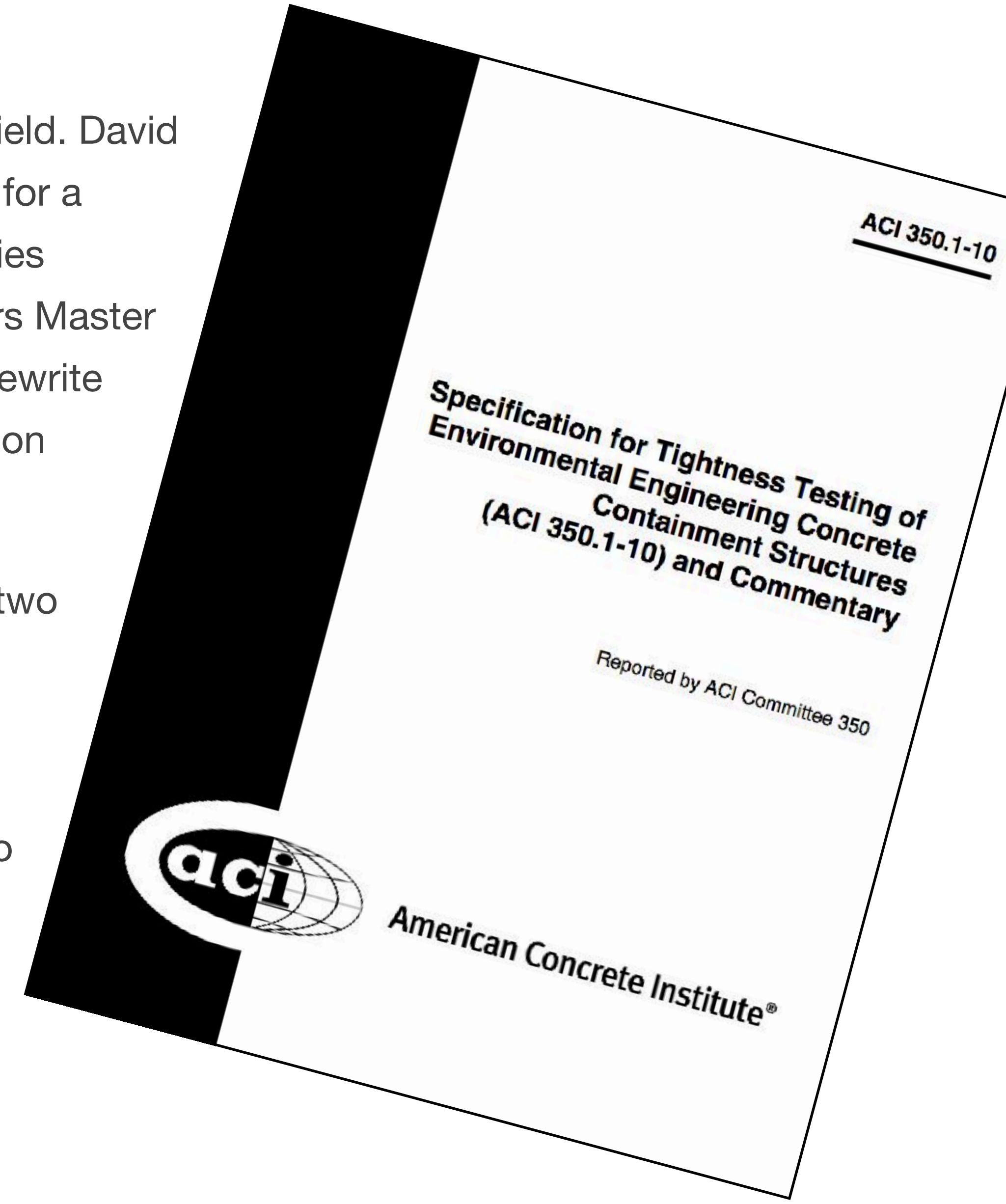
—David R. Poole

David Reid Poole has been with J P Specialties, Inc., the world's leading manufacturer of chemical resistant waterstop (Earth Shield®) for over 20 years and is the president and owner of the company since 2008.

David also serves as secretary of American Concrete Institute (ACI) 350 *Environmental Engineering Concrete Structures Subcommittee K (Hazardous Materials), and G (Tightness Testing).* David is currently co-authoring in committee the revised *"Concrete Structures for Containment of Hazardous Materials".*

A member of the San Diego Chapter of the Construction Specifications Institute (CSI), and a frequent public speaker, David's accredited engineering seminars are requested nationwide by major engineering firms including Montgomery Watson Harza, CH2M Hill, Carollo Engineers, Jacobs Engineers, Camp Dresser McKee, Fluor Corp., Kellogg Brown & Root, and many others. David has also taught waterstop theory, technology, and installation to project owners, concrete accessories distributors, and contractors in the field. David has consulted on and written national and international CSI-format 3-part specifications for a variety of engineering firms and governmental agencies including the July 1995 U.S. Army Corps of Engineers Master Specification (CEGS 03250). In 2010, David helped rewrite the non-proprietary American Water Works Association (AWWA) guide specification for waterstop.

David lives in Temecula, California with his wife and two children, where he recently participated in the inauguration and charter of the Southwest California Manufacturing Council that is attempting to solve some of the complex manufacturing issues related to U.S.-based manufacturers, and specifically in Southern California. David spends as much time as possible enjoying the outdoors, especially the beach, with his family — surfing, biking, and driving throughout Southern California.



Preface

Concrete is everywhere: Buildings, fountains, parking decks, locks and dams, roads and bridges, and myriad other constructions. Because of its long lifespan, high workability, and near-worldwide availability, concrete is the preferred building material for large structures, especially those subject to hydraulic pressure.

Not all concrete structures require protection from the ingress of water or other fluids, but those that do require a properly installed waterstop in and along their concrete joints. The concrete joint is the most likely point of leakage, and waterstops are uniquely designed to prevent this.

This book's sole purpose is to educate the reader on all facets of waterstop. Because this book is digital and online, chapter and volume updates will be frequent, so please check back periodically for (free) updates.

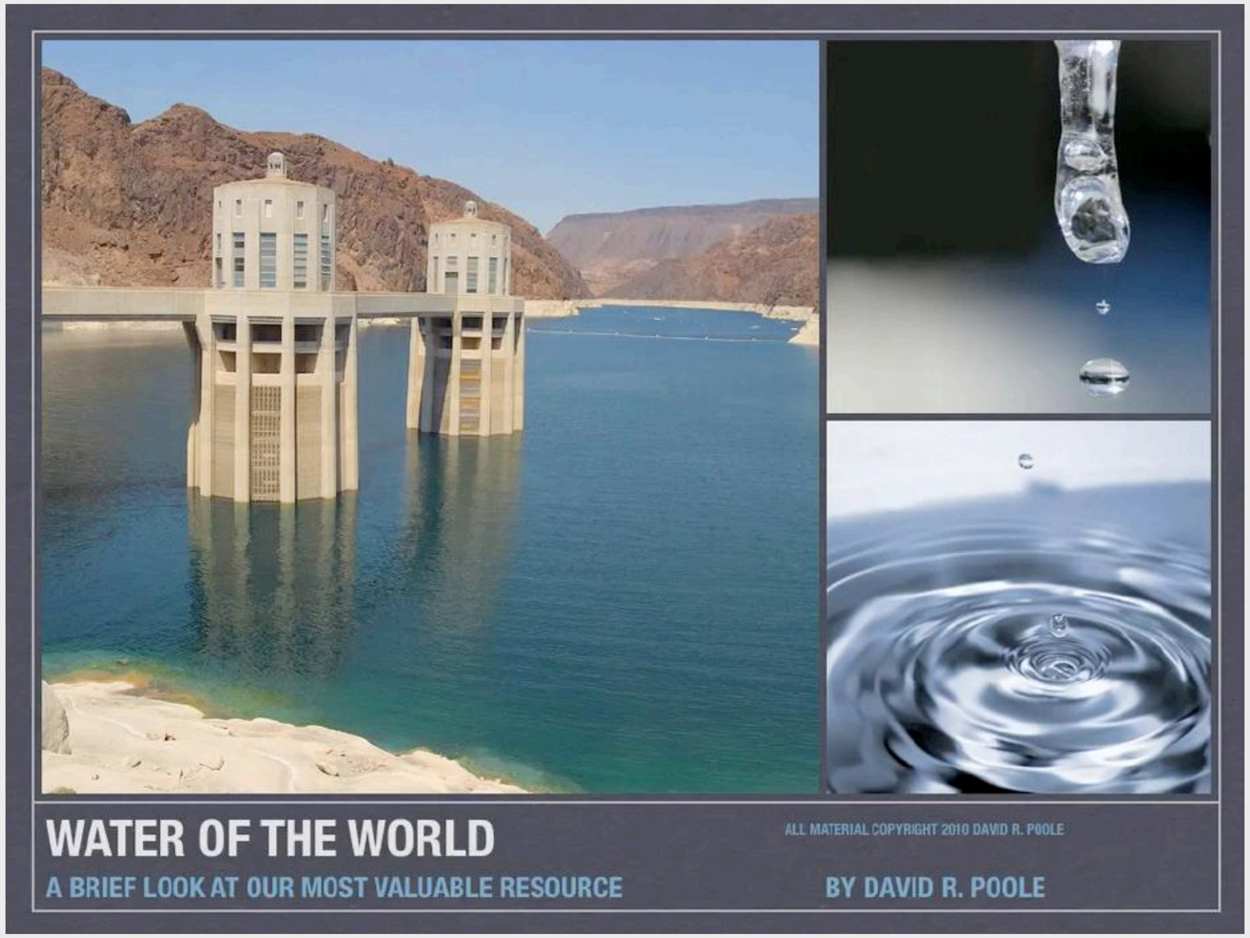
— David R. Poole

Chapter 1

Water for Life

Equaled only by oxygen, water is absolutely essential for life. Beyond human health, water is required for food production, social and economic development, energy production, and restoration of ecosystems.

Movie 1.1 Adapted from “Water of the World”



Originally presented at the Temecula Public Library on July 21, 2010

Life as we know it is unsustainable without water. Water is so essential for life that civilizations have risen and collapsed, due to their capacity, or lack thereof, to harvest a continual supply of water.

Without question, water, along with oxygen, is our most precious resource, and great care must be taken to protect it. Governments around the world have recognized this fact and have crafted byzantine codifications mandating protection protocols, treatment programs, and storage and distribution regulatory requirements. The most predominant problems facing the world in regards to water are:

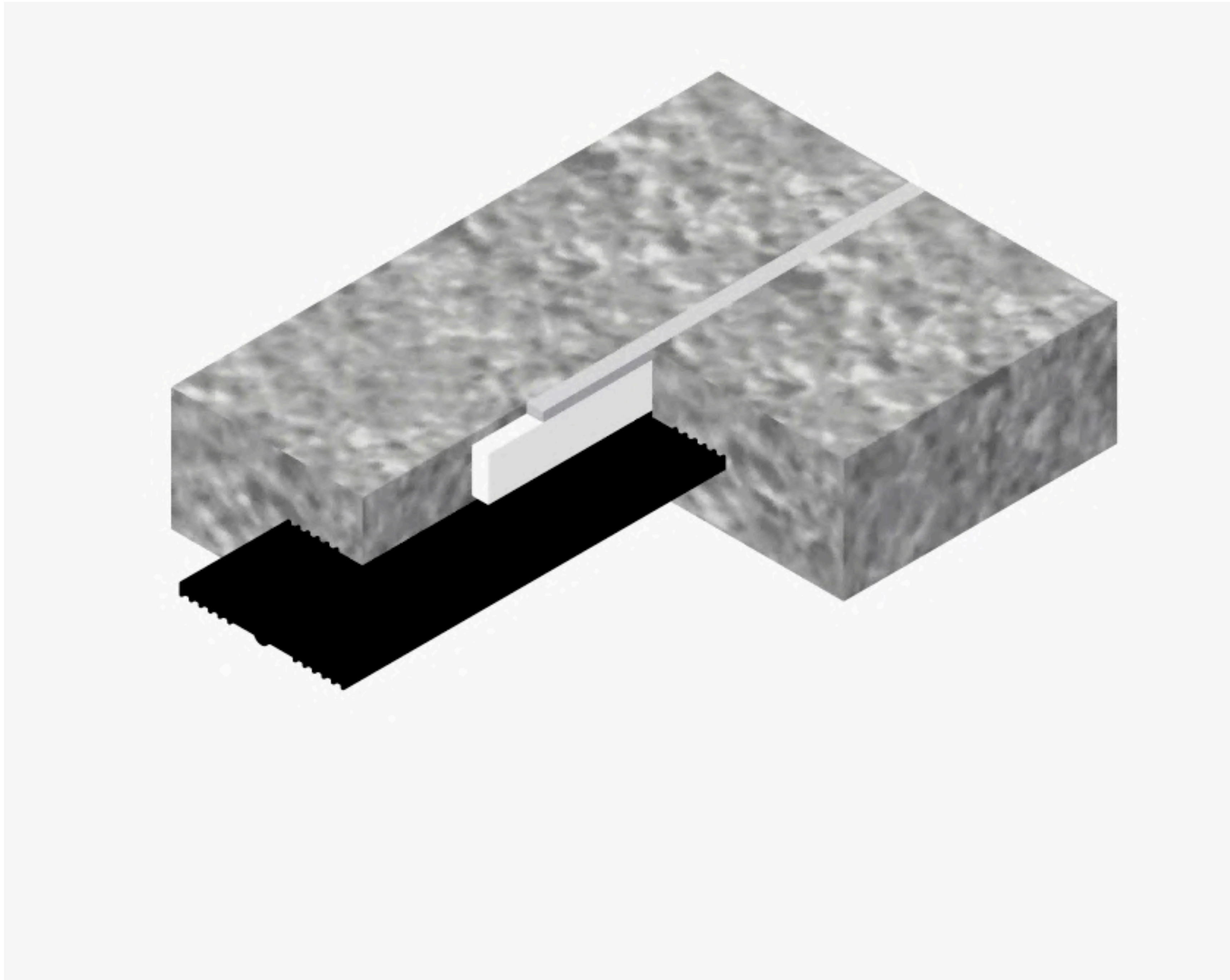
1. Quantity — Only 2.5% of the earth's water is freshwater, and much of it is inaccessible as it is frozen in icecaps or glaciers, or in the ground.
2. Quality — According to the United Nations, by the year 2025, 50% of the world's population will be facing a daily struggle to find enough water to meet their basic needs.

While quantity affects many nations, quality is primarily a problem of the developing world. Modern water treatment systems throughout the developed world have eradicated most deadly pathogens, and thankfully your nightly news is not filled with stories of outbreaks of cholera or typhoid.

Because water is such a finite resource and so basic to our survival, we must take every possible precaution to safeguard it throughout its entire life cycle: extraction, treatment, storage, distribution, and process.

Concrete is the preferred building material used in regards to water structures. Whether it's a megalithic concrete dam, holding back tens of millions of gallons of water, or pretreatment and treatment units at your municipal water treatment plant, you will see that it is made of concrete. Concrete is a great building material for water structures, as it is can be made fluid-proof and strong, and has a very long lifecycle. Concrete is relatively easy to manufacture and install almost anywhere in the world. On the downside, concrete can not be truly functional without joints, and joints will leak unless adequate provisions are made to fluid-proof them. ***The sole function of waterstop is to prevent the passage of fluids through concrete joints.***

Movie 1.2 Waterstop in a Concrete Expansion Joint



Waterstop prevents the passage of fluids through concrete joints, such as the expansion joint illustrated above.

Chapter 2

An Introduction to Waterstop

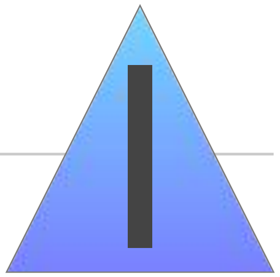
Designed to prevent the passage of fluids through concrete joints, waterstop is the leading specified construction material for waterproofing environmental engineered concrete structures.

Gallery 2.1 From Waterproofing to Waterstop

Without a proper vapor barrier, this attractive hardwood flooring could be destroyed over time from vapor migration through the concrete slab.

To understand what a waterstop is, it is helpful to understand what it is not. Waterstop will not prevent the migration of moisture through a concrete slab, protecting the installed flooring system (such as tile or hardwood) from adhesion failure or deterioration. Nor will waterstop have any effect on capillary water migration through concrete walls. Vapor barriers, drain boards, concrete admixtures, bituminous wraps, flashings, and a myriad of other construction products are available to the specifier, contractor, or end-user for these criteria.

Waterstop has a singular purpose: To prevent the passage of fluids across and along concrete joints. Waterstop does all of its work *at the joint*. Because concrete joints are frequently open and subject to hydrostatic loads, waterstop has *the most critical role* in fluid-proofing a concrete structure. A pinhole or imperfection in a vapor barrier will have little to no noticeable effect. Still, even the slightest defect in the waterstop product or its installation can be truly catastrophic to the fluid-tight integrity of the building envelope. For this reason, a great deal of care must go into what I call the **MSI Process: Manufacturing, Selection, and Installation**.



WATERSTOP MSI PROCESS

1. **Waterstop MANUFACTURING, history, and types of products commercially available. The manufactured waterstop must be of the highest quality from a manufacturer offering specification, detailing, and installation assistance.**
2. **Waterstop product SELECTION is the second most important consideration. Profiles are available for myriad applications and conditions. The designer must choose correctly, preferably with manufacturer consultation.**
3. **Waterstop INSTALLATION. Most waterstop failures occur because the material incorrectly installed.**

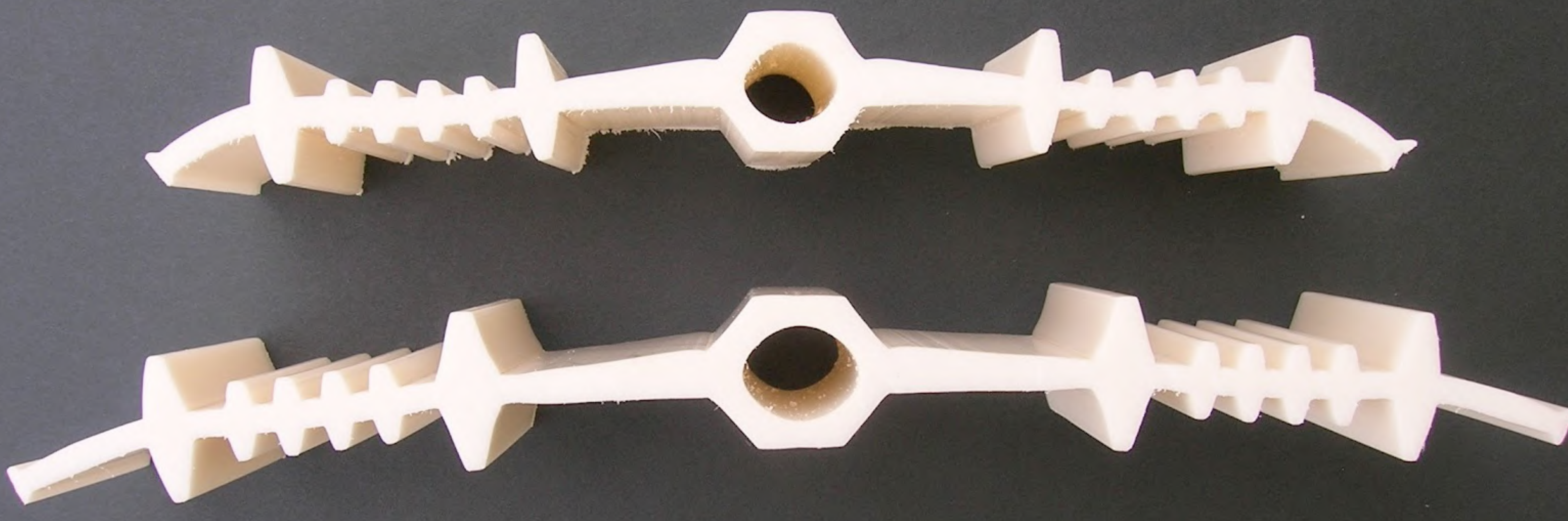
This book is brief by design. Waterstop has the singular purpose of preventing fluid leaks at concrete joints, and I have the singular *goal of educating you on how to achieve this*. Chances you're an adult, actively working in the concrete construction industry, either as an engineer or a contractor. Your life is already

full, and a long, boring book filled with superfluous information can only waste your time and impede my goal. I do much public speaking, and I have found that my audiences appreciate my brevity and clarity. *Waterstop does not need to be overly complicated*. Many of the best waterstop systems are the same simple designs from the early 20th century.

The first waterstops used in construction were strips of lead or copper. In the early 1900s, the preferred waterstop material shifted to vulcanized rubbers such as neoprene or styrene-butadiene rubber (SBR). Rubber waterstops had excellent mechanical properties (high tensile strength and significant elongation). However, they had one major weakness: they were challenging to fabricate as the rubber was vulcanized. It had already taken a "set" (thermoset) and could not be heat welded together like the metals used previously.

In 1926, a new plastic compound was invented by Waldo Semon of the B. F. Goodrich Company: plasticized PVC. Semon was attempting to dehydrohalogenate (*non-plasticized*) PVC in a boiling solvent solution to create an unsaturated polymer that would be useful for bonding rubber to metal. The results of Semon's experiment was the creation of a thermoplastic with properties very similar to rubber.

It took many years for *plasticized* PVC to find suitable commercial applications, and was first used as a waterstop material in the early 1950s. Back then, the material was *properly* labeled as *fPVC or flexible PVC.* The first wide-scale test of any waterstop was performed in 1954 by the Hydro-Electric Power Commission of Ontario, Canada. Many manufacturers still use the results of this test as a benchmark. Other than some new polymers, waterstop has not changed that much since then.



Flexijoint brand PVC Waterstop — White GSP Series

Section 1

Types of Concrete Joints

Contraction Joints

Contraction Joints divide large pours of concrete into smaller structural units. Contraction joints create a man-made plane of weakness to regulate and control (another name for a contraction joint is a control joint) the location of a crack formed by moisture loss of concrete. Without this formed contraction joint, the concrete would freely crack in unexpected and unattractive places.

Construction Joints

Construction Joints are an interruption of the concrete pour 30 minutes or greater.

Expansion Joints

Expansion Joints negate the compressive forces from abutting concrete structures that may occur due to expansion, loads, or differential movements from settlement. Expansion joints require an actual gap between the concrete pours, filled with a compressible joint filler material such as foam, rubber, cork, or cane fiberboard.

EDITORIAL

One of the most significant advantages of embedded, hydrophobic waterstops versus strip-applied hydrophilic waterstops is their ability to be installed and perform as intended in all three types of concrete joints — contraction, construction, and expansion. By contrast, the strip-applied varieties can only function in construction joints, limiting their usefulness throughout the entire project.

I am aware of only one manufacturer who prescribes a nailed-on hydrophilic waterstop for use in an expansion joint. I disagree entirely with its application and doubt it works as advertised.

---David R. Poole

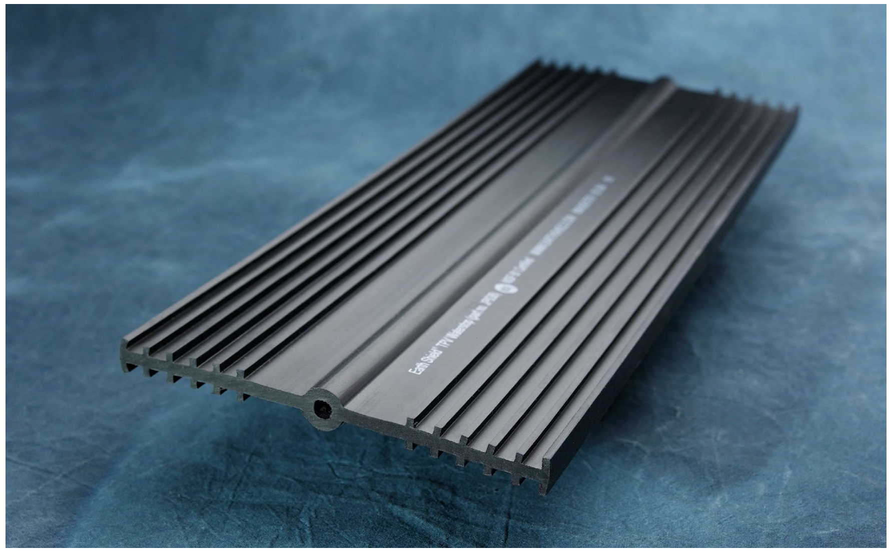
Hydrophobic Waterstop: Internal Dam

HYDROPHOBIC WATERSTOP

1. **Prevents the passage of fluids through concrete joints by creating an internal dam, spanning both sides of and running *continuously* along the concrete joint.**
2. **Somewhat difficult to install properly as split-forming is usually necessary.**
3. **Widest variety of polymer and metallic products to choose from for myriad applications.**
4. **Products are available for above- or below-grade; moving or non-moving applications.**
5. **Designed to last the life of the concrete structure.**
6. **Longest recorded history of use and most available test data.**

When most engineers or contractors think of a "waterstop" what they're generally referring to is a 50-foot long section of a flexible, waterproof material (usually plastic or rubber), four to nine inches wide, and installed along the concrete joint in between the formwork. This waterstop is more accurately defined as a *hydrophobic waterstop*: A waterstop designed to prevent the passage of fluids by repelling them along and away from the waterstop product, and creating an internal dam at and along the concrete joint. Hydrophobicity is the amount of water repulsion of the surface of the waterstop and can be measured: Place a drop of water on the flat side of the waterstop to be tested and measure the relief angle of the water drop. The sharper the angle, the more hydrophobic the waterstop material is. An angle 90 degrees or higher makes the waterstop truly hydrophobic, and this product will actively move fluids along the joint and away from the source.

Gallery 2.2 Hydrophobic Waterstop



Ribbed centerbulb, hydrophobic waterstops are the most versatile type of waterstop manufactured today.

A waterstop that will perform well must have adequate strength and extensibility to avoid be torn or ruptured by joint movement. The best waterstop products maintain high tensile strength and good elongation [ASTM D-412]) when exposed to the installed environment for the service life of the structure. Exposure conditions which could affect a waterstop's service life are:

- Temperature
- UV exposure
- Ozone exposure
- Chemical attack

Because hydrophobic waterstops act as dams at the concrete joint, a general rule of thumb is the greater the size of a waterstop (waterstop size is actually it's width, *e.g.* 4", 6", 9", etc.), the higher the head pressure the waterstop will resist. A small 4" waterstop is more than suitable for a containment wall surrounding a tank farm, or even a swimming pool in a back yard, but would be entirely inappropriate for the foot of a large dam. Giant concrete structures such as dams or locks will require 9" wide waterstops or greater.

It's not just the width (size) that effects waterstop performance. Thickness also plays an important role. Like conventional dams, the thicker waterstops can resist higher head pressures of water (or other aqueous fluids).

Because proper installation plays such a critical part in the effectiveness of a given waterstop system, the very best waterstops can be fused and fabricated easily. For this reason, the majority of today's design engineers specify and require thermoplastic waterstops (such as PVC or TPV), and not the earlier thermoset varieties (neoprene, SBR, natural rubber). Thermoplastic materials can be easily field fabricated for simple change of directions and the joining of straight lengths; whereas, the earlier thermoset rubber materials generally were ineffectively glued and clamped together, causing severe weakness in the waterstop diaphragm and leaking.

Gallery 2.3 Hydrophobicity

A waxed car hood repels water because wax is hydrophobic. Hydrophobic waterstop functions the same way.

A waterstop's cross-sectional area is called its profile, and there are lots of profiles to choose from. Still, they all share the same basic anatomy (illustrated in the next section). A series of fins or bulbs provides interlock with the concrete, the body or web to provide the necessary rigidity and product width, and possibly a hollow cavity or bulb to enable the waterstop with additional movement properties.

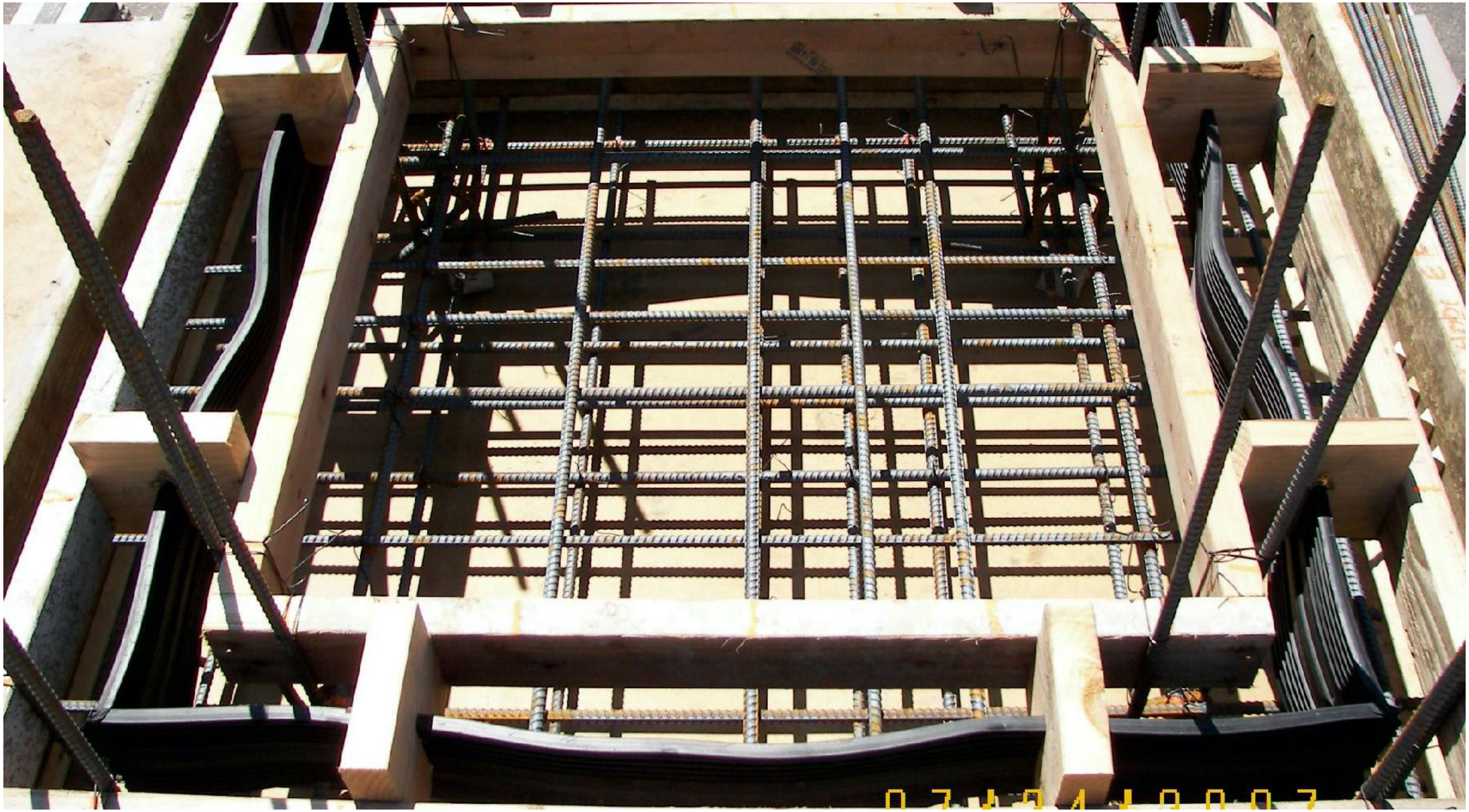
By far, the most significant difference between various waterstops on the market today is the manufactured *polymers* and the *services* offered by multiple manufacturers. This book will cover modern polymers at length, but it is up to the individual designer to find a manufacturer that provides the desired set of services and support for their project. These after-sale services and support separate a great manufactured waterstop from a poor one, and I will leave this crucial consideration to the reader. Just remember, “Choose wisely.” A waterstop is permanently installed in concrete (much like rebar), and there are no second chances to get it right.

TYPICAL WATERSTOP HEAD PRESSURE RATINGS

1. **4-inch wide ribbed centerbulb waterstop: 75 ft head of water (32.5 psi)**
2. **6-inch wide ribbed centerbulb waterstop: 125 ft head of water (54.2 psi)**
3. **9-inch wide ribbed centerbulb waterstop: 175 ft head of water (75.9 psi)**

The above values are “typical” and are representative of multiple manufacturer’s products and polymers. Always check with the specified waterstop manufacturer for what their published fluid pressure ratings are.

Gallery 2.4 Waterstop in Vertical Orientation in Slab



Waterstop suspended for slab pour (top view).

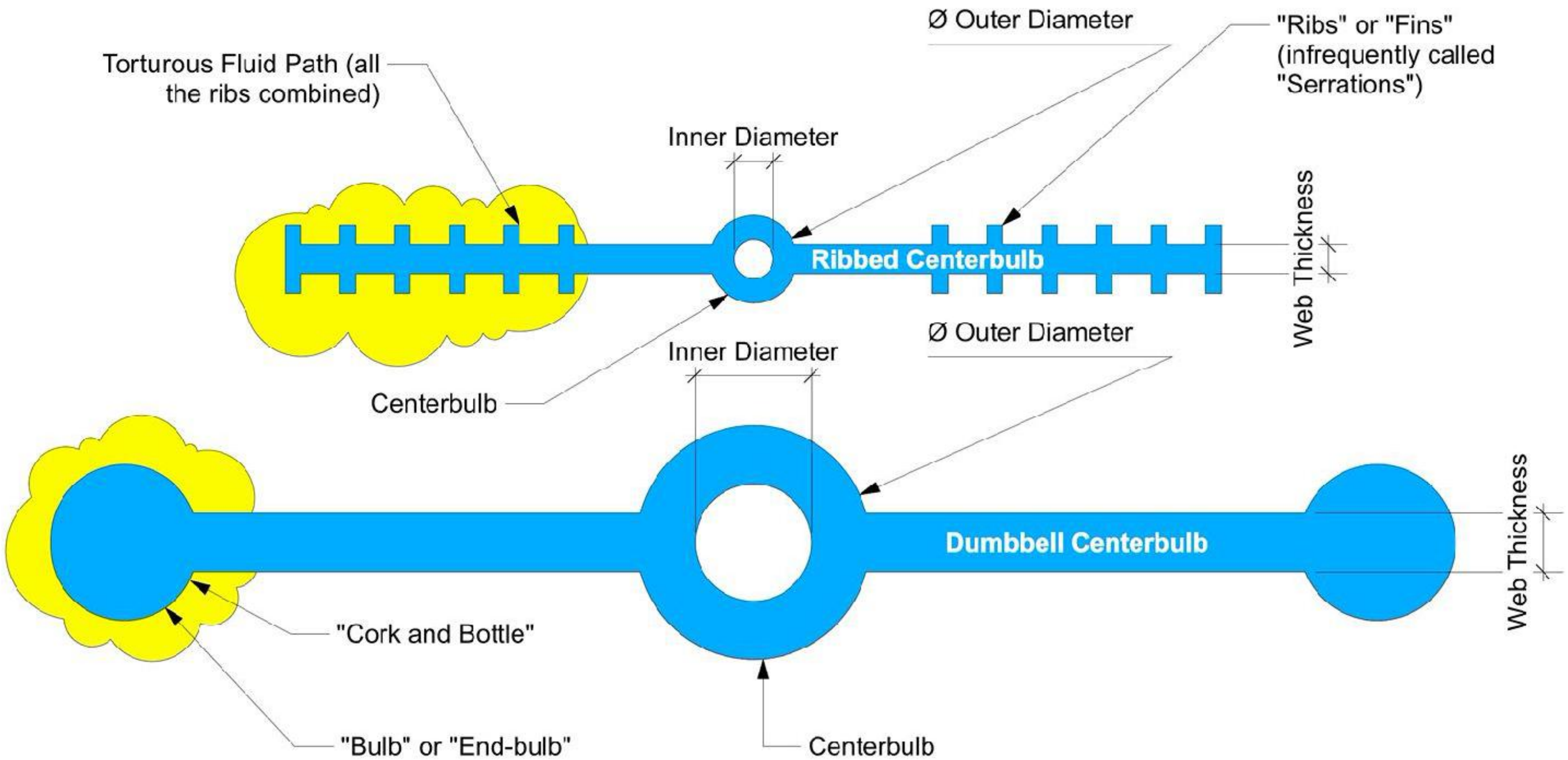
The Anatomy and Selection of Hydrophobic Waterstop

RIBBED CENTERBULB WATERSTOP (6-INCH) AND DUMBBELL CENTERBULB WATERSTOP (9-INCH)

1. Ribs (aka Fins or Serrations) create a “Torturous Fluid Path” by acting as multiple internal dams, making it more difficult for the fluid to migrate past.

2. End-bulbs act as a single internal dam, sealing the joint using the “Cork and Bottle” theory: When the waterstop is placed under tension, the end-bulb is pulled tightly into the more narrow void of the web thickness, sealing the joint much like a cork in a wine bottle.

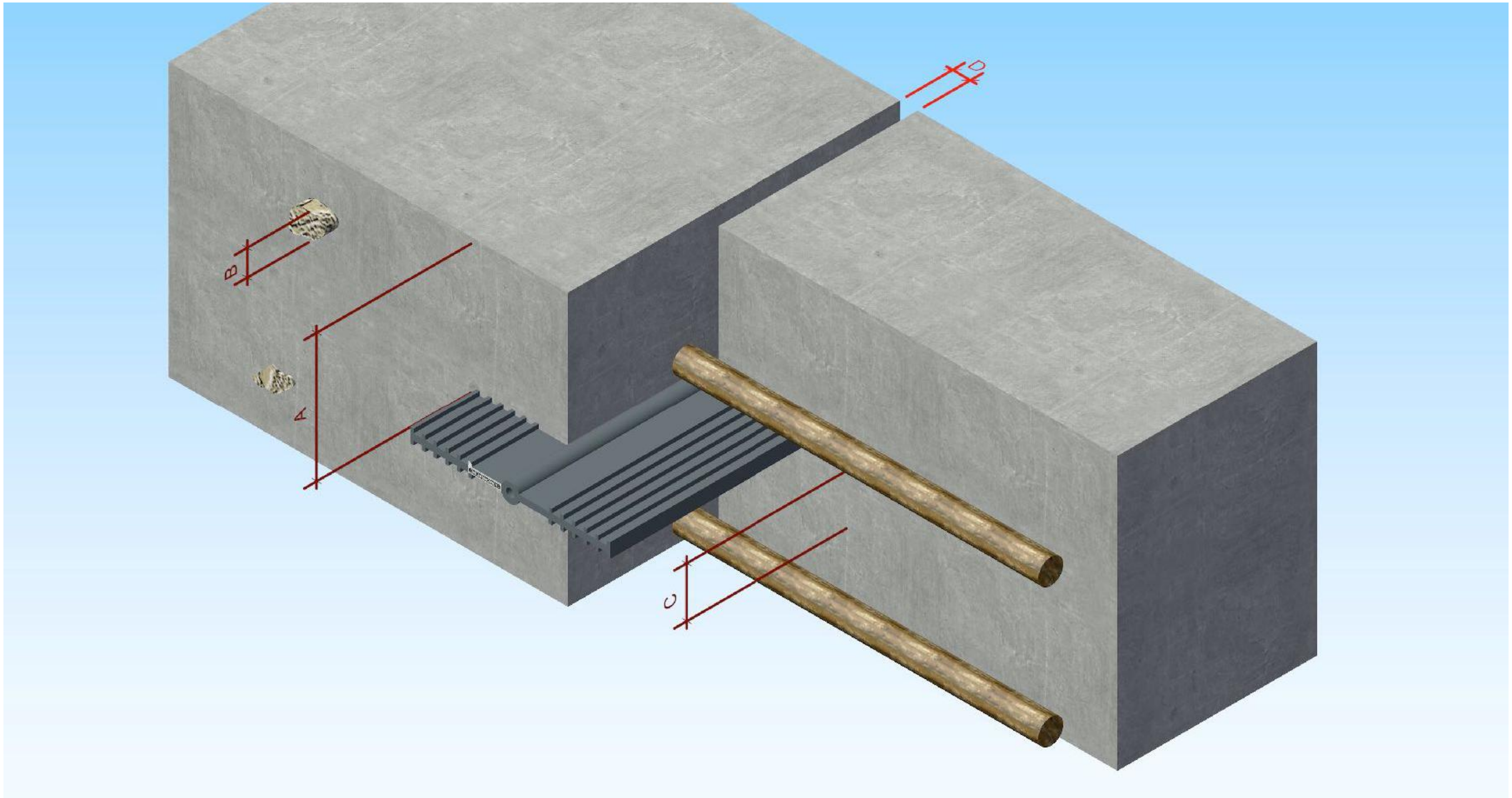
3. Generally, the wider and thicker a waterstop is, the greater the hydrostatic head pressure it can resist.



4. Because of their multiple ribs (or fins), ribbed waterstop offers greater joint protection and higher head pressure ratings than a similarly sized dumbbell waterstop.

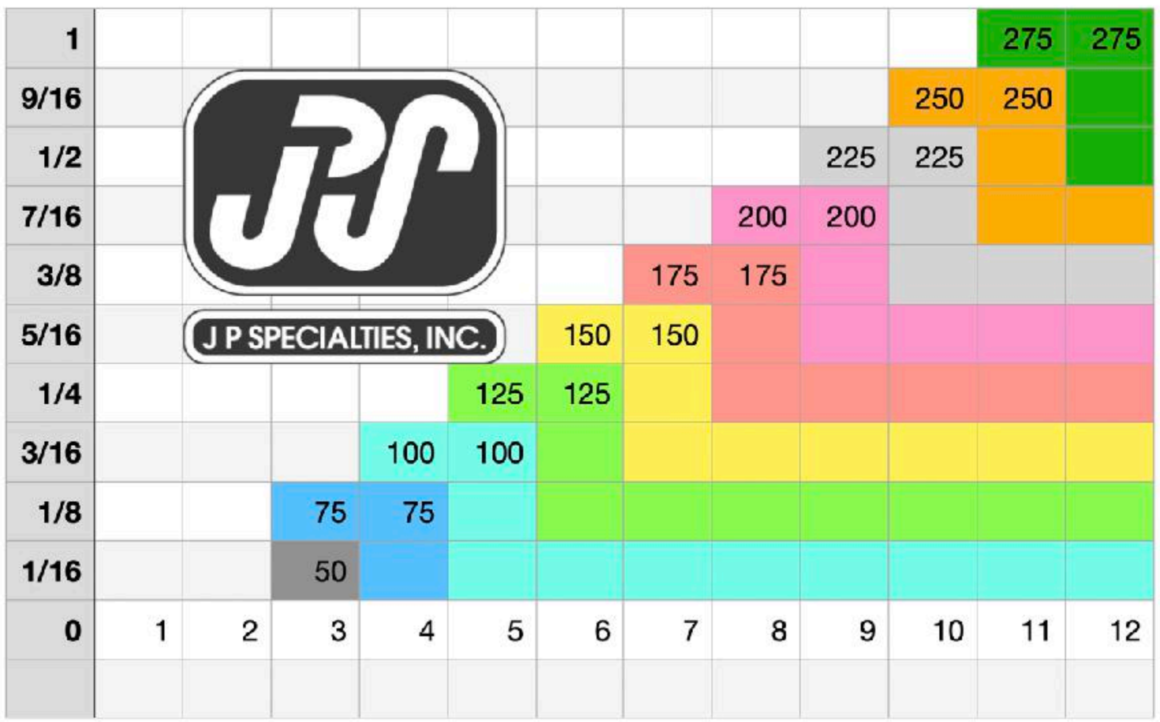
5. Most engineering firms today specify ribbed waterstop profiles because of their greater capabilities. Notable exceptions are the United States Bureau of Reclamation and Army Corps of Engineers.

Gallery 2.5 Non-Metallic Waterstop Design Considerations



A = Waterstop Concrete Coverage — Not less than half waterstop width   B = Largest Aggregate Size   C = Waterstop Distance from Reinforcing Steel — Not less than 1.5 B   D = Joint Opening — Waterstop centerbulb diameter or greater if an expansion joint (can be zero if construction joint)

Non-Metallic Waterstops— Size vs. Hydrostatic Head

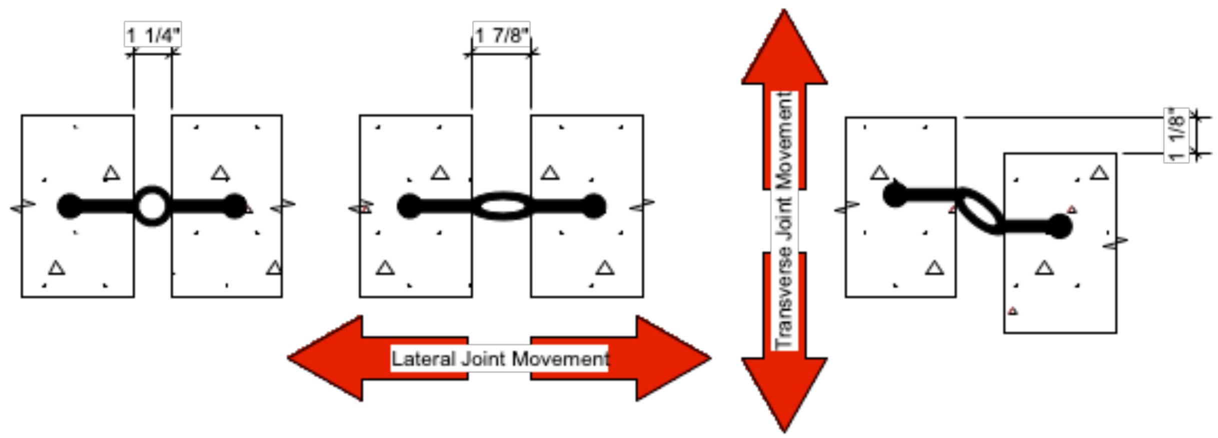


Adapted from Corps of Engineers "Waterstops and Other Joint Materials" — EM1110-2-2102

Calculating Waterstop Head Pressure — The above chart can be used to find the approximate feet head of water (FTW) resistance for thermoplastic waterstops of varying widths and thickness.

The relation of material thickness and width requirements of thermoplastic waterstops versus the height of hydrostatic head. For example in the above graph, a concrete dam or lock that is designed to resist a 125 ft of water head of hydrostatic pressure may require a hydrophobic waterstop that is 6 inches wide and ¼" thick. A wide range of hydrophobic waterstop dimensions may be used to resist a single head pressure. This relationship represents an average value of hydrostatic pressure ratings for various sizes of waterstops and is therefore relatively insensitive to small, subtle variations in the configuration of each individual waterstop. Thus, the graph is only valid for use as general guidance in the design and selection of thermoplastic waterstops.

Waterstop Movement with Centerbulb — Centerbulb waterstop accommodates lateral and transverse movement. Waterstop with centerbulb can be used in expansion, construction, and control joints.



Section 4

Hydrophobic PVC (Polyvinyl Chloride) Waterstop

PVC WATERSTOP

1. Low cost — “The Consumer’s Plastic.”
2. Heat weldable.
3. Replaced rubber waterstops in the 1950s.
4. Contains toxic plasticizers that can leach out in certain conditions.
5. Not designed for chemical containment.
6. The most widely used waterstop in the world, primarily due to its cost.

By far, the most widely-used waterstop today is PVC waterstop. Tough and flexible PVC compounds have been used successfully since the 1950s. Due to their low cost and inherent resistance to many common water and wastewater treatment chemicals, they will continue to be specified in concrete construction for a long time.

PVC, an acronym for *polyvinyl chloride*, is a sturdy, brittle plastic in its natural state. Because concrete joints are subject to movement (lateral, transverse, and shear) and shrinkage due to water loss from concrete hydration, a tough, rigid polymer would not be a good waterstop material choice. To compensate for this shortcoming, manufacturers compound the raw PVC resin with *fillers* (such as calcium carbonate) and *plasticizers (phthalates)* to alter the mechanical properties of the polymer. In this case, modern PVC waterstop manufacturers add a class of heavy metal esters (most frequently phthalates [which are on the California Prop 65 list as known carcinogens]). These plasticizers enable the waterstop to elongate and move like the thermoset rubber waterstops that they largely replaced.

PVC is often called “the consumer’s plastic,” which is to say it’s cheap and therefore used in many consumer products and applications. There is currently a slow movement away from the plastic, as the public becomes aware of the potentially deadly effects of plasticizer extracting from the product (see endocrine disruptors).

Another difficulty for the Specifier of PVC waterstops is the sheer number of choices! Because PVC has such a long history as a waterstop, there have been many manufacturers, all with their ideas, profiles, and marketing strategies. Navigating these baffling number of products can seem insurmountable. In actuality, these multiple products are not that different from one another. In my 30-

year career in the waterstop industry I sold waterstop for arguably the largest PVC manufacturer of the product. They manufacture PVC waterstops in over 100 different profiles; however, only about ten of the products are routinely specified and used. The differences between all the other shapes are just aesthetic and offer nothing in terms of functionality.

Later chapters of this book will show you the most widely-used shapes and how they function. When the specifier contacts a manufacturer, they will most likely recommend one of the popular profiles. It is likely that many of the profiles shown in their catalogs are special order and not stocked in inventory. I think the industry should consider losing some of these repetitive waterstop profiles, making it difficult for the customers.

Gallery 2.6 The Many Uses of PVC Waterstop

Diamond Valley Lake near Hemet, CA is California's largest water reservoir. The author helped the Contractor properly install PVC waterstop throughout the I/O Structure when it was being constructed.

PVC waterstop is specified in the United States at the federal level around a specification called CRD-C-572 (last revision was in 1974; see the attached below for the complete specification). CRD-C-572 is just a measurement of plasticizer extraction when the exposed material to alkalies and a simulated accelerated aging test. Section 6.2 of the specification requires 1,000 psi tensile strength across a waterstop weld but is ambiguous regarding the testing procedure to follow. A Specifier of PVC waterstop should request an *independent* lab test report to the

CRD-C 572-74

CORPS OF ENGINEERS SPECIFICATIONS FOR POLYVINYLCHLORIDE WATERSTOP

1. Scope

1.1 These specifications cover polyvinylchloride waterstop.

2. General Requirements

2.1 Waterstop.- The waterstop shall be of the shape and dimensions shown on the drawings accompanying the project specifications. It shall be produced by an extrusion process such that, as supplied for use, it will be dense, homogeneous, and free from holes and other imperfections. The cross section of the waterstop shall be uniform along its length and shall by symmetrical transversely so that the thickness at any given distance from either edge of the water stop will be uniform.

2.2 Material.- The waterstop shall be extruded from an elastomeric plastic compound, the basic resin of which shall be polyvinylchloride (PVC). The compound shall contain any additional resins, plasticizers, stabilizers, or other materials needed to insure that, when the material is compounded, it will meet the performance requirements given in this specification.

3. Inspection and Testing

3.1 All material and all waterstop will be subject to rigid inspection and testing in order to insure that the supplied waterstop meets the requirements of these specifications. Every facility shall be provided for representatives of the Government to perform careful sampling and inspection of the finished waterstop. The sampling of finished waterstop and all testing of finished waterstop, and job-made splices will be done by the Government.

4. Samples

4.1 A sample not less than 12 in. long (30.48 cm) will be cut from each 200 ft (61 m) of finished waterstop. The sample or samples representing a lot of waterstop will include not less than 4 lineal ft (1.2 m) of finished water stop. The sample or samples will be cut into pieces of convenient size and reduced in thickness to between 1/16 and 1/8 in. (1.6 and 3.2 mm), according to the method specified in CRD-C 515. A total of not less than five dumbbell-shaped specimens will be cut from each sample using die C of CRD-C 573, with the long axis of the dumbbell parallel with the direction of extrusion. Additional specimens will be prepared for the other tests in accordance with the provisions of the applicable test methods. When more than 200 ft (61 m) of waterstop is represented, the tests for tensile strength and elongation will be made on samples representing each 200 ft (61 m), other tests will be made on specimens taken at random from all the samples representing the lot of waterstop.

5. Test Conditions

5.1 Tests will be conducted in a standard laboratory atmosphere of 23 ± 1.6 C (73.4 ± 3 F) and a relative humidity preferably not less than 50 percent, unless otherwise specified in the testing methods.

6. Detailed Requirements

6.1 Finished Waterstop.- Samples taken from the finished waterstop shall meet the requirements listed below when tested by the test method and in the number of specimens shown.

Method of Test	Number of specimens Tested	Requirement*
CRD-C 573	5 per 200 ft (61 m)	Tensile strength, using die c, not less than: 1750 psi (12.17 MPa)
CRD-C 573	5 per 200 ft (61 m)	Ultimate elongation, using die C, not less than: 300%
CRD-C 570	3 per lot	Low temperature brittleness, no sign of failure, such as cracking or chipping at -35 F (-37.2 C)
CRD-C 571	3 per lot	Stiffness in flexure, not less than: 600 psi (4.13 MPa)
		Accelerated Extraction
Par. 7.1 below	5 per lot	Ultimate elongation, using die C, not less than: 280% Tensile strength, using die C, not less than: 1500 psi (10.3 MPa)
		Effect of Alkalies
Par. 7.2 below	3 per lot	Change in weight after 7 days, between: -0.10 and +0.25% Change in Shore durometer readings after 7 days, not more than: ±5

*The average or the median of the results of tests of the group of 3 or 5 specimens tested will be used to determine compliance with the stated requirements, depending on which value is called for by the method of test referenced.

6.2 Job-Made and Factory-Made Splices in Waterstop.- Samples taken across splices should meet the following requirements when tested by the test method shown.

Method of Test	Number of Specimens Tested	Requirement
CRD-C 573	As directed	Tensile strength, using die C, not less than: 1000 psi (6.89 MPa)

7. Methods of Testing

7.1 Accelerated Extraction Test.- The five tensile test specimens cut to the shape and dimensions given in CRD-C 573, using die C, will each be weighed to the nearest 0.001 g. The specimens will be placed in a one liter tall-form beaker with spout. The beaker will be filled within 2 in. (5 cm) of the top with a solution made by dissolving 5.0 g of chemically pure sodium hydroxide and 5.0 g of chemically pure potassium hydroxide in one liter of distilled water. The specimens will be completely immersed and the top of the beaker covered with a watch glass. The beaker will then be placed in a constant temperature bath and the temperature of the solution maintained between 60-65.5 C (140-150 F). A 1/4-in. (6.35 mm) diameter glass tube will be inserted into the spout of the beaker to within 1/2 in. (12.7 mm) of the bottom of the beaker. Air will then be gently bubbled through the solution at the rate of about one bubble per second. The solution will be changed every 24 hr, the new solution being warmed to 65.5 C (150 F) before replacing the old. Once daily, each of the five specimens will be removed from the beaker (preferably at the time of renewing the solution) and rinsed lightly with distilled water. Each specimen will then be superficially dried with a clean cloth. Ten min after the specimens have been thus dried the group of five specimens will be weighed and the weight recorded. The sequence of testing will be carried out continuously for a period of not less than 14 days; after which period, provided the specimens have reached constant weight (Note), they will be tested for tensile strength and elongation. Tensile strength will be calculated from the total load at failure, the nominal width, and the thickness as determined prior to exposure to the extraction test. If the tests for tensile strength and elongation cannot be made within 1 hr after completion of the weighings that demonstrated that constant weight has been achieved, the specimens will be stored immersed in fresh alkali solution at room temperature. Prior to being tested for tensile strength and elongation, the specimens will be removed, rinsed, dried, stored for 10 min, and weighed. The tensile strength and elongation will be determined not more than 72 hr after the weighings which demonstrated that constant weight had been achieved.

Note.- Constant weight is assumed to have been achieved when the weights of the group of specimens on three successive weighings do not differ from each other by more than 0.05 percent of the original weight. If constant weight has not been achieved after 90 days, the exposure will be terminated, the specimen tested for tensile strength and elongation, and a note added to the report indicating the weight losses between the last three successive weighings and the fact that constant weight, as here defined, was not achieved.

(Revised 1 June 1974) C 572

SPECIFICATIONS FOR POLYVINYLCHLORIDE WATERSTOP (C 572-74) 3

7.2 Effect-of-Alkalies Test.- Three specimens, each weighing about 75 g, will be pressed in accordance with CRD-C 515. The specimens will be washed in tap water, rinsed with distilled water, wiped with a clean cloth, and allowed to dry in laboratory air for approximately 1 hr. The weight of each specimen, to the nearest 0.001 g, will be recorded. Ten durometer readings, using the Shore durometer (type A), will be taken on each specimen in accordance with CRD-C 569. The specimens will be completely immersed in a freshly made solution containing 5.0 g of chemically pure sodium hydroxide and 5.0 g of chemically pure potassium hydroxide in one liter of distilled water, kept at 21-24 C (70-75 F). At the end of 7 days, the specimens will be removed, rinsed with distilled water, the surfaces wiped with a clean cloth, and allowed to dry in laboratory air for approximately 1 hr. The weight and durometer hardness will be measured and recorded. Changes in weight and durometer readings will be recorded as a percentage of the weight and durometer readings of the original samples; the averages of these changes for the three specimens tested shall be reported to determine compliance with applicable requirements in Par. 6.2.

8. Rejection

8.1 The waterstop may be rejected if it fails to meet any of the requirements of these specifications.

physical properties stated in their literature from the manufacturer before specifying their waterstop product.

PVC is the first thermoplastic used as a waterstop, and it largely replaced thermoset rubbers (neoprene, natural, styrene butadiene, *et al.*). Thermoplastics have a distinct advantage of thermosets: Namely, they can be reshaped or reformed by the application of heat. In PVC waterstop's case, indirect heat is applied (waterstop splicing iron), the waterstop material becomes molten in the weld area, and the two sides are pressed together and allowed to cool. The two joined waterstops will exhibit nearly the same physical and mechanical properties of the parent material once cooled. If a PVC waterstop lists 1,900 psi tensile strength, the Contractor will be able to achieve at least 80% of that value by field welding the product. Thermosets do not share this advantage. Once thermoset waterstops are cured, they can not easily be heat-welded into continuous lengths and changes of direction as required by the concrete joint layout. It is for this reason that PVC and other thermoplastics are a superior polymer choice for waterstop.

If there is an "Achille's Heel" to PVC waterstop, it is the plasticizer within that can be extracted. On the next page, I show you the significant causes of plasticizer extraction from PVC waterstop. The fifth item — time — is hugely controversial, and remains unacknowledged by most of the waterstop manufacturers. (*PVC geomembrane liner manufacturers do acknowledge plasticizer loss over time, and a simple web search can yield this fact.)*

PVC is also a genuine target of environmentalists, *especially* the plasticizer within. The Healthy Building Network, a leading environmental construction advocacy group considers PVC "a major environmental health disaster." The following excerpt is from their website: PVC is the worst plastic from an environmental

***"When we add end-of-life with accidental landfill fires and backyard burning, the additional risk of dioxin emissions puts PVC consistently among the worst materials for human health impacts..." —* USGBC Technical Science Advisory Committee (TSAC) final report**

Deadly Fire Hazard
PVC poses a considerable risk in building fires, as it releases noxious gases long before it ignites, such as hydrogen chloride, which turns to hydrochloric acid when inhaled. As it burns, whether accidentally or in waste incineration, it releases more toxic dioxins yet. PVC burning in landfill fires may now be the single largest source of dioxin releases to the environment.

PVC PLASTICIZER EXTRACTION

1. **Concentrated ozone (Ozone Contactor Structures)**
2. **Ultraviolet light (UV; sun)**
3. **Hydrocarbons (fuels, oils, etc.)**
4. **Acids (usually in concentrations >30%)**
5. **Time (this is controversial)**

health perspective, posing significant hazards in *manufacture*, *product life*, and *disposal*.

Toxic Manufacturing Byproducts
Dioxin (the most potent carcinogen known), ethylene dichloride and vinyl chloride are unavoidably created in the production of PVC and can cause severe health problems, including:

- Cancer
- Endocrine disruption
- Endometriosis
- Neurological damage
- Birth defects & impaired child development
- Reproductive and immune system damage

Lethal Additives
PVC is useless without the addition of a plethora of toxic chemical stabilizers — such as lead, cadmium and organotins — and *phthalate plasticizers*. These *leach*, *flake*, or *outgas* from PVC over time raising risks that include asthma, lead poisoning, and cancer.

Difficult To Recycle
The multitudes of additives required to make PVC useful make large-scale post-consumer recycling nearly impossible for most products and interfere with the recycling of other plastics. Of an estimated 7 billion pounds of PVC thrown away in the US, only 14 million — less than 1/2 of 1 percent — is recycled. The Association of Post Consumer Plastics Recyclers declared efforts to recycle PVC a failure and labeled it a contaminant in 1998.

PVC in Construction Materials
While the many problems associated with PVC throughout its lifecycle far outweigh the benefits, the construction industry has been unaware of its actual cost and long considered it a cheap, convenient material. Piping, vinyl siding, and vinyl flooring are the most important uses of PVC. Roof membranes have been a growing area. It is also used in electrical wire insulation, conduit, junction boxes, wall coverings, carpet backing, window, and door frames, shades and blinds, shower curtains, furniture, flues, gutters, downspouts, waterstops, weatherstrip, flashing, moldings and elsewhere. *Fortunately, a wide range of cost-effective alternative materials poses less of a health hazard to workers and the public at large.*

PVC-Free Construction Materials
The Healthy Building Network maintains an extensive list of PVC-free construction materials. **We are proud to say that our Earth**

<u>Shield®</u> brand thermoplastic (TPV) waterstop is the only hydrophobic embedded waterstop listed.

Moving Away From PVC in Construction

The Healthy Building Network, the United States Green Building Council, and other environmental advocacy groups are leading the charge away from PVC to less hazardous building materials. Again, from the Healthy Building Network website: Architectural firms, healthcare systems and hospitals, governments, and major corporations all over the world are dropping PVC. A wide range of major corporations, including Microsoft, HP, Shaw, Wal-Mart, Firestone, Nike, Mattel, Lego, Johnson & Johnson, GM, VW, and Honda, have switched to alternative materials. San Francisco and New York State have banned PVC pipe. An increasing number of major projects, from the U.S. EPA headquarters in Washington, DC to the 2000 Olympic village in Sydney, Australia, have vastly reduced or eliminated the use of PVC. More government agencies are eliminating it from wiring, flooring and other applications, including the US Navy, Air Force, and NASA.

Despite the potential toxicity, PVC remains the number-one specified waterstop in the world and installed in your local water treatment plant. It will take time and education to change this fact.

Toxin-Free PVC Waterstop

J P Specialties brought a new, toxin-free PVC waterstop to market in 2018. The waterstop is manufactured <u>without</u> hazardous phthalates and is California Proposition 65 certified. Additional certifications include NSF 61 and NSF 372 (lead-free).

Earth Shield® Polyvinyl Chloride (PVC) Waterstop is used as a fluid-tight diaphragm, embedded in concrete, across and along the joint, for environmental engineered concrete structures. Earth Shield® Flexible PVC Waterstops are resistant to a wide range of water and wastewater treatment chemicals and are certified to meet or exceed the performance requirements of CRD C572-74.

Install Earth Shield® Flexible PVC Waterstop in all concrete joints. Waterstop should be centered in, and run the extent of the joint. All changes of directions should be prefabricated, leaving only butt-welding for the field. If installing in an expansion joint, keep centerbulb unembedded to allow it to accommodate movement as designed. Use optional factory-installed brass eyelets (or #3 hog rings) and tie wire to secure waterstop to reinforcing steel to avoid displacement during the concrete pour. Splice straight lengths of waterstop and Shop Made Fittings to straight lengths, with an ST-10® In-Line Waterstop Splicer with the iron temperature set to 350°F to 380°F.

Certified Non-Toxic
PROPOSITION 65
Your right to know!

Suggested Proprietary Short Form Guide Specification
Flexible PVC Waterstop

Waterstop indicated in drawings and specifications for contraction (control), expansion and construction joints shall be Earth Shield® Polyvinyl Chloride (PVC) Waterstop Part No. #### [Designer insert appropriate part number here] as manufactured by J P Specialties, Inc.; Murrieta, CA 92562; Phone 951-763-7077

1. Flexible Polyvinyl Chloride (PVC) Waterstop shall be manufactured with prime virgin resin.
2. Flexible Polyvinyl Chloride (PVC) Waterstop shall be independently certified for use in potable water per NSF/ANSI Standard 61. Third-party certified documentation to be provided by the manufacturer.
3. Flexible Polyvinyl Chloride (PVC) Waterstop shall be California Prop 65 compliant and contain no hazardous phthalates.
4. No equals or substitutions allowed.

Property	Test Method	Required Results
Specific Gravity	ASTM D792	1.38 to 1.40
Shore A Hardness (15 sec.)	ASTM D2240	77±3 at 25°C (77°F)
Tensile Strength	ASTM D638	2,100 psi
Ultimate Elongation	ASTM D638	400%
Stiffness in Flexure	ASTM D747	700 psi
Tear Resistance	ASTM D624	320 lbs./inch
Brittle Point	ASTM D746	-37°C (-35°F)
Accelerated Extraction Tensile Strength	Corps of Engineers	2,005 psi
Accelerated Extraction Elongation	Corps of Engineers	390%
Effect of Alkali Weight Change	CRD C572-74	+0.11%
Effect of Alkali Hardness Change	CRD C572-74	-0.6 points
Drinking Water Safe	NSF/ANSI 61 NSF	Waterstop certified by NSF for use in potable water

Polyvinyl Chloride (PVC) Waterstop

Section 5

Hydrophilic Waterstop: Expandable Internal Sealant

HYDROPHILIC WATERSTOP

1. **Prevents the passage of fluids through concrete *construction* joints by acting as an internal sealant, with the ability to expand in the presence of *water* moisture.**
2. **Very easy to install — Much more so than Hydrophobic Waterstops.**
3. **Limited product choices for the Designer.**
4. **Products are only suitable for non-moving, construction joint applications.**
5. **Repeated wet/dry cycling can cause product deterioration.**
6. **Inexpensive, especially considering labor costs.**
7. **To be used in WATER ONLY. The waterstop will not swell as intended in fluids other than water.**

In Gallery 2.3, a waxed car hood illustrates the property of *hydrophobicity*, and a sponge illustrates *hydrophilicity*. The term *hydrophilic* means “water loving.” The sponge, being hydrophilic, absorbs the water (or other polar fluid) and swells. At their most basic level, hydrophilic waterstops are like the sponge, absorbing water and growing in size in its presence. This is the entire concept of the hydrophilic waterstop: It is designed to swell when exposed to water, and therefore seal the concrete joint.

Commercially available for several decades, hydrophilic waterstops have long track records, *albeit not always positive*. As you will see, great care must be taken at the specification level to ensure your project meets the rather narrow application scope of this range of products.

The first hydrophilic waterstops sold commercially were a mixture of sodium bentonite clay, which acts as the expansive or hydrophilic component of the product. Butyl rubber serves as the cohesive, tacky base. Sodium bentonite-based hydrophilic waterstops are still commercially available today. However, their use has diminished by the advent of chemically modified rubber waterstops that provide the required hydrophilic expansion with water, without the degradation and breakdown of the natural product.

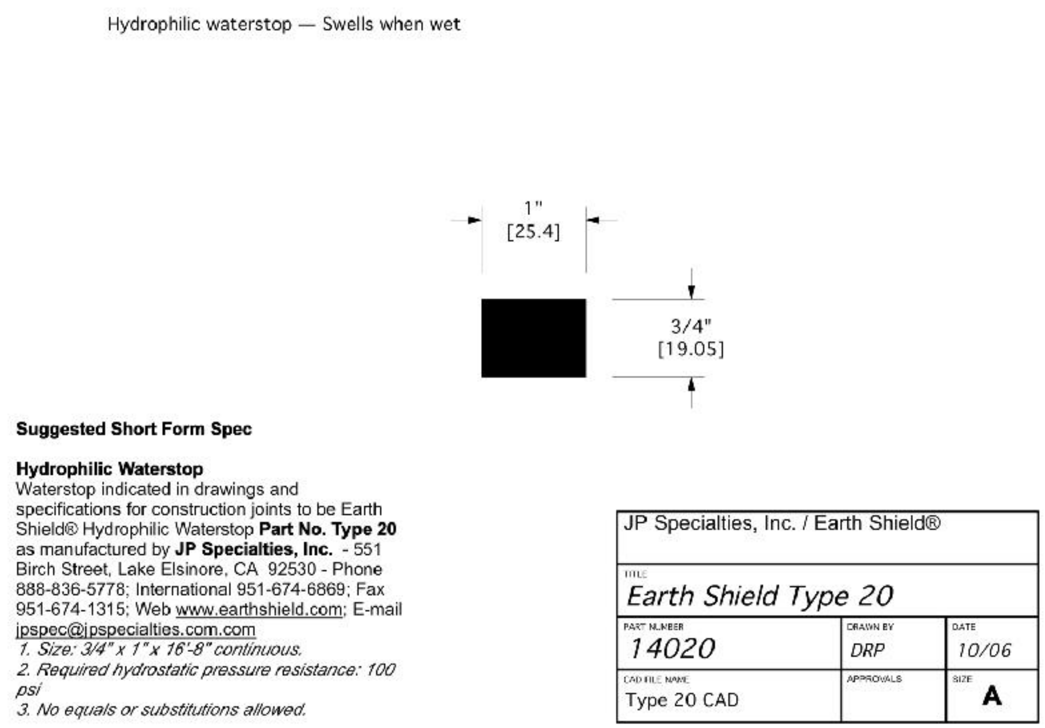
Most commercially available hydrophilic waterstops are sold in rolls or strips. The profile is usually a small rectangle or trapezoidal shape, with 3/4” x 1” being somewhat standard. These strips are adhered to existing concrete using an adhesive or primer, or alternately concrete nails at 12” on-center spacing. This adhesion is essential, as only three sides of the waterstop are exposed to fresh concrete. If the waterstop is displaced during the concrete pour, it can quickly lose most of its effectiveness.

Hydrophilic Waterstops — The "Pros"

The greatest advantage of hydrophilic waterstops is their ease of installation — the products get glued in place at the cold joint, and concrete is then cast on top of them (the second pour). The installation efficiency of this class of products makes them a favorite amongst contractors in the field.

Another "pro" is their relatively low cost. At the time of publication, a "typical" sodium bentonite-based waterstop is approximately $2.00 per linear foot, and a "typical" chemical-modified rubber is $6.00 per linear foot. When combined with the low labor cost, strip-applied hydrophilic waterstops are real time and money savers.

Gallery 2.7 Hydrophilic Waterstop



Hydrophilic waterstops are usually a simple rectangular shape. No bulbs, ribs, or any other features typical in hydrophobic waterstops.

Hydrophilic Waterstops — The "Cons"

To read the manufacturer's product literature, you would think that they are indeed the perfect waterstop product... Cheap and easy to install, and extremely high head pressure resistance. Truthfully, these products are not the panacea the manufacturers claim, and the essential information concerning their use is often not published. For instance, a leading manufacturer of hydrophilic waterstop states the following *minimum requirements* on their datasheet:

•8-inch thick concrete or greater
•Double row of reinforcing steel
•3,000 psi concrete or greater
•3 inches of concrete coverage on all sides of the waterstop (minimum)
•Non-moving construction joints only

Obviously, the designer is seriously limited by these requirements. Few concrete projects consist of just construction joints, and eight-inch thick concrete is rare in both residential and light commercial construction. The first four prevent the hydrophilic reaction (waterstop swelling in the presence of water) from cracking or blowing out the concrete. The leading manufacturer of bentonite-based waterstops includes 75% sodium bentonite into the manufacture of their product. This high concentration of bentonite allows the product to rapidly swell when exposed to water, which is good as it will seal the joint more quickly. However, this high concentration of bentonite can also create problems such as concrete cracking or even the potential of blown-out joints due to the internal pressure of the rapidly expanding waterstop and the low tensile strength of uncured concrete.

Another limitation is the product's inability to swell as intended in fluids other than water. All of the commercially available hydrophilic waterstop products have published data for swell ratios; however, this data is for potable water (often distilled) and saltwater. Since the products need to swell to seal the concrete joint, a designer for a non-water facility (such as secondary containment of petroleum products) can not specify hydrophilic waterstops with confidence as they will not swell as intended and may deteriorate. The American Concrete Institute recommends against the use of hydrophilic waterstops for fluids other than water (ACI 350.2R-04).

Bentonite-based hydrophilic waterstops are also susceptible to product disintegration over the long term, especially when the moisture or saturation conditions are cyclical. The continual expansion/shrinkage/re-expansion causes the products to break down, and the bentonite migrates from the butyl rubber, leaving a smaller, cracked, non-expandable product.

> *"Expansive rubber waterstops expand on contact with water and may contract if permitted to dry out. Joints using such waterstops may leak until adequate moisture is present to re-expand the waterstop. Furthermore, the waterstop may not have the same expansive properties when exposed to chemicals instead of water."*
>
> ***— Source: ACI 350.2R-04***

Earlier I mentioned that the most well-known bentonite-based hydrophilic waterstop has 75% bentonite content. There are other manufacturers (including my own company [Type 20, Type 23, et al]) who make similar products, albeit with lower bentonite concentration (usually 45 to 55%). Waterstop products containing less bentonite are less likely to break or blow out the concrete joint and are less likely to break down over time from bentonite migration. However, they also swell slower and less volumetrically. These reduced bentonite products should never be used in saltwater as their hydrophilic reaction is so severely limited.

Hydrophilic Waterstops — Chemical-Modified Chloroprene Rubber

Not all hydrophilic waterstops use bentonite clay as their hydrophilic agent. Earth Shield® Type NB190® is very different from all the older technology butyl rubber/bentonite clay waterstops, as it is 100% chloroprene rubber, chemically modified to swell in the presence of *water**. Therefore, the problem of wet/dry cycling that so negatively affects the bentonite-based products is obviated, and the waterstop holds up much better over time. Other product features make chemically modified hydrophilic waterstops a good choice for a variety of applications. However, this class of hydrophilic waterstop also suffers from many of the same weaknesses as the more inexpensive bentonite-based waterstop products — Namely, the inability to swell in fluids other than water, slow swell time, and the lack of expansion and contraction joint functionality.

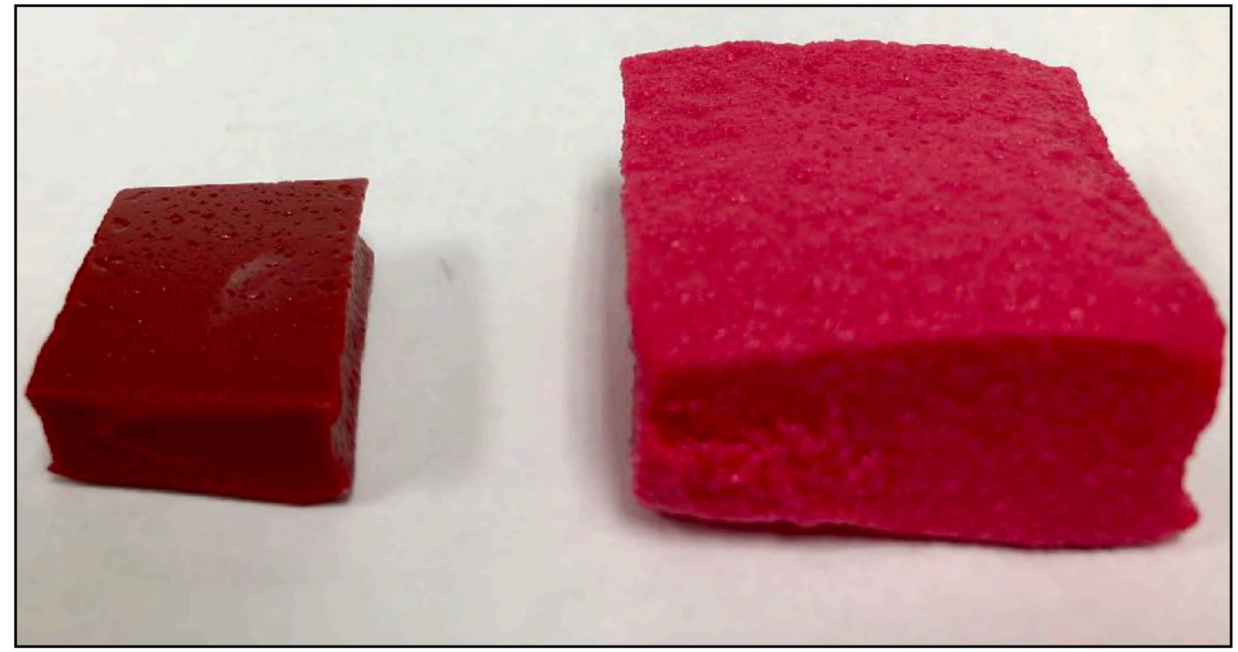
** All of the commercially available hydrophilic waterstop products have published data for swell ratios; however, this data is for potable water (often distilled). The American Concrete Institute recommends against the use of hydrophilic waterstops for fluids other than water (ACI 350.2R-04).*

TYPICAL HYDROPHILIC WATERSTOP HEAD PRESSURE RATINGS

1. **1-inch x 3/4-inch hydrophilic waterstop (hydrophilic percentile ±40% or >): 230 ft head of water (100 psi)***

The above values are "typical" and are representative of multiple manufacturer's products and polymers. Always check with the specified waterstop manufacturer for what their published fluid pressure ratings are.

****CLOSED joint.***



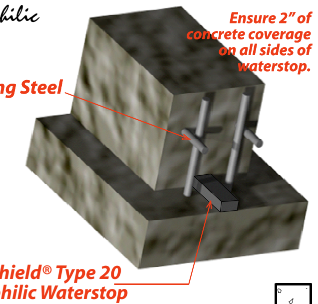
Earth Shield® Type NB190® Hydrophilic Modified Chloroprene Waterstop

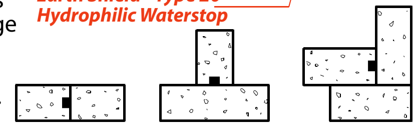
Bentonite Butyl Rubber Waterstop

Effective & Economical Hydrophilic

Type 20 & 23

High-Quality Hydrophilic Waterstop for Concrete Construction





Earth Shield® Type 20 & Type 23 Hydrophilic Butyl Rubber Waterstops are designed to swell when exposed to water, yet maintain a solid structural integrity that will not deteriorate due to uncontrolled expansion, unlike many of the traditional, clay-based waterstops currently on the market. This swelling ability prevents the passage of water through concrete construction joints.

Type 20 & 23 waterstops are fast, easy, and economical to install. Simply apply Earth Shield Primer to the existing concrete, firmly press the waterstop to the primed surface, and place your second pour of concrete. No splitting of forms or difficult field welding is necessary to achieve a watertight seal.

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Earth Shield Type 20 & 23 Hydrophilic Butyl Rubber Waterstops are ideal for:

- Non-moving Joints
- Pipe Penetrations
- Slabs & Walls
- Utility Vaults
- Manholes
- Cast-in-Place Applications

Installation Instructions

1. Brush and remove loose dirt and particles from the surface.
2. Brush one coat of Type 20 Primer Adhesive on to the clean, concrete surface. Type 20 Primer Adhesive is available in one gallon cans.
3. Allow primer to cure (per directions on can).
4. Press Type 20 firmly onto the primed surface.
5. Overlap ends (1" minimum), and join with a kneading action, press ends together until there is no separation or air pockets.
6. Remove separation paper.
7. You are now ready for your second pour.

Suggested Short Form Guide Specification

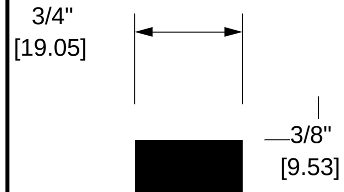
Waterstop indicated in drawings and specifications for construction joints to be **Earth Shield® Hydrophilic Type 20 Waterstop** as manufactured by **JP Specialties, Inc.** — 551 Birch Street, Lake Elsinore, CA 92530 — Phone 800-821-3859; International 951-674-6869; Fax 951-674-1315; Web www.jpspecialties.com ; E-mail jpspec@jpspecialties.com

1. *Size: 3/4" x 1" x 16'-8" continuous.*
2. *Required hydrostatic pressure resistance: 100 psi.*
3. *No equals or substitutions allowed.*

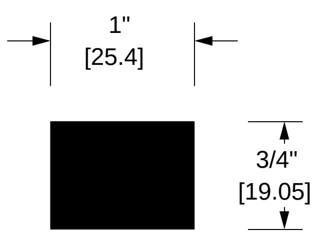
www.jpspecialties.com/Waterstop_for_Concrete_Joints/jpproduct.html

Typical Physical Properties

Specific Gravity, 77°F *ASTM D71*	1.35
Hydrocarbon content *ASTM D297*	47%
Volatile Matter *ASTM D6*	1%
Penetration, Cone 77°F *150 gm. 5 sec. ASTM D217*	40 mm
Service Temp., °F	-30° to 180°F
Color	Black
Type 20 Packaging	6 rolls per carton 100 lft. per carton 3/4" x 1" x 16'8"
Type 23 Packaging	8 rolls per carton 200 lft. per carton 3/8" x 3/4" x 25'



Type 23



Type 20

JP Specialties, Inc.
P.O. Box 1507, Lake Elsinore, CA 92531
Phone: 800-821-3859; Fax: 951-674-1315
E-mail: jpspec@jpspecialties.com
Web: www.jpspecialties.com

Type 20 & 23 Waterstop is not intended for use in expansion joints. IT SHOULD BE USED IN NON-MOVING JOINTS ONLY. Earth Shield® is a registered trademark of JP Specialties, Inc.

Modified Chloroprene Rubber Waterstop

Section 03150 • MasterFormat™ 03 15 13

www.facebook.com/waterstop

J P SPECIALTIES, INC.

Hydrophilic Waterstop — Bentonite-free

Type NB190®

From the manufacturer of EARTH SHIELD

Earth Shield® Type NB190® (Profile A) is the ideal waterstop for concrete construction joints.

Earth Shield® Type NB190® (Profile A) can be used for pipe or column joints.

Type NB190® is a modern, hydrophilic rubber waterstop with unmatched durability and watersealing capabilities. Manufactured NON-BENTONITE, modified chloroprene rubber, Type NB190® more than doubles its original size (400% volume swell) when exposed to water. This expansion creates an effective compression seal within joints of limited to no movement. Type NB190® can expand and reexpand unlimited times with virtually no loss of physical properties. Additionally, Type NB190® has excellent resistance to many chemicals, is heat-resistant, and can be safely used in drinking water.

- *Comprised of* ***NON-BENTONITE****, modified chloroprene rubber*
- *100-plus year lifespan*
- *Simple, low cost installation*
- *Ideal for retrofit as well as new construction*
- *Most profiles have a minimum of 231 ft (100 psi) resistance to water head pressure*

Typical Applications

- *Water treatment plants*
- *Wastewater treatment*
- *Pipe penetrations*
- *Storage tanks*
- *Slab on grade*
- *Foundations*
- *Tunnel segments*
- *... And many more*

Earth Shield® Chemical Resistant Waterstop
Phone: 800-821-3859; 951-763-7077
Fax: 951-763-7074
www.earthshield.com

www.facebook.com/waterstop

J P SPECIALTIES, INC.

Mastic Waterstops

MASTIC WATERSTOP

1. **Prevents the passage of fluids through concrete *construction* joints by acting as an internal sealant.**
2. **Very easy to install — Much more so than Hydrophobic Waterstops.**
3. **Limited product choices for the Designer.**
4. **Products are only suitable for non-moving, construction joint applications.**
5. **Low cost.**
6. **Lowest performance of any commercially available waterstop.**
7. **Can be classified as an internal sealant.**
8. **Referenced by Federal Specification SS-210-A**
9. **Sticky, clay-like compound.**

Like the hydrophilic waterstops in the previous section, most commercially available mastic waterstops sell in rolls or strips. The profile is usually a small rectangle or trapezoidal shape, with 3/4” x 1” being somewhat standard. These strips are adhered to existing concrete using an adhesive or primer, or alternately concrete nails at 12” on-center spacing. This adhesion is important. Only three sides of the waterstop get encased in fresh concrete. If the waterstop displaces during the concrete pour, it can quickly lose most of its effectiveness. Like their similar hydrophilic cousin, mastic waterstops are designed for non-moving construction joints only (no expansion, isolation, or contraction joints).

Unlike the hydrophilic waterstops in Section 4, mastic waterstops are simply a strip of tacky, rubbery compound (usually based on bitumen and butyl rubber). Mastic waterstops “stick” to a primed surface of a cured concrete cold joint on one side, and have fresh concrete cast against the remaining three sides, with the heat from the hydrating concrete causing the product to become even tackier, and therefore sealing the joint by acting as an internal, adhered sealant.

This waterstop function is minimal as the only barrier to migrating fluids is the adhesion to the concrete and compression of the mastic waterstop product within the joint. Mastic waterstops tend to be more effective in construction joints where the concrete wall is cast onto the slab. Mastic waterstops are far less effective when installed in vertical applications such as a wall joint.

Mastic waterstops are the lowest-performing of any commercially available waterstop. They are also the lowest cost waterstop. Because of the low cost and ease of installation, mastic waterstops are the favored products of commercial constructors and home builders.

Earth Shield® Type 10 Hydrostatic Pressure Test Procedure and Results

1. Test procedure: Select a 14" diameter by 3" thick circular concrete test specimen.
2. The specimen shall be manufactured with six pieces of rebar placed approximately 1-1/2" from the edge of the specimen.
3. The rebar shall be equally spaced around the circumference of the test specimen.
4. The top of the specimen shall consist of a flat surface with the rebar protruding out.
5. With a 1" wide paint brush, apply a 1" wide strip of Earth Shield primer around the circumference of the area closest to the inside of the protruding rebar posts.
6. After allowing primer to thoroughly dry, apply a single piece of Earth Shield Type 10 Waterstop 3/4" x 1" x 16'-8" to the primed area; the ends of the piece shall be molded together in order to form a continuous seal.
7. A sheet of 15-pound tarpaper shall be placed on the remaining exposed concrete surface of the test specimen. The tarpaper creates a separation between the precast section and the cast in section of the test specimen.
8. Plumbing connections and a forming ring shall be placed over the precast test specimen.
9. Concrete is poured into the forming ring casting the Type 10 Waterstop into the test specimen. Allow the test specimen to cure for 48 hours before removing forming ring.
10. Threaded rods and clamping brackets shall be placed over the test specimen.
11. Begin testing by filling the center cavity with water allowing the concrete to become saturated for 12 days. Water shall be added as needed.
12. Hydrostatic pressure is introduced into the center cavity and maintained for the duration of the test.

Results

PSI	Hours	Result
10	168	No leaks
13	168	No leaks
20	168	No leaks

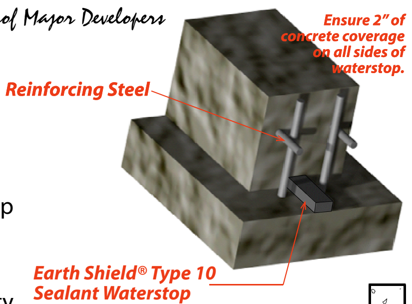
A typical manufacturer's hydrostatic head test for a mastic waterstop. In this case, our own Type 10 Mastic Waterstop.

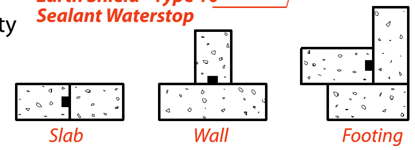
Mastic Rubber Waterstop

Type 10

The Preferred Choice of Major Developers

High-Quality Mastic Sealant Waterstop for Concrete Construction Joints





Earth Shield® Type 10 is a high-quality, self-sealing mastic waterstop which prevents water from penetrating non-moving joints in concrete construction.

Type 10's ease of installation makes it the ideal choice for a variety of applications, including:

- Concrete Vaults
- Utility Vaults
- Septic Tanks
- Burial Vaults
- Retaining Walls
- Tunnels
- Storage Tanks
- Box Culverts
- Pipe Penetrations
- Slabs-on-Grade
- Foundations
- Cast-in-Place Applications

The Type 10 Advantage

- Provides permanently flexible watertight joints.
- Quick and easy to install. Does not require skilled labor.
- Excellent adhesion to clean dry surfaces.
- Sealed joints will not shrink, harden or oxidize upon aging.
- Rugged service temperature: -30°F to 200°F (-34°C to 93°C).

Installation Instructions

1. Brush and remove loose dirt and particles from the surface.
2. Brush one coat of Type 10 Primer Adhesive on to the clean, concrete surface. Type 10 Primer Adhesive is available in one gallon cans.
3. Allow primer to cure (per directions on can).
4. Press Type 10 firmly onto the primed surface.
5. Overlap ends (1" minimum), and join with a kneading action, press ends together until there is no separation or air pockets.
6. Remove separation paper.
7. You are now ready for your second pour.

Suggested Short Form Guide Specification

Waterstop indicated in drawings and specifications for construction joints to be **Earth Shield® Type 10 Waterstop** as manufactured by **JP Specialties, Inc.** — 551 Birch Street, Lake Elsinore, CA 92530 — Phone 800-821-3859; International 951-674-6869; Fax 951-674-1315; Web www.jpspecialties.com ; E-mail jpspec@jpspecialties.com

1. *Size: 3/4" x 1" x 16'-8" continuous.*
2. *Required hydrostatic pressure resistance: 20 psi.*
3. *Required certification to Federal Spec. SS-S-210A.*
4. *No equals or substitutions allowed.*

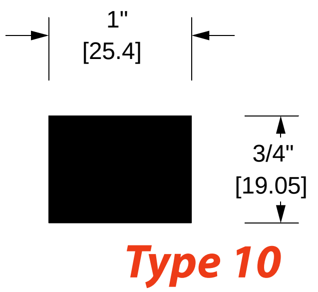
www.jpspecialties.com/Waterstop_for_Concrete_Joints/jpproduct.html

Typical Physical Properties

Type 10 Waterstop is certified *for use in Federal Specification SS-S-210A.*

Type 10 Waterstop is certified *for use in U.S. Army Corps of Engineers Guide Specification for Military Construction CEGS 03250 Section 2.4.5 Preformed Elastic Adhesive.*

Hydrocarbon Content *ASTM D4*	52%
Specific Gravity, 77°F *ASTM D71*	1.22
Inert Mineral Filler *Federal Spec SS-S-210A*	48%
Volatile Matter *ASTM D6*	1%
Softening Point, Ring and Ball *ASTM D36*	370°F (188°C)
Penetration, Cone 77°F *150 gm. 5 sec. ASTM D217*	62 mm
Flash Point, C.O.C., °F *ASTM D92*	630°F (332°C)
Fire Point, C.O.C., °F *ASTM D92*	630°F (332°C)
Color	Black
Packaging	6 rolls per carton 100 lft. per carton 3/4" x 1" x 16'8"



JP Specialties, Inc.
P.O. Box 1507, Lake Elsinore, CA 92531
Phone: 800-821-3859; Fax: 951-674-1315
E-mail: jpspec@jpspecialties.com
Web: www.jpspecialties.com

Type 10 Waterstop is not intended for use in expansion joints. IT SHOULD BE USED IN NON-MOVING JOINTS ONLY. Earth Shield® is a registered trademark of JP Specialties, Inc.

Section 7

Hydrophilic and Mastic Waterstop Primer

In Section 4 and 5, we discussed the use of hydrophilic and mastic waterstop systems. We also learned their greatest advantage: Ease of installation — the products are glued in place at the cold joint with a *primer*, and concrete is then cast on top or against them. Primers today come in two forms: Water-based and solvent-based, each with their advantages (and disadvantages).

Gallery 2.8 Waterstop Primer

A typical gallon of primer can generally yield 500 to 900 lineal feet of waterstop installed.

Water-based Primer

Water-based primer has the best performance of the two commercially available primers, and consequently, it costs more (a lot more) than the solvent-based variety. If properly applied, a water-based primer can adhere the strip waterstop to a vertical surface; whereas, the solvent-based products can not.

Water-based primers are subject to damage from freezing as the primer and water separate, and the product freezes. If this happens, the product should be safely and legally discarded per local regulations, as it is useless.

Solvent-based Primer

The solvent-based varieties of primer are less expensive than the water-based, but also do not perform as well. You can not successfully adhere strip waterstops to a vertical surface using just a solvent-based primer, but also need to use nails 12” on center or the waterstop will fall out of place. Because these products are solvent-based, they are not susceptible to freezing and separation.

Injection Tubes Waterstop

INJECTION TUBES

1. **Construction joints only.**
2. **Not well-suited as a primary waterstop, but excellent as a secondary system.**
3. **Hydrophilic resin can be injected after construction to seal any remaining leaks that the primary waterstop let pass.**
4. **Manufacturers advertise the products as "reinjectable" although they frequently are not.**
5. **Complex and costly.**

Somewhat complicated to install, quite expensive, and only suitable for construction joints, injection tube waterstops have been slow to gain acceptance by the AEC community, at least as a primary waterstop. In my opinion, they can have their place in the construction joint, but only as a secondary waterstop in a "belt and suspenders" capacity.

Injection tube waterstops are usually permeable or perforated tubes installed during new construction with a series of injection ports and valves. Should a leak occur after construction, a grout pump can be used to pump a hydrophilic resin (usually polyurethane or vinyl ester) to seal the leak and fill any nearby voids.

Many of these systems purport to be "reinjectable," but they are rarely installed correctly due to their inherent complexity, and this claim by the manufacturers is questionable.

Section 9

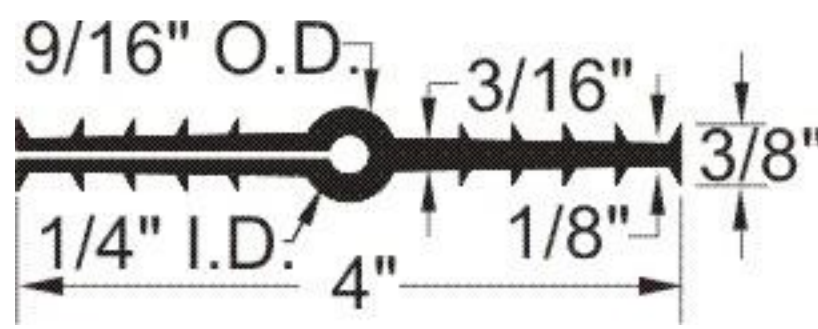
Split Waterstop

SPLIT WATERSTOP

1. **Waterstop is “split” on one half, so formwork splitting is not necessary.**
2. **Profiles for moving and non moving joints.**
3. **High likelihood of failure if there are any change of directions.**
4. **Water only. Never for secondary containment of chemicals.**

This is the easiest chapter to write, as my advice is simple: Do not specify or use split waterstop. They leak.

The concept behind a split waterstop is simple: Rather than split the formwork to accommodate the embedded waterstop, the waterstop itself is “split,” which allows the split side to be place flat against the formwork when the first pour is made. After the first pour has cured and the formwork removed, the two halves of the split leg can be glued together. This sounds like a lot of labor, but in actuality it is far easier than splitting formwork.



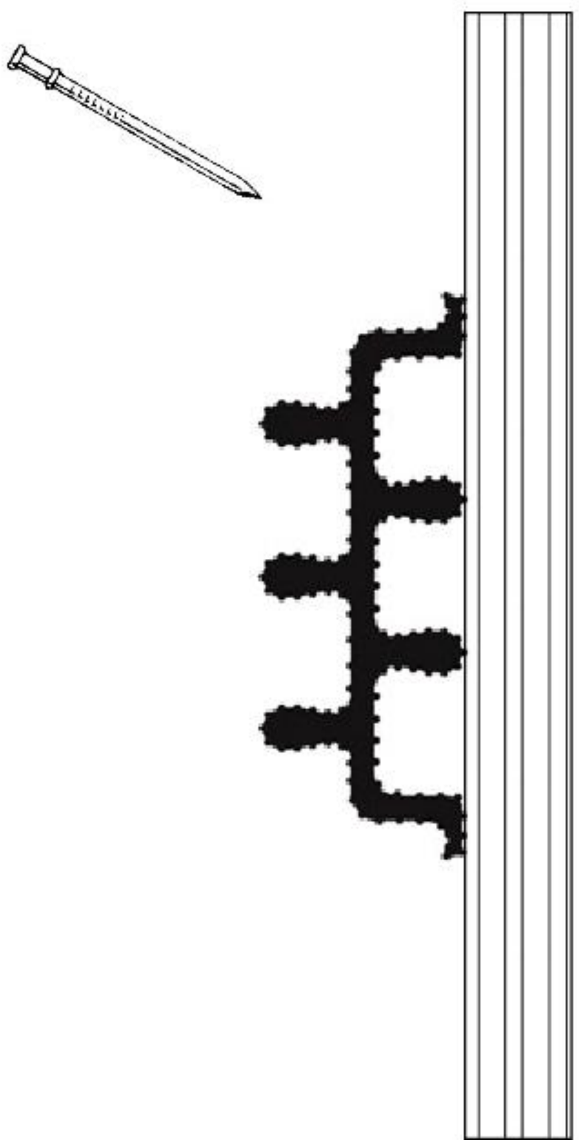
The split waterstop system would ostensibly work if your concrete joints are in continuous straight lines. However, few (if any) projects have only straight concrete joints with no turns or intersections; therefore, split waterstop fails as the “split” can not open up properly and be placed against formwork in a change of direction configuration.

Section 10

Labyrinth Waterstop

LABYRINTH WATERSTOP

1. **Waterstop is nailed to formwork, so formwork splitting is not necessary.**
2. **Profiles for non moving joints only.**



M

Labyrinth waterstops are double-headed nailed to the formwork; therefore, obviating the need to split the formwork to accommodate one half of the waterstop.

Because of their keyway-like shape and multitudinous miniature ribs, they do an adequate job of preventing the passage of water through non-moving construction joints.

Labyrinth waterstops are double-headed nailed to the formwork; therefore, obviating the need to split the formwork to accommodate one half of the waterstop.

Because of their keyway-like shape and multitudinous miniature ribs, they do an adequate job of preventing the passage of water through non-moving construction joints.

Because of their non-symmetrical geometry, they are very limited in changes of directions.

Chapter 3

Typical Waterstop Properties

In order to properly specify waterstop, you must first understand the various physical properties listed on its data sheet. This chapter will guide you through the most common physical properties and what they mean to you.

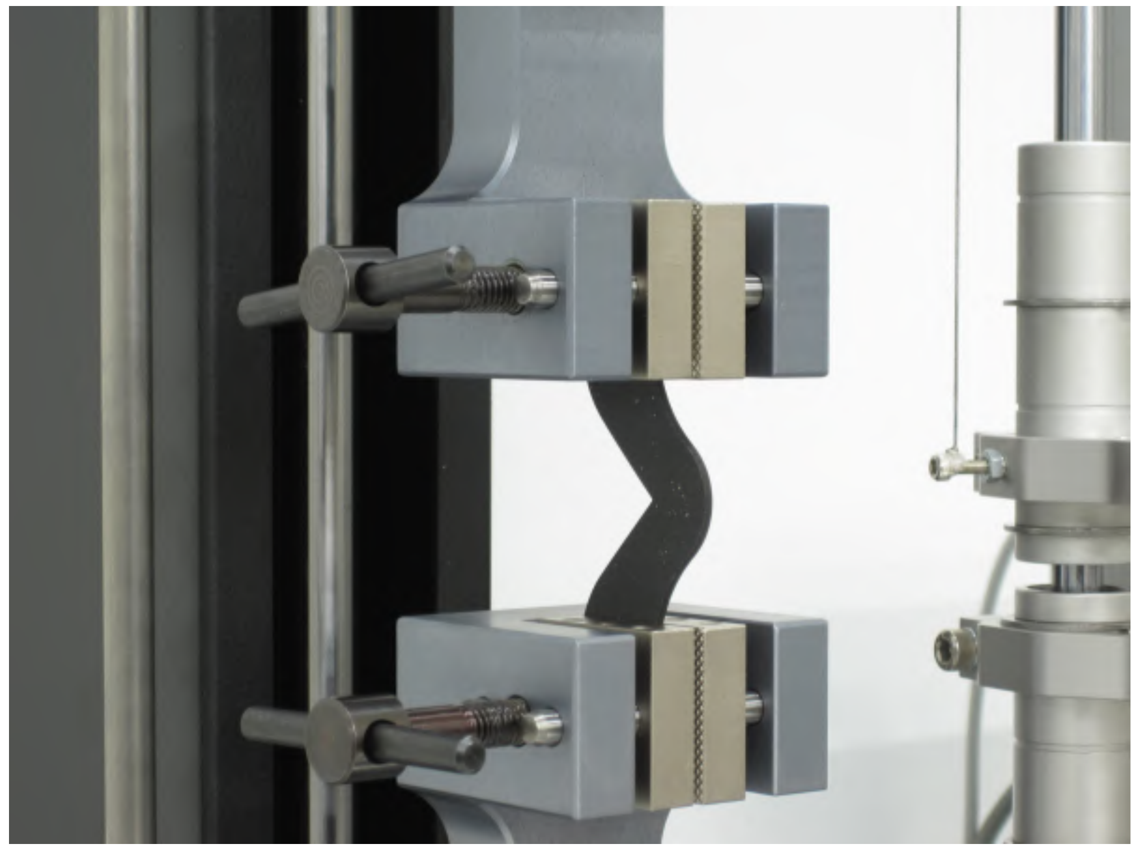
There are several physical properties you should consider when choosing the right material for your waterstop application. These include hardness, tensile strength, modulus, elongation, tear resistance, and compression set.

Hardness — ASTM D2240
Hardness is resistance to indentation under specific conditions. There are two hardness tests predominate in the rubber and plastic industry: Shore durometer and International Rubber Hardness Degrees (IRHD).

Most commercially available waterstops use the Shore A scale to measure hardness. Higher Shore durometer numbers mean the harder (and stiffer to flexure) waterstop product.

Tensile Strength — ASTM D412
Typically noted in either pound per square inch (psi) or megapascals (MPa), tensile strength is the amount of force required to break a plastic or rubber waterstop specimen. (To convert from MPa to psi, simply multiply the MPa figure by 145. For example, 14 MPa converts to 2,030 psi. Converting from psi to MPa is just a matter of dividing the psi number by 145.)

Image 3.1 ASTM D412



ASTM D412 tests the mechanical properties of plastic and rubber waterstop, including its elongation and tensile strength.

100% Modulus — ASTM D412
Modulus is the force (stress) in pounds per square inch (psi) required to produce a certain elongation (strain). 100% is the most widely used figure for testing and comparison purposes of commercially available waterstops. Generally speaking, the harder a waterstop (ASTM D2240), the higher its modulus. Because it is a measure of tensile strength at a particular elongation (rather than at rupture). Modulus is also known as tensile modulus or tensile stress.

Ultimate Elongation — ASTM D412
Elongation is the percentage increase in the original length (strain) of a rubber or plastic waterstop specimen resulting from tensile force (stress) applied to the specimen. Elongation is inversely proportional to hardness, tensile strength, and modulus. Therefore, the higher a waterstop's hardness, tensile strength, and modulus, the less it will elongate under stress. It takes more force to stretch a hard waterstop having high tensile strength and high modulus than to stretch a soft material with low tensile strength and low modulus.

Ultimate elongation is the elongation at the moment the specimen breaks. Per ASTM D412, ultimate elongation is a percentile; therefore, when comparing waterstops, the higher the number (%), the better.

Tear Resistance (aka Tear Strength) — ASTM D412
Tear resistance (also known as tear strength) is resistance to the growth of a cut or nick in a waterstop specimen when tension is

applied. Values expressed in pound-force per inch (lbf/in), so again, the waterstop with the higher value is superior, as it is more resistant to tearing.

Compression Set — ASTM D395

Compression set is the permanent deformation remaining when a force applied to a waterstop specimen for a period of time is removed. Tested under ASTM D395, the compression set is a percentile related to the percentage of deformation compared to the waterstop's original thickness. Therefore, a low value is better as it denotes the waterstop did not "take a set" and returned close to its original shape and size after the force is removed. A high value means the waterstop became deformed (squished) under pressure and did not return to its original shape and size. **The compression set represents the percent of deflection that did not return**.

Additional Waterstop Testing Criteria

Earlier in this chapter, you learned of the mechanical properties that evaluate waterstops. A waterstop with high tensile strength, excellent elongation, and low compression set may still not be a good fit for your project. The following are some additional criteria you can use when deciding what waterstop to use for a given project.

Drinking-Water Safe — NSF 61
Water is arguably the most valuable resource in the world. Today's water treatment, distribution, and storage projects are under ever-increasing layers of regulations and requirements. One of the foremost is that components and materials that contact potable water do not have potential adverse human effects.

NSF Standard 61 establishes minimum requirements for the chemical contaminants and impurities indirectly imparted to drinking water from products, components, and materials used in drinking water systems. **Standard 61 covers specific materials or products that come into contact with drinking water, drinking water treatment chemicals, or both**. The focus of Standard 61 is the evaluation of contaminants or impurities imparted indirectly to drinking water.

In the U.S., 47 of 50 states have legislation that requires compliance with NSF Standard 61. Products that are NSF Certified against NSF/ANSI Standard 61 demonstrate compliance with both Canadian and U.S. Plumbing Codes. NSF Certification and Testing is widely accepted. NSF data is recognized by ASSE, BOCA, IAPMO, ICBO-ES, SBCCI, City of Los Angeles, and many others.

Very few waterstops have NSF 61 certification, which is pretty surprising

NSF/ANSI STANDARD 61
Drinking Water System Components - Health Effects

NOTE: Unless otherwise indicated for Materials, Certification is only for the Water Contact Material shown in the Listing. Click here for a list of Abbreviations used in these Listings.

JP Specialties, Inc. / Earth Shield Waterstop
551 Birch Street
Lake Elsinore, CA 92530
United States
800-821-3859
951-674-6869
Visit this company's website

Facility : Lake Elsinore, CA

Joining and Sealing Materials

Trade Designation	Size	Water Contact Temp	Water Contact Material
Waterstop			
Earth Shield® Waterstop	[1]	CLD 23	TPE
Earth Shield® Waterstop part no. JP1149	[1]	CLD 23	TPE
Earth Shield® Waterstop part no. JP1225	[1]	CLD 23	TPE
Earth Shield® Waterstop part no. JP158	[1]	CLD 23	TPE
Earth Shield® Waterstop part no. JP211	[1]	CLD 23	TPE
Earth Shield® Waterstop part no. JP320L	[1]	CLD 23	TPE
Earth Shield® Waterstop part no. JP325T	[1]	CLD 23	TPE
Earth Shield® Waterstop part no. JP336L	[1]	CLD 23	TPE
Earth Shield® Waterstop part no. JP436	[1]	CLD 23	TPE
Earth Shield® Waterstop part no. JP450T	[1]	CLD 23	TPE
Earth Shield® Waterstop part no. JP500	[1]	CLD 23	TPE
Earth Shield® Waterstop part no. JP540L	[1]	CLD 23	TPE
Earth Shield® Waterstop part no. JP621L	[1]	CLD 23	TPE
Earth Shield® Waterstop part no. JP636	[1]	CLD 23	TPE
Earth Shield® Waterstop part no. JP647	[1]	CLD 23	TPE
Earth Shield® Waterstop part no. JP648	[1]	CLD 23	TPE
Earth Shield® Waterstop part no. JP678	[1]	CLD 23	TPE
Earth Shield® Waterstop part no. JP936	[1]	CLD 23	TPE
Earth Shield® Waterstop part no. JP948	[1]	CLD 23	TPE
Earth Shield® Waterstop part no. JP949	[1]	CLD 23	TPE
Earth Shield® Waterstop part no. JP978	[1]	CLD 23	TPE
Earth Shield® Waterstop part no. JPEB350	[1]	CLD 23	TPE
Earth Shield® Waterstop part no. JPEB375	[1]	CLD 23	TPE
Earth Shield® Waterstop part no. JPEB375R	[1]	CLD 23	TPE

[1] This material is approved as a waterstop for use in any potable water treatment or retaining structure.

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Number of matching Products is 24
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considering that waterstops are often installed in drinking water facilities. I believe this is one of the more essential requirements for a waterstop (NSF 61 certification) and that specifiers should require it.

Resistance to Chemicals — ASTM D471
ASTM D471 tests the waterstop in a given concentration of a specific fluid* for 166 at hours at a specified temperature* (*customer request of fluid and usually 23°C for the temperature). After the testing time has elapsed, remove the waterstop from the fluids. Then a variety of physical tests are performed that gauge its durability and corrosion resistance to the liquid of immersion. A waterstop that performs well in this test can be considered "chemical resistant," but only to the specific fluid tested. A waterstop could be a good choice for fuel oil, but a poor choice for hydrochloric acid. This distinction is essential, as no one metal or polymer waterstop is chemically resistant to everything.

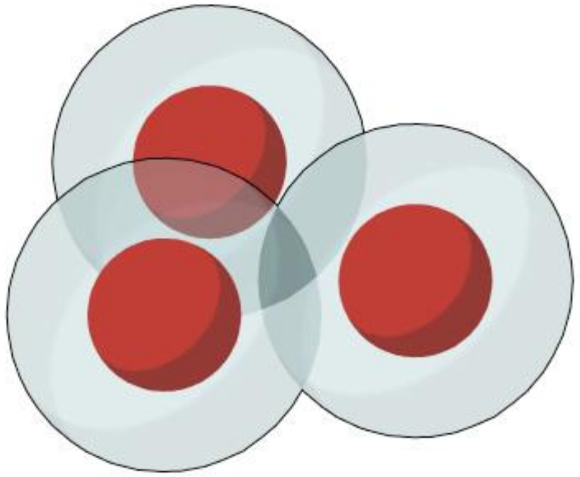
Image 3.2 Chemical Attack

Severe corrosion of metal.

Resistance to Ozone — ASTM D1171

ASTM D1171 tests the waterstop in a given concentration* of ozone (*usually expressed in Parts Per Million (PPM) or Parts Per Hundred Million (PPHM). After the testing time elapsed, remove the waterstop from the ozone chamber, and a variety of physical tests gauge its durability and corrosion resistance to the ozone.

Because many waterstops fail in high concentrations of ozone, this is an important test when selecting a waterstop for an ozone contactor application. A waterstop that performs well in this test is "ozone resistant," but only to the concentration tested.



An ozone — O^3 — molecule

Section 2

A Sample Waterstop Specification

This specification is available in a variety of computer formats on CD-ROM or DVD. Contact Earth Shield® Technical Sales for more information. It can also be found on the web at www.earthshield.com.

Suggested Short Form Guide Specification

Flexible PVC Waterstop for Concrete Joints
Waterstop indicated in drawings and specifications for contraction (control), expansion, and construction joints shall be Earth Shield® Polyvinyl Chloride (PVC) Waterstop **Part No. ####** [Designer insert appropriate part number here] as manufactured and available from J P Specialties, Inc. — Murrieta, CA, USA 92562 — Phone 800-821-3859; 951-763-7077; Fax 951-763-7074; www.earthshield.com; E-mail davidp@earthshield.com

1. *Flexible Polyvinyl Chloride (PVC) Waterstop shall be manufactured with prime virgin resin.*
2. *Flexible Polyvinyl Chloride (PVC) Waterstop shall be independently certified for use in potable water per NSF/ANSI Standard 61. Third-party certified documentation to be provided by the manufacturer.*
3. *Flexible Polyvinyl Chloride (PVC) Waterstop shall be California Prop 65 compliant and contain no hazardous phthalates.*
4. *No equals or substitutions allowed.*

PVC Waterstop Shop Made Fittings for Directional Changes
Intersection and change of direction waterstops shall be factory fabricated as manufactured and available from J P Specialties, Inc. — Murrieta, CA, USA 92562 — Phone 800-821-3859; 951-763-7077; Fax 951-763-7074; Web www.earthshield.com; E-mail davidp@earthshield.com and installed at all locations on the drawing by the Contractor. The Contractor shall only weld straight lengths of waterstop with all change of directions (fittings) being fabricated and supplied by Manufacturer.

1. *No equals or substitutions allowed.*

Suggested Long Form Guide Specification

PART 1 GENERAL

1. Provision Includes
   - A. Embedded waterstop in concrete including contraction, expansion and construction joints creating a continuous diaphragm to prevent the passage of fluid.
   - B. The use of nonmetallic waterstops for use in concrete joints subjected to chlorinated water, sea water, and many waterborne chemicals.

1. References

The publications listed below form a part of this specification to the extent referenced. The publications are referred to in the text by basic designation only.

- A. American Society for Testing and Materials (ASTM)
- B. Federal Specifications
  1. COE CEGS-03250 July 1995 Guide Specification for Military Construction.
  2. Corps of Engineers — CRD C572-74
  3. Bureau of Reclamation — C-902
- C. Canadian General Standards Board
  1. 41-GP-35M Types 1 and 3
- D. NSF International
  1. NSF/ANSI Standard 61 Certification for Drinking Water System Components — Health Effects.

3. Submittal Procedures

- A. Flexible PVC Waterstop
  1. Earth Shield® PVC Waterstop submittal shall contain the following:
     - a. Samples of each size and shape to be used.
     - b. Plate drawings of the waterstop profile indicating all dimensions.
     - c. Shop drawings of shop made fittings to be provided by the manufacturer or prepared by the contractor.
     - d. Manufacturer's Literature, MSDS sheets, installation, safety, and splicing instructions.
     - e. Certificate of compliance to physical properties outlined in this specification with third-party independent test reports (all testing reports within three years of date of submittal).
  2. Flexible PVC Waterstop and Splices — Specimens identified to indicate manufacturer, type of material, size, quantity of material, and shipment or lot represented. Each sample shall be not less than 6 inches long of each type, size, and lot furnished. One splice sample of each size and type for every 50 splices made in the shop and every 10 splices made at the job site. The splice samples shall be made using straight run pieces with the splice located at the mid-length of the sample and finished as required for the installed waterstop. The total length of each splice shall be not less than 12 inches long.

4. Delivery and Storage

Material delivered and placed in storage shall be stored off the ground and protected from sunlight, moisture, dirt, and other contaminants.

PART 2 PRODUCTS

1. Flexible PVC Waterstop

Intersection and change of direction waterstops shall be factory fabricated.

- A. Manufacturer:
  J P Specialties, Inc. — Murrieta, CA, USA 92562 — Phone 800-821-3859; 951-763-7077; Fax 951-763-7074; Web www.earthshield.com; E-mail davidp@earthshield.com
- B. Flexible Polyvinyl Chloride (PVC) Waterstop shall be manufactured from a prime virgin, flexible polyvinyl chloride (PVC) compound, containing no pigments, scrap or reclaimed material.
- C. Flexible Polyvinyl Chloride (PVC) Waterstop shall be certified for use in potable water per NSF/ANSI Standard 61. Third-party certified documentation to be provided by manufacturer.
- D. Flexible Polyvinyl Chloride (PVC) Waterstop shall be California Prop 65 compliant and contain no hazardous phthalates.

Flexible Polyvinyl Chloride (PVC) Waterstop shall conform to the following typical physical properties:

Property	Test Method	Required Results
Specific Gravity	ASTM D 792	1.38 to 1.40
Shore A Hardness (15 sec.)	ASTM D 2240	77±3 at 25°C (77°F)
Tensile Strength	ASTM D638	2,100 psi
Ultimate Elongation	ASTM D638	400%
Stiffness in Flexure	ASTM D747	700 psi
Tear Resistance	ASTM D624	320 lbs./inch
Brittle Point	ASTM D746	-37°C (-35°F) No Failure

Property	Test Method	Required Results
Accelerated Extraction Tensile Strength	Corps of Engineers	2,005 psi
Accelerated Extraction Elongation	Corps of Engineers	390%
Effect of Alkali Weight Change	CRD C572-74	+0.11%
Effect of Alkali Hardness Change	CRD C572-74	-0.6 points
Drinking Water Safe	NSF/ANSI 61	Waterstop certified by NSF for use in potable water
California Prop 65	CA Prop 65	Compliant — No hazardous phthalates

PART 3 EXECUTION

1. Waterstop, Installations and Splices — Waterstops shall be installed at the locations shown to form a continuous fluid-tight diaphragm. Adequate provision shall be made to support and completely protect the waterstops during the progress of the work. Any waterstop punctured or damaged shall be repaired or replaced. Exposed waterstops shall be protected during application of form release agents to avoid being coated. Suitable guards shall be provided to protect exposed projecting edges and ends of partially embedded waterstops from damage when concrete placement has been discontinued. Splices shall be made by certified, trained personnel using approved equipment and procedures.
   A. Flexible PVC Shop Made Fittings — Fittings shall be shop made using a machine specifically designed to mechanically weld the waterstop. A miter guide, proper template (profile dependent), and portable power saw shall be used to miter cut the ends to be joined to ensure good alignment and contact between joined surfaces. The splicing of straight lengths shall be done by squaring the ends to be joined and using an ST-10® waterstop splicing tool. Continuity of the characteristic features of the cross section of the waterstop (ribs, tabular center axis, protrusions, etc.) shall be maintained across the splice.
   B. Flexible PVC Waterstop — The splicing of straight lengths shall be done by squaring the ends to be joined and using an ST-10® waterstop splicing tool utilizing a thermoplastic splicing iron with a non-stick surface specifically designed for waterstop welding. The correct temperature (350°F to 380°F) shall be used to sufficiently melt without charring the plastic. The spliced area, when cooled, shall show no signs of separation, holes, or other imperfections when bent by hand in as sharp an angle as possible.

2. Preparation
   A. Uncoil waterstop 24 hours prior to installation for ease of handling and fabrication.
   B. Position waterstop to ensure proper distance from steel reinforcing bars to prevent rock pockets and honeycomb (see installation section 3.04).
   C. Protect waterstop from damage during progress of work.
   D. Clean concrete joint after first pour to remove debris and dirt.

3. Examination/Inspection
   A. Prior to placement of concrete notify engineer for field inspection approval.
   B. Inspect waterstop and field splices for defects and conformance to Quality Assurance Standard section 3.05.

   C. Upon inspection of waterstop installation, replace any damaged or unacceptable waterstop and dispose of defective material.

4. Installation
   A. Position waterstop in joint as indicated on drawings.
   B. Center waterstop on joint, with approximately one-half of waterstop width to be embedded in concrete on each side of the joint.
   C. Allow clearance between waterstop and reinforcing steel of a minimum two times the largest aggregate size. Prevent rock pockets and air voids caused by aggregate bridging.
   D. Ensure centerbulb is not embedded at expansion joints.
   E. Secure waterstop in correct position using optional factory-installed brass eyelets (or JPS hog rings crimped between last two ribs on 12 inch maximum centers), and wire tie to adjacent reinforcing steel. Center-to-center spacing may be increased upon written request and approval from ENGINEER.
   F. Carefully place concrete without displacing waterstop from proper position.
   G. Thoroughly and systematically vibrate concrete in the vicinity of the joint, and to maximized intimate contact between concrete and waterstop.
   H. After first pour, clean unembedded waterstop leg to ensure full contact of second concrete pour. Remove laitance, spillage, form oil and dirt.

5. Quality Assurance — Edge welding will not be permitted. Centerbulbs shall be compressed or closed when welding to non-centerbulb type. Waterstop splicing defects which are unacceptable include, but are not limited to the following:
   A. Tensile strength not less than 60 percent of parent sections.
   B. Free lap joints.
   C. Misalignment of centerbulb, ribs, and end bulbs greater than 1/16 inch.
   D. Misalignment which reduces waterstop cross section ore than 15 percent.
   E. Bond failure at joint deeper than 1/16 inch or 15 percent of material thickness.
   F. Misalignment of waterstop splice resulting in misalignment of waterstop in excess of 1/2 inch in 10 feet.
   G. Visible porosity in the weld.
   H. Charred or burnt material.
   I. Bubbles or inadequate bonding.
   J. Visible signs of splice separation when cooled splice (24 hours or greater) is bent by hand at sharp angle.

END OF SECTION

All information is presented in good faith and the results are believed to be accurate. All testing was done independently of Earth Shield® and J P Specialties, Inc.; therefore, neither Earth Shield® nor J P Specialties, Inc. makes any guarantee as to the testing data accuracy or the results obtained.

Chapter 4

Waterstop for Fluids Other Than Water

Today, waterstops are manufactured to prevent the passages of fluids other than water through concrete joints. Oils, acids, process chemicals, and other deleterious fluids can be stopped in their tracks by a properly specified and installed waterstop made out of chemical-resistant polymers or metals.

The Buncefield Incident — Hertfordshire Oil Storage Terminal — December 2005

Previously you learned about waterstops designed to prevent the passage of *water* — Specifically PVC (polyvinyl chloride), hydrophilic (sodium bentonite and chemically modified rubber), and mastic waterstop. This chapter is devoted to the passage of fluids *other than water:* Fuels and other aqueous hydrocarbons, acids, process chemicals, and other various HAZMAT.

In many nations, chemical resistant waterstops are a *requirement* to be used in concrete joints exposed to various HAZMAT. In the United States, the Environmental Protection Agency has codified the use of chemical resistant waterstops. The EPA's Title 40 (Clean Water Act) CFR 265.193 Subpart J states that environmental engineered concrete structures used to contain HAZMAT must be: "...Constructed with chemical resistant waterstops at all joints (if any)." Unless the structure you design is entirely monolithic (free of all joints and one single concrete pour), you must incorporate a chemical resistant waterstop into your design. This edict is where it gets tricky... What is a chemical resistant waterstop?

Gallery 4.1 TPV Waterstop for Fluids Other Than Water

Our Sales Manager, Mr. Tom Nelson, assists a contractor on-site in the Kingdom of Saudi Arabia on chemical resistant waterstop installation.

Chemical Resistant Waterstop

Chemical resistant waterstops are specifically designed to be immune to the deleterious effects of a variety of oils, acids, fuels, process chemicals, and other fluids classified as HAZMAT by the EPA. It is not enough for a waterstop manufacturer to state that their material *should* stand up to these fluids, but rather be able to prove it. The accepted industry benchmark for waterstop chemical resistance testing is ***ASTM D471 — Standard Test Method for Rubber Property—Effect of Liquids***. ASTM D471 tests the waterstop in a given concentration of a specific fluid* for 166 at hours at a specified temperature* (*customer request of fluid and usually 23°C for the temperature). After the testing time has elapsed, the waterstop is removed from the fluids and subjected to a variety of physical tests that gauge its durability and corrosion resistance to the material of immersion. A waterstop that performs well in this test is "chemical resistant," but only to the specific fluid tested. A waterstop could be the right choice for fuel oil, but a poor choice for hydrochloric acid. This distinction is essential, as no one metal or polymer waterstop is chemically resistant to everything.

BLOGGER — AUGUST 21ST, 2011 — RCRA AND SPCC FINES FOR ROANOKE, VA COMPANY

ROANOKE, VA -- The U.S. Environmental Protection Agency announced today that a chemical distributor in Roanoke, Va. has agreed to pay a $43,967 penalty and complete more than $200,000 in safety improvements to settle alleged violations of federal environmental laws designed to protect and inform the public about hazardous chemicals.

The company, Chemicals and Solvents, Inc. (doing business as Chemsolv, Inc.) is located at 1111 Industry Ave., S.E., Roanoke. The settlement applies to Chemsolv and Austin Holdings-VA, LLC, owner of two of three properties that make up the facility.

According to an EPA complaint, the alleged violations include the facility's lack of fire protection, inadequate secondary containment, and improper storage of incompatible chemicals. Other violations concern the company's failure to fully implement its risk management program that is designed to help prevent chemical releases, and the company's failure to submit required documentation to state, county and local officials for the facility's numerous hazardous chemicals. States and communities can use this information to improve chemical safety and to protect public health and the environment in the event of a release.

The settlement announced today follows up on an EPA order in June 2008 for Chemsolv to take extensive measures to ensure that its storage facilities complied with industry standards and risk management program regulations. To comply with the order, Chemsolv rebuilt two large warehouses at the facility.

In the settlement, Chemsolv has agreed to pay a cash penalty of $43,967.00 and to implement two additional safety upgrades that exceed regulatory requirements: (1) installation of a nitrogen blanketing system on 20 storage tanks containing flammable materials at a cost of $153,000.00 and (2) installation of a dry disconnect system on hoses at the facility, which will eliminate drips and accidental spills during loading and unloading of chemicals, at a cost of $63,000.00 In the settlement documents, the company neither admitted nor denied liability for the alleged violations.

---David R. Poole

BLOGGER — JULY 13TH, 2011 — NEW YORK DEC RELEASES FRACKING REPORT WITH SECONDARY CONTAINMENT REGULATIONS

Penn Yan, NY — The Department of Environmental Conservation released its revised recommendations on mitigating the environmental impacts of high-volume hydraulic fracturing "fracking" July 1.

Those opposed to the practice argue that the recommendations allow the state to apply double standards to protecting drinking water supplies.

The recommendations contain these major revisions:

- High-volume fracturing would be prohibited in the New York City and Syracuse watersheds, including a buffer zone.
- Drilling would be prohibited within primary aquifers and within 500 feet of their boundaries.
- Surface drilling would be prohibited on state-owned land including parks, forest areas and wildlife management areas.
- High-volume fracturing will be permitted on privately held lands under rigorous and effective controls.
- DEC will issue regulations to codify these recommendations into state law.

The Department's review has resulted in recommendations for controls on high-volume fracturing on private lands such as:

Protecting Drinking Water

- Well water and other water protection: No permits would be issued for sites within 500 feet of a private water well or domestic use spring. No permits may be issued for a proposed site within 2,000 feet of a public drinking water supply well or reservoir at least until three years of experience elsewhere have been evaluated. No permits will be issued for well pads within a 100-year floodplain.
- Additional Well Casing to Prevent Gas Migration: In most cases, an additional third, cemented well casing is required around each well to prevent the migration of gas. The three required casings are the surface casing, the new intermediate casing and the production casing.
- Spill control: Flowback water on site must use watertight tanks within a *secondary containment*. No open containment may be used. *Secondary containment for all fracturing additive containers, additive staging areas and flowback tanks will be required*.

---The Courier

Hydrophobic TPV (Thermoplastic Vulcanizate) Waterstop — Earth Shield®

HYDROPHOBIC TPV WATERSTOP

1. **Prevents the passage of corrosive fluids through concrete joints by creating an internal dam, spanning both sides of and running *continuously* along the concrete joint.**
2. **Somewhat difficult to install properly as split-forming is usually necessary.**
3. **Contains no plasticizer to leach out (unlike PVC) from exposure to hydrocarbons, acids, ozone, ultraviolet radiation, or time.**
4. **Products are available for above- or below-grade; moving or non-moving applications.**
5. **Designed to last the life of the concrete structure.**
6. **NSF 61 certification* for drinking water.**
7. **Wider temperature range than conventional PVC waterstops.**
8. **Highest physical properties of any polymer waterstop.**

**Earth Shield® has NSF 61 certification for health and human safety*

Earth Shield® Thermoplastic Vulcanizate (TPV) Waterstop is used as a fluid-tight diaphragm, embedded in concrete, across and along the joint, for primary and secondary containment structures. Earth Shield® Chemical Resistant Waterstops are resistant to a *wide range* of oils, solvents, and aggressive chemicals. Alcohol, ketones, glycols, esters, and aqueous solutions of acids, salts, and bases have little effect on Earth Shield® Thermoplastic Vulcanizate Waterstop.

Unlike polyvinyl chloride (PVC) waterstop, Earth Shield® TPV waterstop contains no plasticizer, stabilizer, or filler to leech out when exposed to chemicals, fuels, and aggressive industrial fluids. Also, unlike PVC waterstop, Earth Shield® TPV waterstop can withstand prolonged exposure to high and low temperatures (-78°F to 275°F long term) without detrimental effect.

Earth Shield® TPV waterstop is NSF Standard 61 certified for use in drinking water and is made of a recyclable polymer, so it is good for health and the environment.

The superior chemical resistance of Earth Shield® Thermoplastic Vulcanizate Waterstop is enhanced by using a ribbed centerbulb configuration, which is available in a 4, 6, and 9-inch width. This profile provides superior mechanical bonding with the concrete and a barrier against the migration of liquid flow around the waterstop. The ribbed centerbulb style also allows for joint movement and may be used above or below grade. Additional shapes are available for retrofit, extreme expansion, stainless steel, and base seal applications.

.

Different varieties and grades of thermoplastic elastomers (TPE) are commercially available. On the low-end, there is thermoplastic polyolefin (TPO), which has a rubber phase that is not cross-linked. On the high-end, there is thermoplastic vulcanizate (TPV). Earth Shield® has chosen a fully cross-linked TPV as our standard elastomer compound, which provides superior mechanical properties, retention, and chemical resistance. When compared side-by-side, no competitive product is close to achieving the physical properties of Earth Shield®.

Earth Shield® has been tested extensively under the aforementioned ASTM D-471 Standard Test Method for Rubber Property—Effect of Liquids, and a very lengthy chemical resistance chart is here.

Property	Test Method	Required Results
Specific Gravity	ASTM D792	.96
Shore A Hardness (5 sec.)	ASTM D2240	90±3 at 25°C (77°F)
Tensile Strength	ASTM D412	2,300 psi
Ultimate Elongation	ASTM D412	530%
100% Modu-lus	ASTM D746	1,000 psi
Tear Strength	ASTM D624	278 pli at 25°C (77°F)
Compression Set	ASTM D395	29% at 25°C (77°F)
Brittle Point	ASTM D746	-61°C (-78°F)
Drinking Water Safe	NSF/ANSI 61	Waterstop certified by NSF for use in potable water
Ozone Resistance	ASTM D1171	Passed, no cracking at 600 pphm
Chemical Resistance	ASTM D471	Meet or exceed spe-cific testing standards for contained fluids as required by Owner and certified by Manufac-turer
Green Certification	GreenSpec	Approved

BLOGGER — SEPTEMBER 23RD, 2011 — TPE AND TPV... MY DEFINITION

TPEs and TPVs are such niche items that I seriously doubt that you'll ever find them listed in a printed dictionary or encyclopedia. Therefore, I decided to put my definition on the Web for all to use as needed.

1) TPE and TPV defined:

a) Thermoplastic Elastomeric Rubber (TPE [sometimes referred to as TPER]) — An alloy of rubber and plastic usually that bridges the price/performance gap of the two parent materials. TPEs have many of the physical properties and characteristics of rubber, but process like plastics.

b) Thermoplastic Vulcanizate Rubber (TPV) — Same as a TPE, but the rubber phase of the product is vulcanized (or cross-linked), which provides the finished elastomer with higher chemical resistance and substantially better mechanical properties.

c) (From Handbook of Thermoplastic Elastomers by Benjamin M. Walker and Dr. Charles P. Rader.) TPEs first appeared as commercial entities during the late 1950s, with the introduction of thermoplastic polyurethane elastomers by both B. F. Goodrich and Mobay Chemical. This was followed by the production of styrene butadiene and styrene isoprene block copolymers by the Shell Chemical Company during the middle and late 1960s. a significant innovation in the TPE field was the commercial introduction of copolyester block copolymers by the Du Pont Company during the 1970s, which was followed by the introduction of a group of rubber-plastic blends — primarily polypropylene and EPDM rubber — by the Uniroyal Chemical Company. The 1980s saw introduction of elastomeric alloy thermoplastic vulcanizates (TPVs), by the Monsanto Chemical Company in 1981, and elastomeric alloy melt processible rubbers (MPRs), by the Du Pont Company in 1985. The Monsanto TPV (now Santoprene by ExxonMobil), based upon a unique process of dynamic vulcanization, consists of a two-phase system — a finely divided dispersion of a highly vulcanized rubber phase in a continuous phase of polyolefin.

---David R. Poole

Thermoplastic Vulcanizate (TPV) Waterstop

www.facebook.com/waterstop

Section 03150 • MasterFormat™ 03 15 13

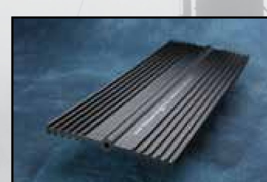
EARTH SHIELD®

Waterstops for Chemical, Industrial, & Environmental Applications

All ribbed Earth Shield® Waterstop profiles are available with factory installed brass eyelets. The eyelets provide for a convenient and durable tie-off point for wire tying the waterstop to the steel reinforcement prior to the concrete pour.

Earth Shield® Retrofit Column and Pipe Fitting (part number JP320LC1.XX* [*XX is diameter in inches]) is manufactured with a flexible, chemical-resistant polymer and includes all stainless steel anchoring hardware.

See page 14 for more info



Earth Shield® JP636 TPV Ribbed Centerbulb (6” width) is the industry standard, utilized on most jobs for its proven fluid-sealing properties.

See page 4 for more info

Waterstops play a critical role in the integrity of concrete structures. They provide a fluid-tight diaphragm when embedded in, and running through concrete joints. Earth Shield® Thermoplastic Vulcanizate Waterstop (TPV), by JP Specialties, Inc., greatly expands the scope of conventional waterstop by offering unmatched chemical resistance to a broad spectrum of aggressive chemicals, solvents, and hot petroleum oils. Manufactured NSF certified, EPA-compliant waterstop profiles are available for new construction and retrofit, as well as the tools and accessories for proper field installation.

JP Specialties, Inc. is the leading manufacturer of chemical resistant waterstop and related concrete accessories. Our NSF 61 certified Earth Shield® line of chemical resistant waterstop is used throughout the world by major engineering firms and project owners for primary and secondary containment applications, as well as industrial wastewater treatment and ozone contactor structures. We invented and hold the patent on the technology used to mechanically weld thermoplastic waterstops.

Services offered include free blueprint take-off and shop drawings, on-site welding certification, and individual corrosion resistance certification for the project owner.

Earth Shield® Chemical Resistant Waterstop
Phone: 800-821-3859; 951-763-7077
Fax: 951-763-7074
www.earthshield.com
J P SPECIALTIES, INC.

www.facebook.com/waterstop

Hydrophobic SS (Stainless Steel) Waterstop — Earth Shield®

HYDROPHOBIC SS WATERSTOP

1. **Prevents the passage of extremely corrosive fluids (even at elevated temperatures) through concrete joints by creating an internal dam, spanning both sides of and running *continuously* along the concrete joint.**
2. **The most difficult to install waterstop, as split-forming is always necessary (with the exception of retrofit profiles). Also, TIG or MIG welding is required.**
3. **Contains no plasticizer to leach out (unlike PVC) from exposure to hydrocarbons, acids, ozone, ultraviolet radiation, or time.**
4. **Products are available for above- or below-grade; limited-moving or non-moving applications.**
5. **Designed to last the life of the concrete structure.**
6. **Able to withstand extreme temperature conditions (high heat, LNG, etc).**

Earth Shield® Stainless Steel Waterstop can stop even the most corrosive fluids in their tracks, even at severely elevated temperatures. A variety of metals, grades, and gauges are available. Earth Shield® utilizes 20 gauge grade 316 low carbon as our standard alloy. This steel offers broad-spectrum corrosion resistance to most aggressive media. It is virtually untouched by the deleterious effects of ozone, making it ideal for ozone contactor structures used in modern water treatment plants.

Earth Shield® Stainless Steel Waterstop is available in many standard shapes and sizes, including profiles for new construction and retrofit. All change of direction fabrications can be pre-manufactured, leaving only straight butt welding for the field.

Movie 4.1 Welding Stainless Steel Waterstop

Demonstrates the proper way to weld Earth Shield® Stainless Steel Waterstop.

Gallery 4.2 Stainless Steel Waterstop

Stainless steel factory fabricated fittings. (Flat Cross to Vertical Ell Transition and a Flat Tee.)

INSTALLING SS WATERSTOP

1. Stainless Steel — Splices in stainless steel waterstops shall be welded using a TIG (recommended) or MIG process utilizing a weld rod to match the stainless (weld rod: 316ELC; diameter — .035 to .045). Damaged waterstops shall be repaired by removing damaged portions and patching. Patches shall overlap a minimum of 1 inch onto undamaged portion of the waterstop. Weld all straight run material edge-to-edge (no overlapping).
2. Preparation — Position waterstop to ensure proper distance from steel reinforcing bars to prevent rock pockets and honey comb (see installation section 3.04).
3. Protect waterstop from damage during progress of work.
4. Clean concrete joint after first pour to remove debris and dirt.
5. Examination/Inspection — Prior to placement of concrete notify engineer for field inspection approval.
6. Upon inspection of waterstop installation, replace any damaged or unacceptable waterstop and dispose of defective material.
7. Installation — Position waterstop in joint as indicated on drawings.
8. Center waterstop on joint, with approximately one-half of waterstop width to be embedded in concrete on each side of the joint.
9. Allow clearance between waterstop and reinforcing steel of a minimum two times the largest aggregate size. Prevent rock pockets and air voids caused by aggregate bridging.
10. Carefully place concrete without displacing waterstop from proper position.
11. Thoroughly and systematically vibrate concrete in the vicinity of the joint, and to maximized intimate contact between concrete and waterstop.
12. After first pour, clean unembedded waterstop leg to ensure full contact of second concrete pour. Remove laitance, spillage, form oil and dirt.

Stainless Steel Waterstop

EARTH SHIELD®

Metallic Waterstop for Extreme Chemical Resistance

Earth Shield does fabricate custom waterstop profiles for our engineering and owner clients. Feel free to contact us directly if your project requires a fabricated profile that you do not see listed in our catalog. Additional grades and gauges are available (including copper, galvanized, carbon steel and others).

Waterstops play a critical role in the integrity of concrete structures. They provide a fluid-tight diaphragm when embedded in, and running through concrete joints.

Earth Shield® Metallic Waterstop can stop even the most corrosive fluids in their tracks, even at severely elevated temperatures. A variety of metals, grades, and gauges are available. Earth Shield utilizes 20 gauge 316 low carbon as our standard alloy, which offers broad spectrum corrosion resistance to most aggressive media, and is virtually untouched by the deleterious effects of ozone, making it an ideal choice for ozone contactor structures used in modern water treatment plants.

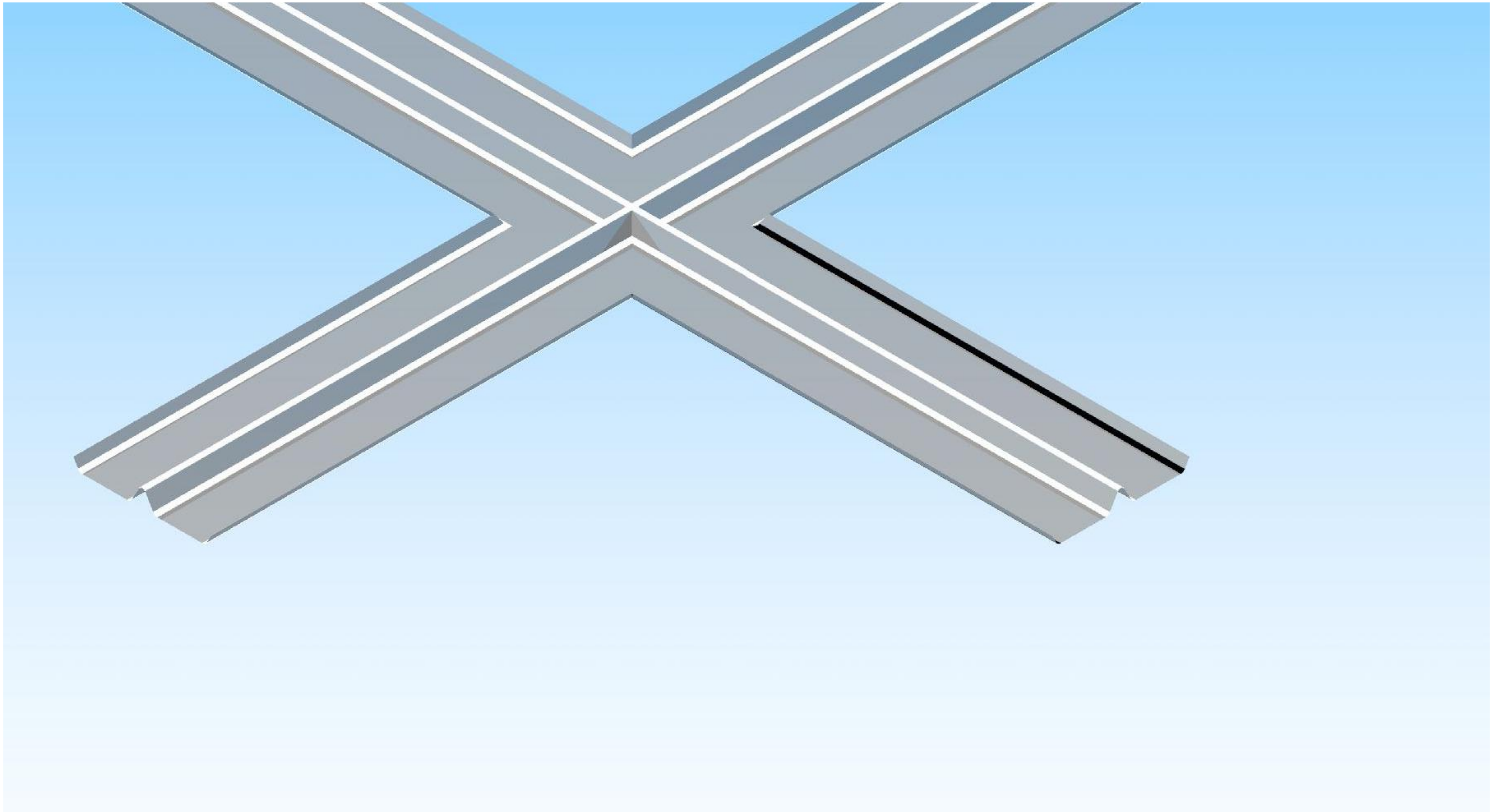
Earth Shield Stainless Steel Waterstop is available in many standard shapes and sizes (see inside), including profiles for new construction and retrofit. All change of direction fabrications can be premanufactured leaving only straight butt welding for the field.

JP Specialties has been the respected innovator in the waterstop industry since 1954. We are known worldwide for our high-quality waterstop, and we hold the patent on the ST-10® In Line Waterstop Splicing Table and the XLT2000 Waterstop Fabrication Table — the equipment used to mechanically weld thermoplastic waterstops.
www.earthshield.com/sswaterstop.html

Earth Shield® Chemical Resistant Waterstop
P.O. Box 1507, Lake Elsinore, CA 92531
Phone: 888-836-5778; Fax: 951-674-1315
E-mail: davidp@earthshield.com
Web: www.earthshield.com

J P SPECIALTIES, INC.

Gallery 4.3 Typical Stainless Steel Waterstop Fittings



JP558X1 — Flat Cross

Other Types of Metallic Waterstops

METALLIC WATERSTOP

1. The very first waterstops historically.
2. High head pressure resistance and long, proven track record.
3. Can corrode and deteriorate over time.
4. Many grades, gauges, and types of metals available.
5. Still specified today by the U.S. Bureau of Reclamation, Black & Veatch, and others.
6. Mostly replaced by thermoset and thermoplastic materials.

Gallery 4.4 Metallic Waterstop

Antique copper waterstop installed in a Bureau of Reclamation dam project in the 1930s

M

Strips of copper and lead were found as far back as the Roman Empire as waterstop. Embedded in concrete, and still functioning today, these antique waterstops are a testament to the longevity and function of metallic waterstop. Many grades, gauges, and [types of metal are commercially available from J P Specialties](), and we maintain licensed TIG and MIG welders on staff for fabrication purposes.

Stainless steel is the most popular type of metallic waterstop. However, [carbon steel waterstop]() is widely used today, as Black & Veatch engineers often specify its use.

Copper waterstop was widely used up until 1935, when thermoset rubbers replaced it as the material of choice for specifying engineers. It is still occasionally used today in dams.

Carbon Steel Waterstop

Meets or exceeds Black & Veatch specification requirements

Carbon Steel Waterstop

Earth Shield® Carbon Steel Waterstop is available in a variety of grades, gauges, widths, and finishes. All waterstop is made to order to the required ASTM or specification requirements.

Earth Shield® Carbon Steel Waterstop — Part No. JP550 (left); Part No. JP550B (right).

Reference ASTM Specifications — Hot-Rolled Carbon

ASTM A569 — Standard Specification for Steel, Carbon (0.15 Maximum, Percent), Hot-Rolled sheet and Strip Commercial.

ASTM A505 — Standard Specification for Steel, Sheet and Strip, Alloy, Hot-Rolled and Cold-Rolled, General Requirements For.

ASTM A506 — Standard Specification for Steel, Sheet and Strip, Alloy, Hot-Rolled and Cold-Rolled, Regular Quality and Structural Quality.

ASTM A570 — Standard Specification for Steel, Sheet and Strip, Alloy, Carbon, Hot-Rolled (Replaced by ASTM A1011).

ASTM A1011 — (Replaces ASTM A570) Standard Specification for Steel, sheet and Strip, Hot-Rolled, Carbon, Structural, High-Strength Low-Alloy and High-Strength Low Alloy with Improved Formability.

ASTM A36 — Standard Specification for Carbon Structural Steel.

Reference ASTM Specifications — Cold-Rolled Carbon

ASTM A109 — Standard Specification for Steel, Strip, Carbon, Cold-Rolled.

ASTM A366 — Standard Specification for Commercial Steel (CS) Sheet, Carbon (.15 Maximum, Percent) Cold-Rolled.

ASTM A505 — Standard Specification for Steel, Sheet and Strip, Alloy, Hot-Rolled and Cold-Rolled, General Requirements For.

ASTM A506 — Standard Specification for Steel, Sheet and Strip, Alloy, Hot-Rolled and Cold-Rolled, Regular Quality and Structural Quality. www.jpspecialties.com/sswaterstop.html

JP Specialties, Inc.
P.O. Box 1507, Lake Elsinore, CA 92531
Phone: 800-821-3859; Fax: 951-674-1315
E-mail: jpspec@jpspecialties.com
Web: www.jpspecialties.com

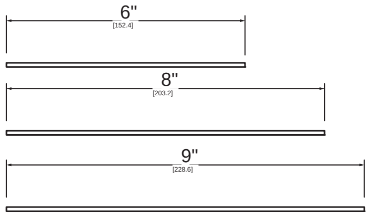
Distributed by:

Typical Physical Properties

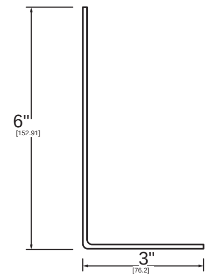
Earth Shield® CS Waterstop is certified *for use in Black & Veatch Specifications.*

Earth Shield® CS Waterstop is certified *for use in U.S. Army Corps of Engineers Guide Specification for Military Construction CEGS 03250 Section 2.4.2 Rigid Metal Waterstops.*

Width	Various
Length	10 lft
Yield Strength	49,741 psi
Tensile Strength	70,187 psi
Elongation	30%



JP550 *(various widths available • 12 gauge thick standard)*



JP550B *(various widths available • 12 gauge thick standard)*

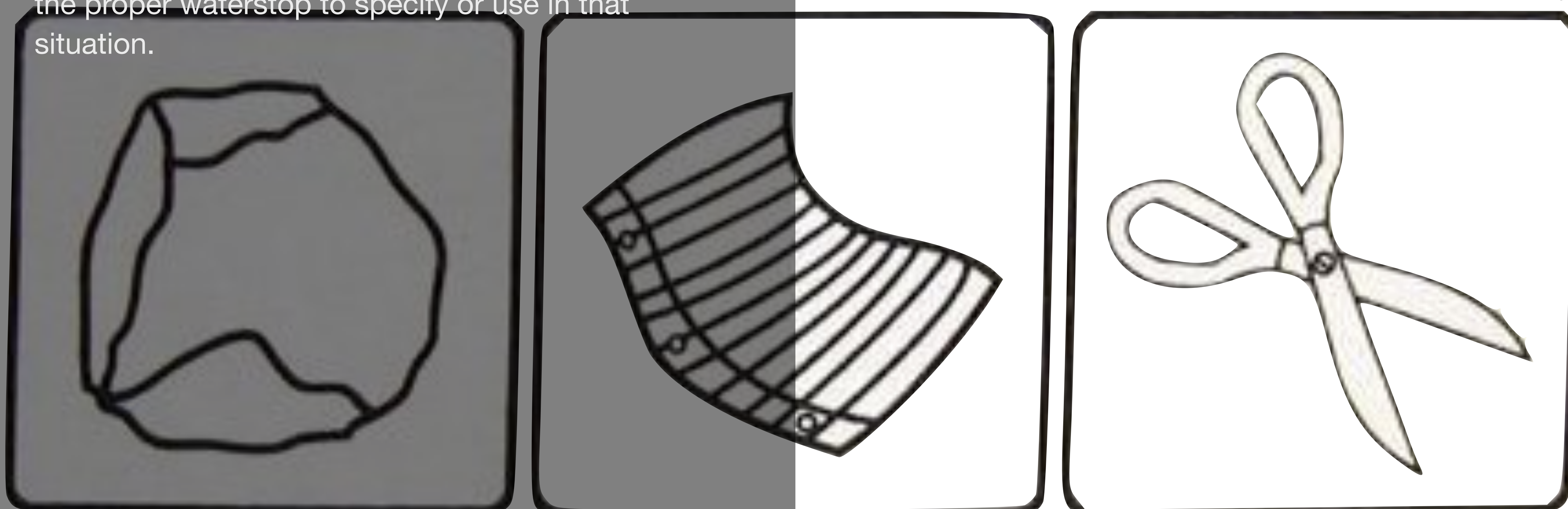
www.jpspecialties.com/sswaterstop.html

Chapter 5

Specific Applications for Waterstop

Different applications require different solutions. this chapter will give you some specific applications and the proper waterstop to specify or use in that situation.

"Choose Wisely"



Specific Applications for PVC Waterstop

Water and Wastewater Treatment Plants
More PVC waterstop is installed into this type of project than all the other types combined. As the population grows, so does the need for treated water and wastewater. PVC waterstop is ideally suited for wastewater, but not appropriate for all types of water treatment facilities (see Ozone Contactor Structure).

Dams, Locks, and Canals
Dams, locks, and canals were originally mostly metallic waterstops, but ever since the Ontario Hydro Study in 1954, PVC has become an acceptable material for these applications.

Gallery 5.1 PVC Waterstop Applications

Salt River Project — Theodore Roosevelt Dam was modified with concrete in 1995 by J.A. Jones Construction. Photo by U.S. Bureau of Reclamation (Bob Knotts 06/08/94).

Commercial Construction
Commercial construction is not too demanding as far as head pressure, corrosion, movement, and temperature. Because of this PVC or hydrophilic waterstop, or a combination of both products, it can be the right choice.

Swimming Pools and Fountains
PVC waterstop has the same basic chemistry as swimming pools, so from a chemical compatibility standpoint, it is the best choice of waterstop.

Water Tanks
PVC waterstop is the product of choice for water tanks. (Note, the need for NSF 61 certification for this application.)

Reverse Osmosis, UV Disinfection, and Micro-filtration
Although PVC is a poor choice for water treatment using ozone, it is an excellent choice for modern water treatment projects. Reverse osmosis, microfiltration, and nanofiltration force water through membranes with exceptionally small holes at high pressure. The membrane's holes are large

enough to let the water molecule pass but block the pathogen or salt molecule (see the movie at the right) depending on the process.

Movie 5.1 Reverse Osmosis

Modern water treatment plants use a variety of filter membranes to remove various molecules. Reverse osmosis is the process used to remove salt from water.

Specific Applications for Hydrophilic Waterstop

S

Light Commercial Construction
Commercial construction is not too demanding as far as head pressure, corrosion, movement, and temperature, and because of this PVC or hydrophilic waterstop, or a combination of both products, can be a good choice.

Swimming Pools and Fountains
Because hydrophilic waterstop requires a constant source of water in order to remain in its expanded (hydrophilic) state, a swimming pool or fountain is a great application, as the water is nearly always present. Furthermore, health and human safety are not generally affected should a leak occur.

Water Tanks
Because hydrophilic waterstop requires a constant water source to remain in its expanded (hydrophilic) state, a waters tank can be a great application, as the water is nearly always present. However, health and human safety are concerned with drinking water as few hydrophilic waterstops are certified safe in drinking water and carry NSF 61 certification.

Section 3

Specific Applications for Mastic Waterstop

Homebuilding
Residential construction is not too demanding as far as head pressure, corrosion, movement, and temperature, and because of this, mastic waterstop can be the right choice. Mastic waterstop is the country's leading homebuilders' preferred choice due to its application performance in this segment and its low cost.

Burial Vault Lids and Other Precast
Mastic waterstop can be used as a sticky, compression seal when installed in burial vault lids and other precast elements. The product adheres to the precast joint, and the lid is placed on top of it, squishing the rubbery material, and forming an excellent compression seal.

Section 4

Specific Applications for TPV Waterstop

Railroad and Airport Fuel Farms, Terminals, and Wash-down Stations

One of TPV waterstop's primary uses is as a fuel stop. Unlike PVC, Earth Shield® TPV waterstop contains no plasticizers to leach out when exposed to hydrocarbons, so it doe not become brittle and craze. Some swelling can occur, and a minimal amount of physical properties depreciate, but overall, Earth Shield® TPV is an excellent choice for these fuel-related applications.

Ozone Contactor Structure

In 1998 the U.S. EPA designated the pathogen cryptosporidium as harmful to human health and must be eradicated from the nation's drinking water supply and storage. Because PVC waterstops fail in high concentrations of ozone, other waterstops were needed to fill the void. Initially, stainless steel was the Engineer's choice material, but after rigorous testing, Earth Shield® TPV waterstop is now the primary chosen material for ozone contactor structures. Earth Shield® TPV waterstop is suitable for applications up to six parts per million ozone concentration.

Gallery 5.2 TPV Waterstop Applications

A Union Pacific Rail Road train can be seen behind this circular tank foundation that has TPV waterstop installed at it's base. When completed this tank will hold diesel fuel for locomotives. (UPRR Denison, TX. Photo by Tom Nelson.)

Mines and Minerals

Earth Shield® TPV Waterstop is installed worldwide in mines — from bauxite in Brazil to copper in Arizona and Australia. Earth Shield® TPV Waterstop has outstanding resistance to 98% sulfuric acid, making it the ideal choice for mines and their associated processes.

Pulp and Paper

Wood pulp is bleached to make paper. U.S. EPA's HazMat list regulates bleach (CFR 261). Earth Shield® TPV Waterstop is "A-rated" and tested per ASTM D-471 immersion testing in bleach, making it the perfect choice for today's pulp and paper plants.

Refineries and Basic Chemicals

Earth Shield® TPV Waterstop has broad-spectrum resistance to a variety of aqueous solutions and chemicals. Certified for most of the HazMat found in CFR 261. We maintain a large database of tested chemicals on-line that can be found here.

Other Applications
NSF 61 certified safe for drinking water, GreenSpec® Listed, PVC replacement, non-toxic, no BPAs, highest physical properties.

Section 5

Specific Applications for Metallic Waterstop

Ozone Contactor Structure

In 1998 the U.S. EPA designated the pathogen cryptosporidium as harmful to human health and must be eradicated from the nation's drinking water supply and storage. Because PVC waterstops fail in high concentrations of ozone, other waterstops were needed to fill the void. Initially, stainless steel was the Engineer's choice material, but after rigorous testing, Earth Shield® TPV waterstop is now the primary chosen material for ozone contactor structures. Earth Shield® stainless steel waterstop is suitable for applications beyond five parts per million ozone concentration.

Gallery 5.3 Metallic Waterstop Applications

The Tolt Water Treatment Plant in Washington state was retrofitted with an ozone contactor unit right after the law change in 1998 mandating the eradication of the pathogen Cryptosporidium form the water supply. Ozone is and effective agent for killing Cryptosporidium and other pathogens. Earth Shield stainless steel waterstop was installed throughout the contactor unit and attached mechanically to PVC waterstop in the clearwater structure. The author devised a mechanical connection joining the two materials.

LNG Facility

Liquefied natural gas, or LNG, is stored at a temperature of -162 °C (-260 °F). LNG storage tanks have double containers, where the inner contains LNG, and the outer container contains insulation materials. LNG is a cryogen, and is in its liquid state at subzero temperatures. The tank's temperature will remain constant if the pressure is kept constant by allowing the boil-off gas to escape from the container. This process is known as auto-refrigeration.

However, should LNG escape its primary vessel in a liquified form and penetrate the concrete joints, standard plastic waterstops will not be up to the task. Even Earth Shield® TPV Waterstop is only rated for -78°F temperature, causing cold crack of the plastic. It is for this reason that Earth Shield® Stainless Steel Waterstop be specified instead of TPV for LNG applications.

High Temperature

Earth Shield® TPV Waterstop can operate, in temperatures above 200°F, but become very soft at 300°F, and melt at 410°F. Therefore, for applications requiring high heat resistance, Earth Shield® Stainless Steel Waterstop should be specified and installed instead.

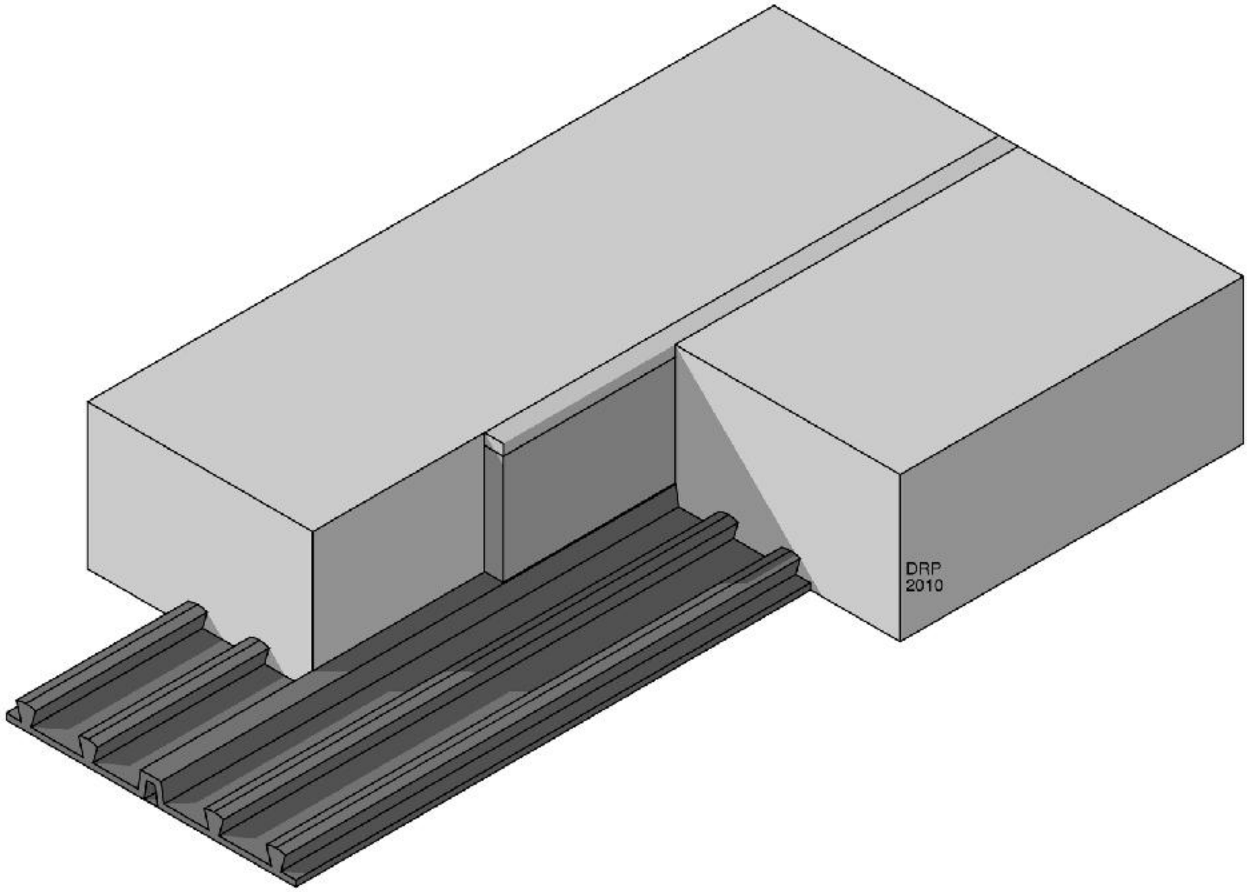
Chapter 6

Base Seal Waterstop

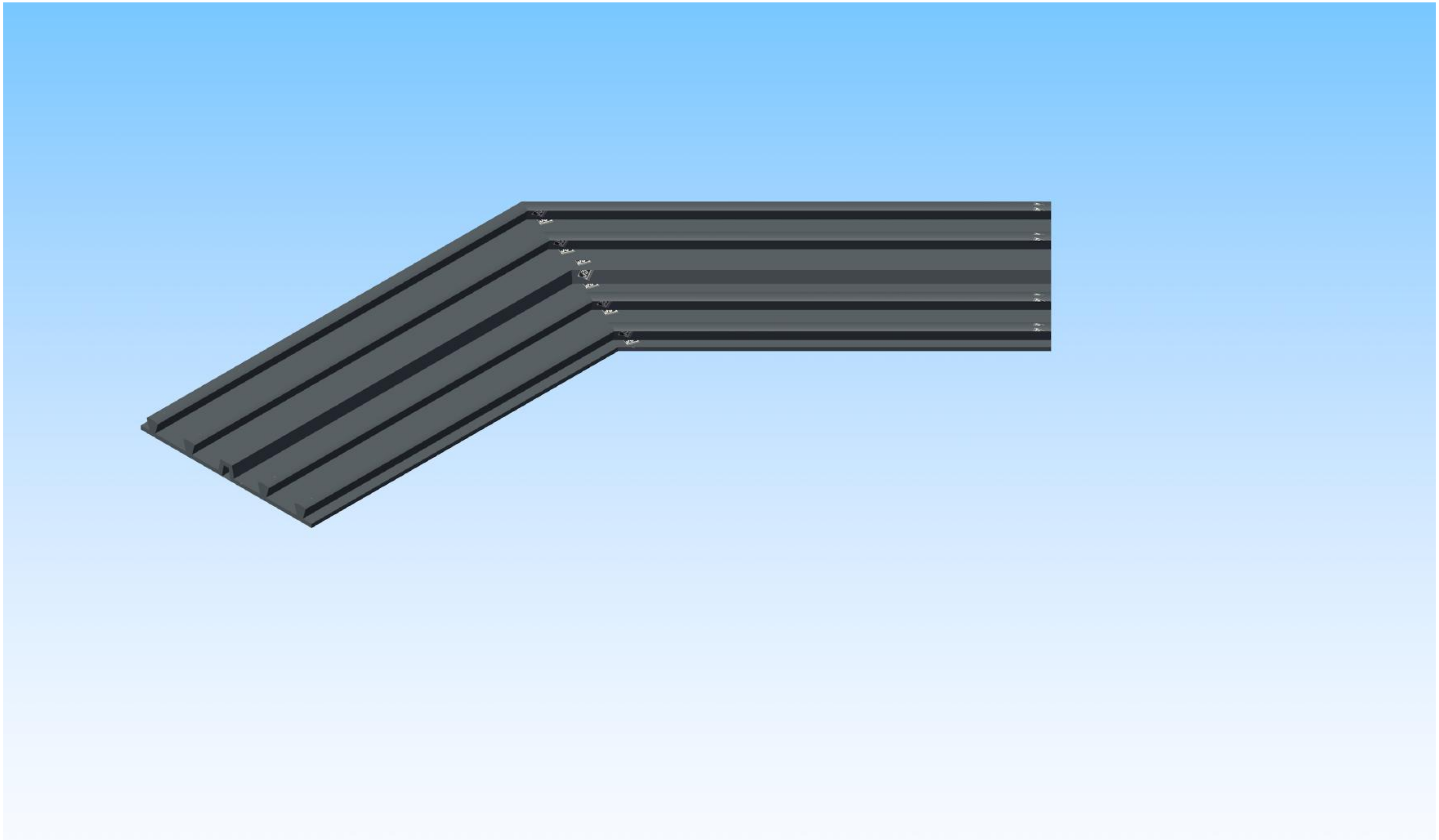
Base seal waterstop is ideal for flat pavement jobs such as runways and large containment slabs. Base seal waterstop is by far the easiest waterstop to install. Lay the waterstop directly on the compacted sub-grade, place and finish concrete, and create a control joint using a saw cut or another method. The profile provides a permanent, life-of-structure seal at the bottom of the joint. Base seal waterstop is suitable for construction, contraction (control), and expansion joints. Base seal waterstop should not be used on jobs that make interior wall transitions as the part is non-symmetrical and therefore, cannot function correctly. For considerable hydrostatic head pressures (>50 foot) ribbed centerbulb should be used instead.

Gallery 6.1 Base Seal and Base Seal Retrofit

JP621L installed around a trench at a large refinery in Saudi Arabia.



Gallery 6.2 JP211 Base Seal Waterstop (aka Rearguard) Typical Waterstop Fittings

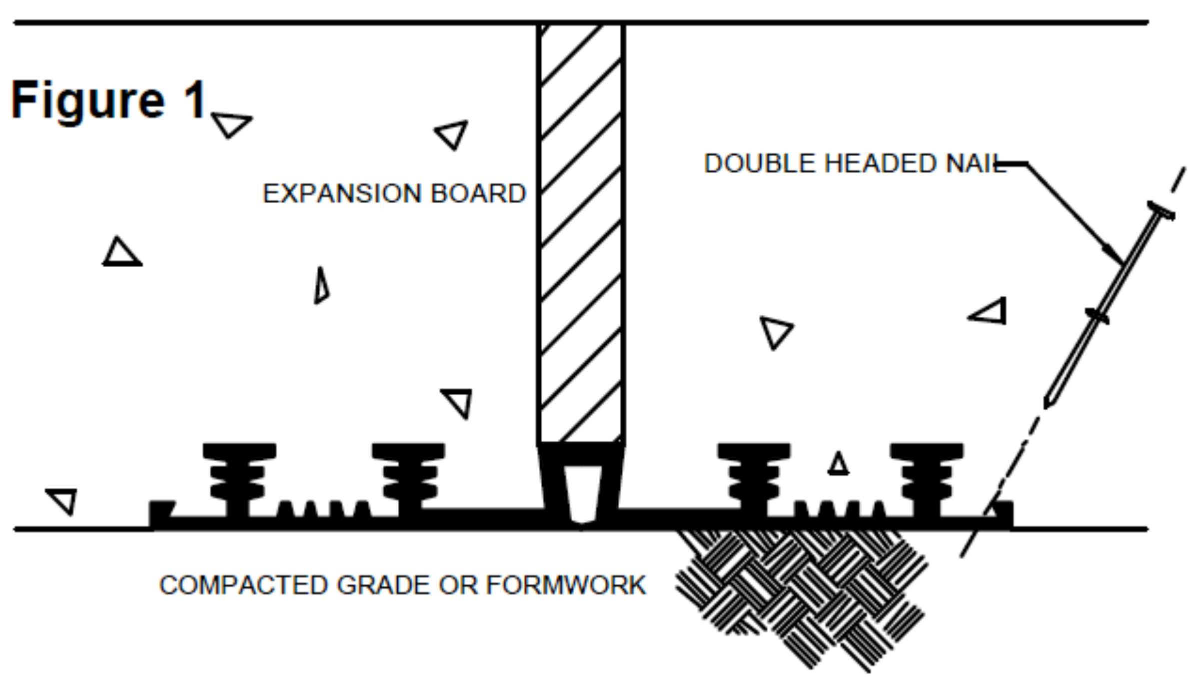


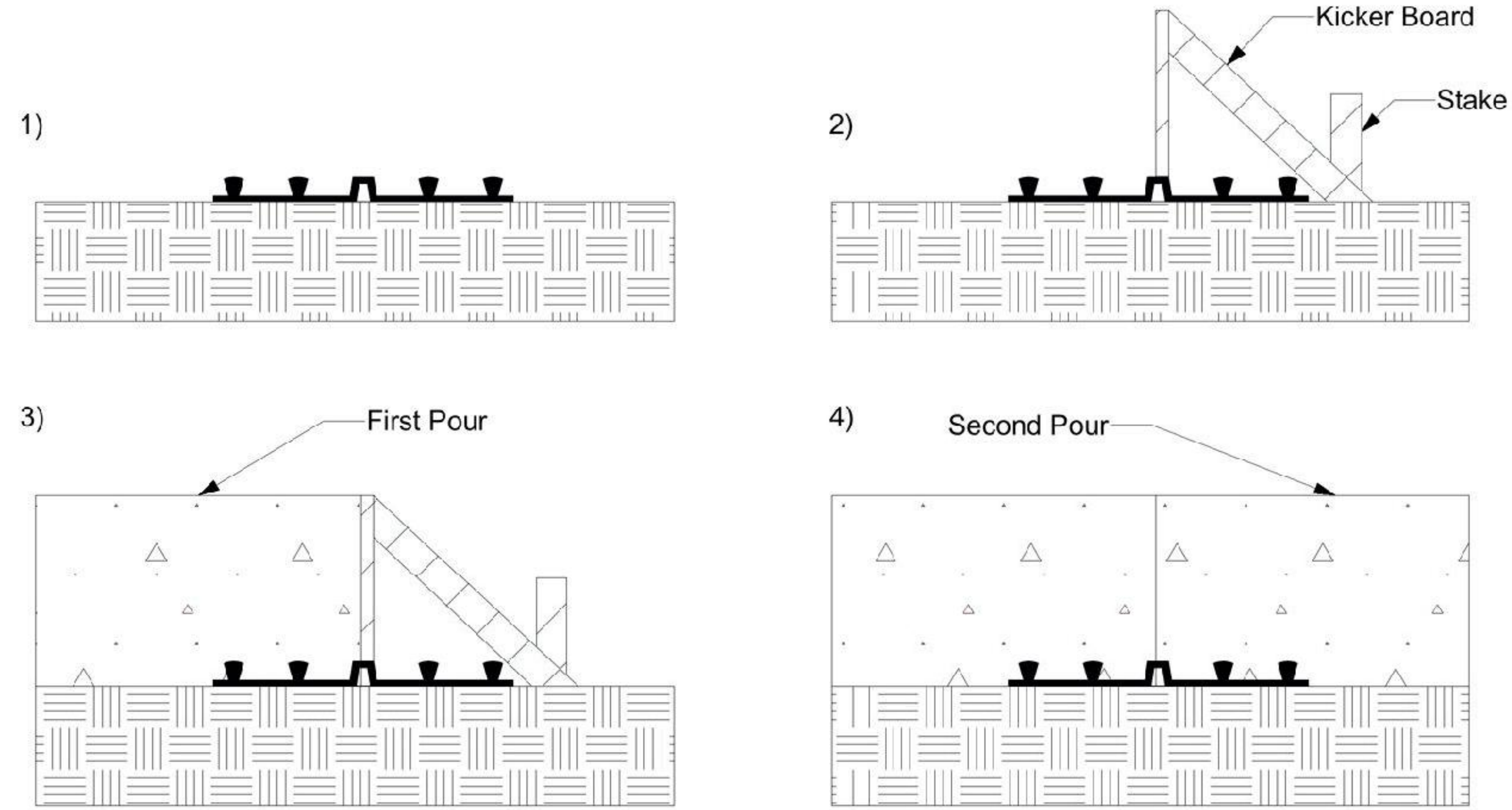
A variety of Earth Shield® Base Seal Waterstop fittings and photos.

Base Seal Waterstop Installation

Base seal type waterstops (sometimes referred to as externally placed waterstops or rearguard) are installed before placement of concrete and reside either on compacted grade, mud-slabs, or vertical formwork. Base seal waterstops are positioned such that only the ribbed side of the waterstop engages the concrete. The design of these waterstops eliminates the need for split forming. A solid backing is required for proper initial support as well as for in-service performance. Lack of support can lead to ballooning of the waterstop when exposed to high hydrostatic pressure. Base seal waterstops are secured in position by nailing or staking the outer edges of the profile to the underlying support, as shown in *Figure 1*. Doubled headed nails should be placed through the outer edges of the waterstop to secure the waterstop to the formwork. Larger nails or spikes should be used in securing the waterstop directly to compacted subgrade. The waterstop should be positioned such that the longitudinal centerline of the waterstop coincides with the protected joint. The outer side of the waterstop must be protected from potential mechanical damage or long-term exposure to ultra-violet light. Take great care in the placement of concrete to prevent movement or displacement of the waterstop.

Figure 1





JP Specialties, Inc. / Earth Shield® 551 Birch Street • Lake Elsinore, CA 92530 www.jpspecialties.com phone 800-821-3859 • International 951-674-6869 • fax 951-674-1315		
TITLE Base Seal Waterstop Installation		
PART NUMBER JP211	DRAWN BY DRP	DATE 04/13
CAD FILE NAME JP211 Installation	APPROVALS	SIZE A

Retrofit Base Seal Waterstop Installation

The below installation guidelines are applicable to the following Earth Shield® retrofit waterstop profiles:

- **Part No. JP621L** — 4-1/2” x 3/16” large movement retrofit, as manufactured by J P Specialties, Inc. (for joining concrete to existing surface; large shear movements) NSF

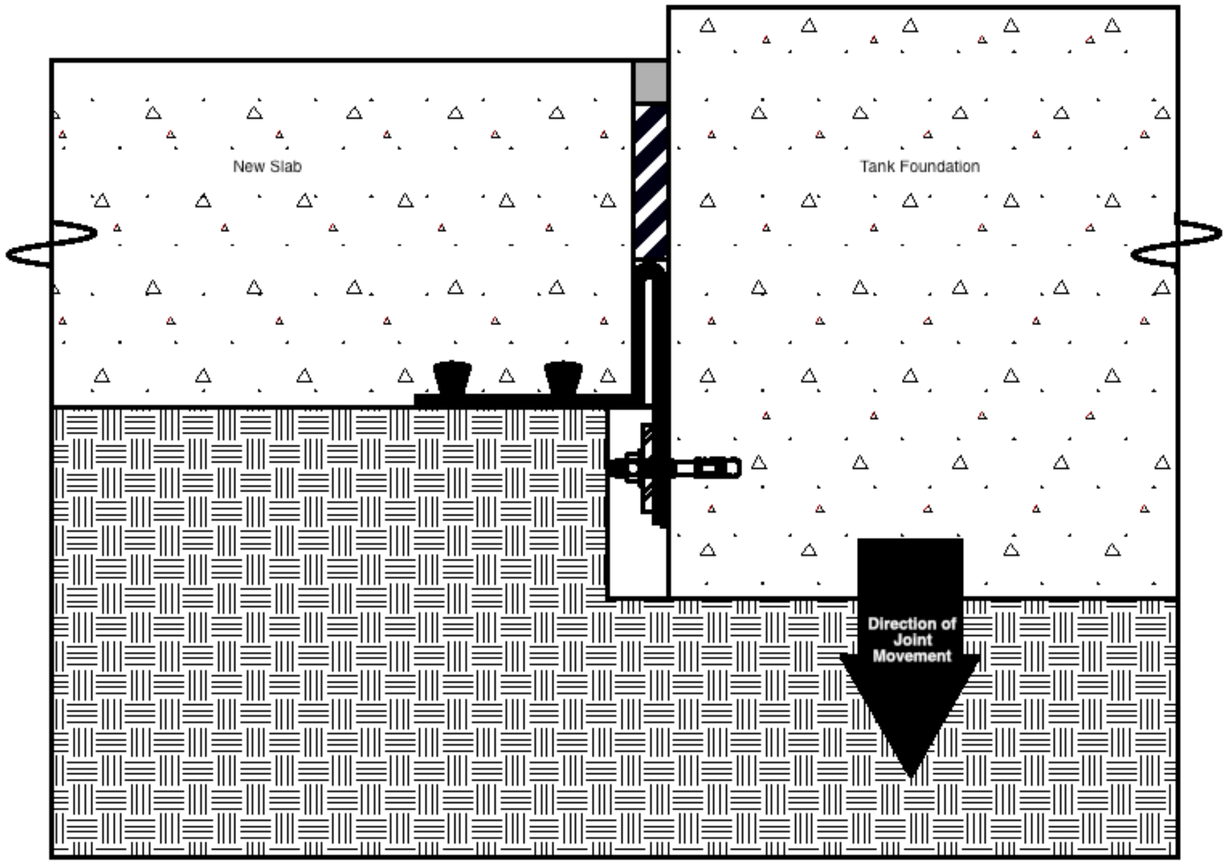
Properly installed retrofit, polymer waterstops rarely (if ever) fail from catastrophic failure, such as bursting under high hydrostatic stress. Furthermore, if properly installed, the centerbulb and tear web varieties can even accommodate fairly substantial joint movements. Unfortunately, there are far too few resources for the contractor in the field, and retrofit waterstops are frequently installed improperly.

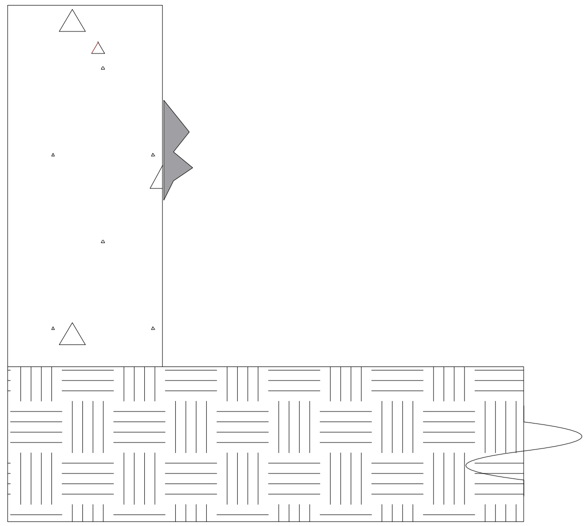
Preparation

1. **Uncoil waterstop 24 hours prior to installation for ease of handling and fabrication. (Plastics have a memory, and this will remove the curl from the waterstop.)**
2. **Position waterstop to ensure proper distance.**
3. **Protect waterstop from damage during progress of work.**
4. **Clean concrete joint after first pour to remove debris and dirt.**

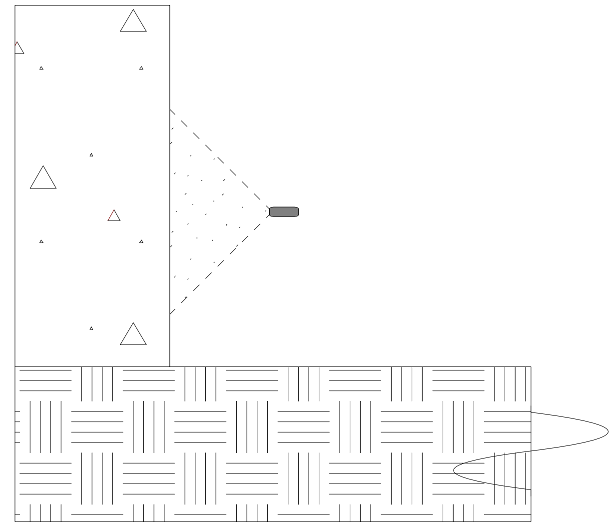
Examination/Inspection

1. **Prior to placement of concrete notify engineer for field inspection approval.**
2. **Inspect waterstop and field splices for defects.**
3. **Upon inspection of waterstop installation, replace any damaged or unacceptable waterstop and dispose of defective material.**

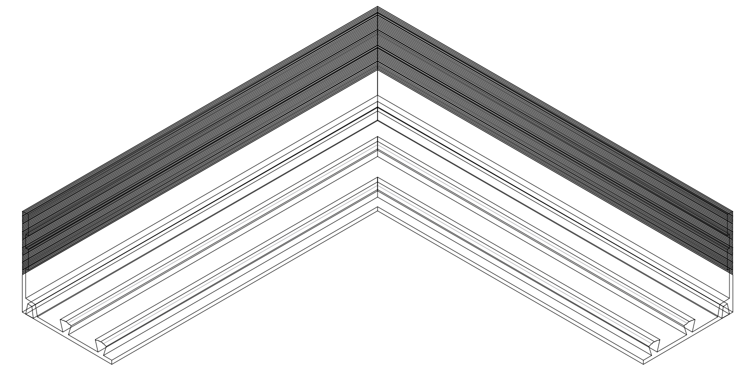




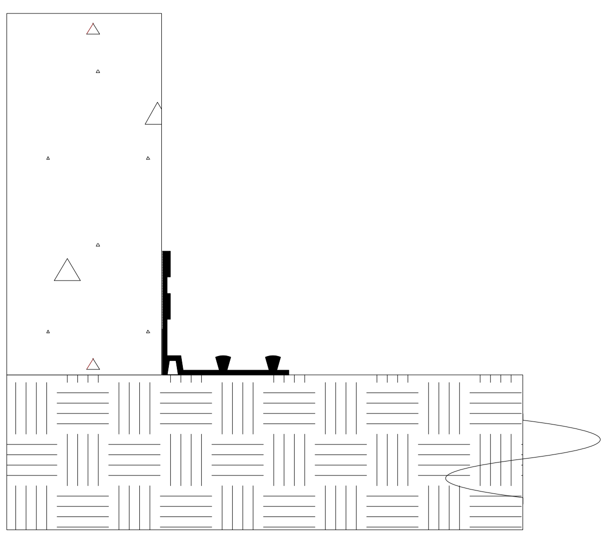
1) Prepare existing concrete by grinding away any irregularities.



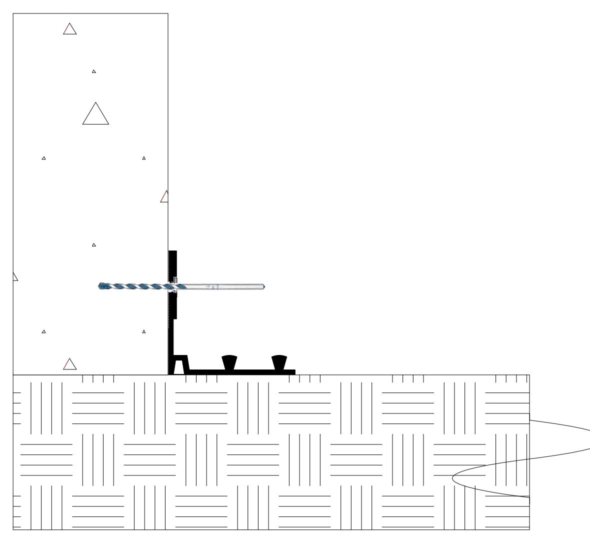
2) Thoroughly clean existing concrete using a wire brush, high pressure waterblast, or sand blast.



3) Heat weld waterstop profile to appropriate length and directional changes to fit concrete surface.



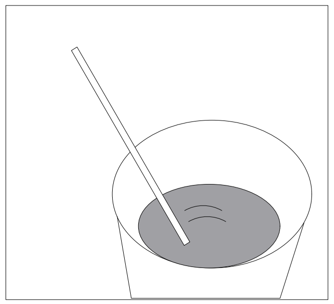
4) Check heat welded waterstop for proper location, orientation and fit.



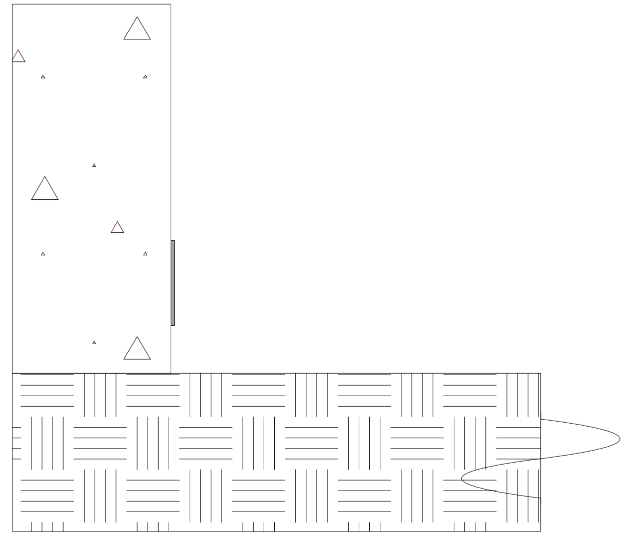
5) Using the prepunched stainless steel batten bar as a template, drill 1/4" holes 2-3/4" deep through waterstop and concrete. Clean out holes.

J P Specialties, Inc. / Earth Shield® Waterstop
25811 Jefferson Avenue, Murrieta, CA 92562
951-763-7077 • www.jpspecialties.com

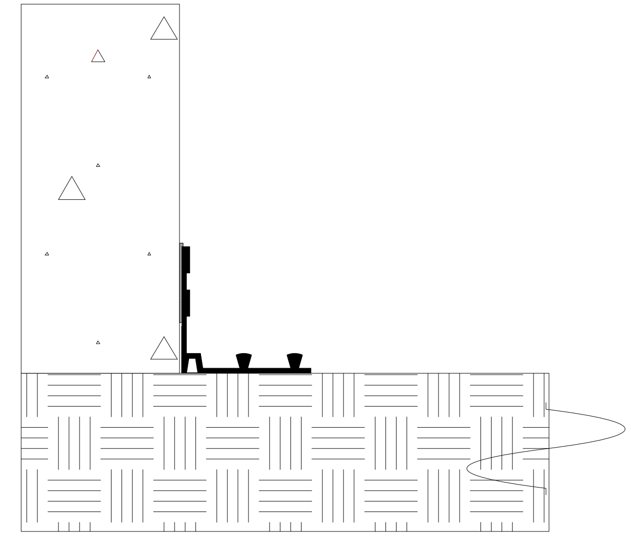
TITLE *JP216L Retrofit Install*		
PART NUMBER	DRAWN BY *DRP*	DATE *09/18*
CAD FILE NAME JP216L Retrofit Install	APPROVALS	SIZE **A**



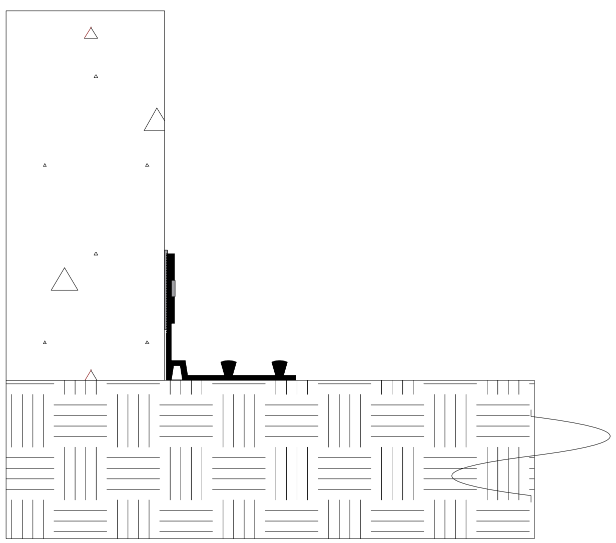
6) Mix appropriate amount of epoxy per mixing instructions on epoxy can.



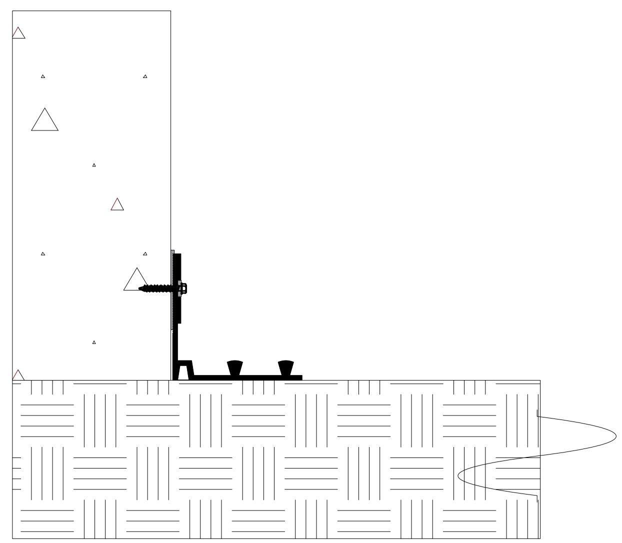
7) Place epoxy strip 1/8" deep by 3" wide on concrete surface at designated location.



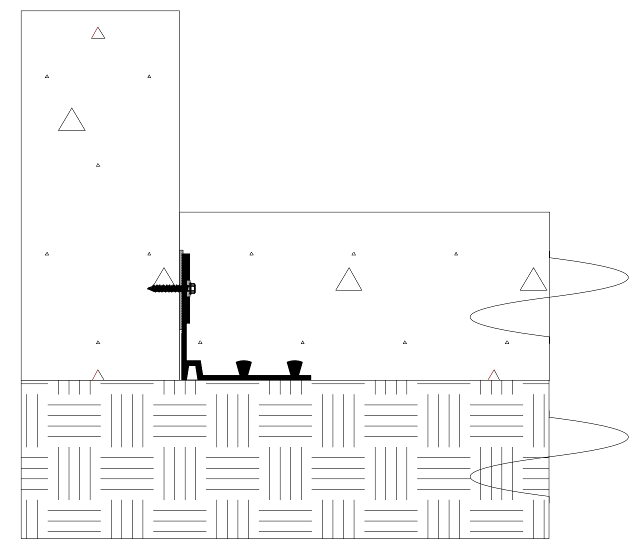
8) Embed waterstop into strips of uncured epoxy.



9) Place stainless steel batten bar in recesses of retrofit waterstop.



10) Install fasteners through predrilled holes in batten bar and waterstop and tighten as required.



11) Allow installed retrofit waterstop system to cure for 24 hours before placing the second pour of concrete.

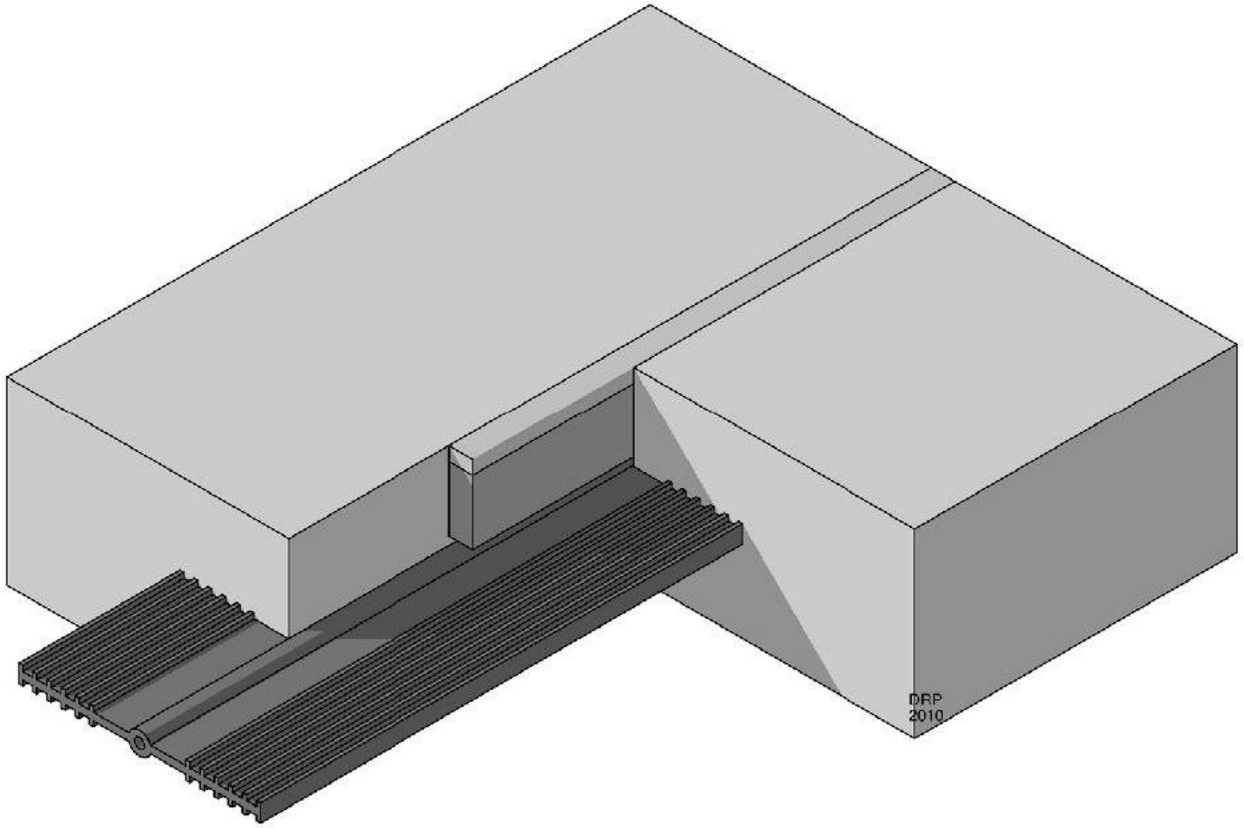
For welding, fabrication, placement, execution, and quality assurance please follow all procedures stated in Earth Shield® Master Specification Section 03250.

Chapter 7

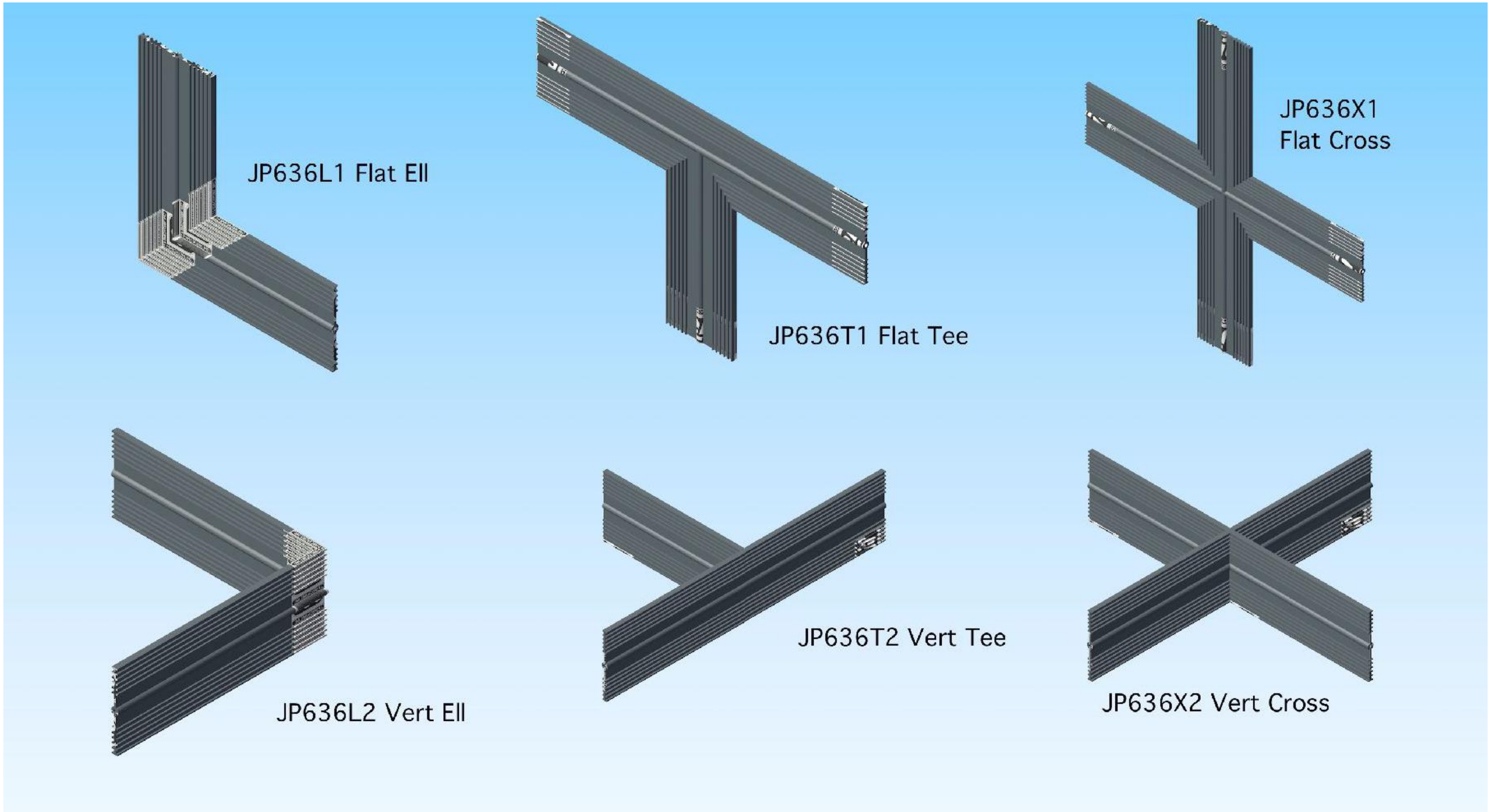
Ribbed Centerbulb Waterstop

Ribbed centerbulb is the most versatile type of waterstop available. The centerbulb accommodates lateral, transverse, and shear movement. The profile is appropriate in expansion, construction, and control joints. Superior anchoring abilities and a long fluid-flow path because of the multiple ribs on the exterior flanges. Under stress, the numerous ribs will distort less than a dumbbell type waterstop, because the pressure is first applied to the inward-most anchoring rib, and decreases to the subsequent ribs.

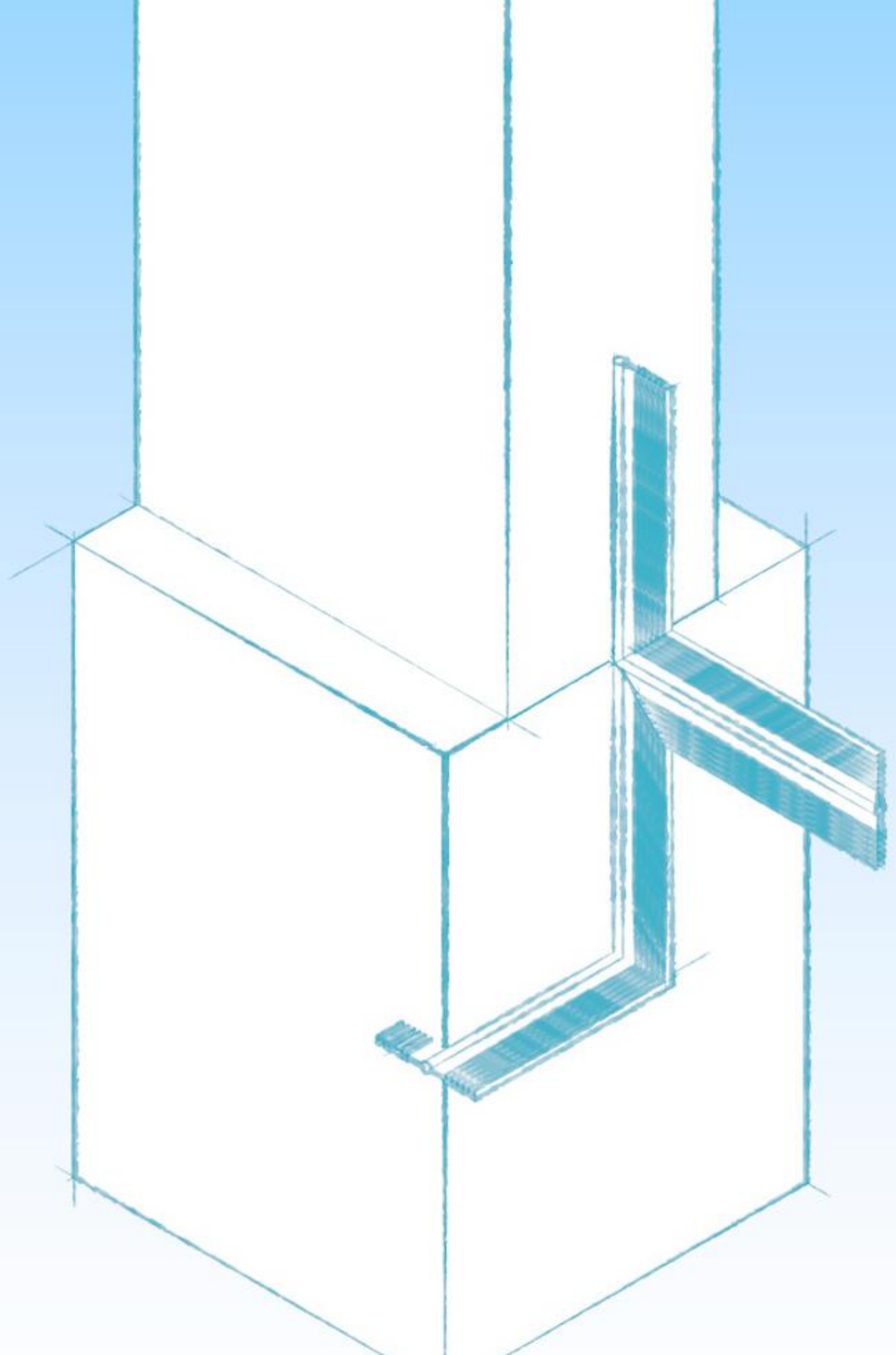
The centerbulb allows for joint movement beyond the ultimate elongation of the material (530%), without distorting the anchoring ribs. The centerbulb, coupled with our polymers' outstanding mechanical properties (ultimate elongation, tensile strength, etc.), provides for unsurpassed joint movement and sealing abilities. Like all our polymer waterstops, Earth Shield® ribbed centerbulb waterstop can be heat-welded using a standard waterstop splicing iron, allowing for easy field fabrications. Ribbed centerbulb waterstop functions as a continuous, homogeneous, fluid-tight diaphragm.



Gallery 7.1 Ribbed Centerbulb Waterstop Typical Waterstop Fittings



A variety of Earth Shield® Ribbed Centerbulb Waterstop fittings and photos.



Ribbed Centerbulb Waterstop Installation

The below installation guidelines are applicable to the following Earth Shield® ribbed centerbulb waterstop profiles:

Preparation

1. **Uncoil waterstop 24 hours prior to installation for ease of handling and fabrication. (Plastics have a memory, and this will remove the curl from the waterstop.**
2. **Position waterstop to ensure proper distance (See Installation step 3.)**
3. **Protect waterstop from damage during progress of work.**
4. **Clean concrete joint after first pour to remove debris and dirt.**

Examination/Inspection

1. **Prior to placement of concrete notify engineer for field inspection approval.**
2. **Inspect waterstop and field splices for defects.**
3. **Upon inspection of waterstop installation, replace any damaged or unacceptable waterstop and dispose of defective material.**

Installation

1. **Position waterstop in joint as indicated on drawings.**
2. **Center waterstop on joint, with approximately one-half of waterstop width to be embedded in concrete on each side of the joint. (If expansion joint, see step D.) Use split form installation method. — do not bend or fold waterstop flat against forms (See Figure 3).**
3. **Allow clearance between waterstop and reinforcing steel of a minimum of 1.5 times the largest aggregate size. Prevent rock pockets and air voids caused by aggregate bridging.**
4. **Ensure centerbulb is not embedded at expansion joints. Use the specified brand of expansion joint filler above and beneath the waterstop bulb.**
5. **Secure waterstop in correct position using optional factory-installed brass eyelets (See Figure 1, or JPS hog rings crimped between last two ribs on 12 inch maximum centers), and wire tie to adjacent reinforcing steel**
6. **Carefully place concrete without displacing waterstop from proper position. (If Installation step 5 is followed, this will not be a problem.)**
7. **Thoroughly and systematically vibrate concrete in the vicinity of the joint, and to maximized intimate contact between concrete and waterstop. (Pay particular attention to the area beneath the waterstop leg.)**

8. After first pour, clean unembedded waterstop leg to ensure full contact of second concrete pour. Remove laitance, spillage, form oil and dirt.

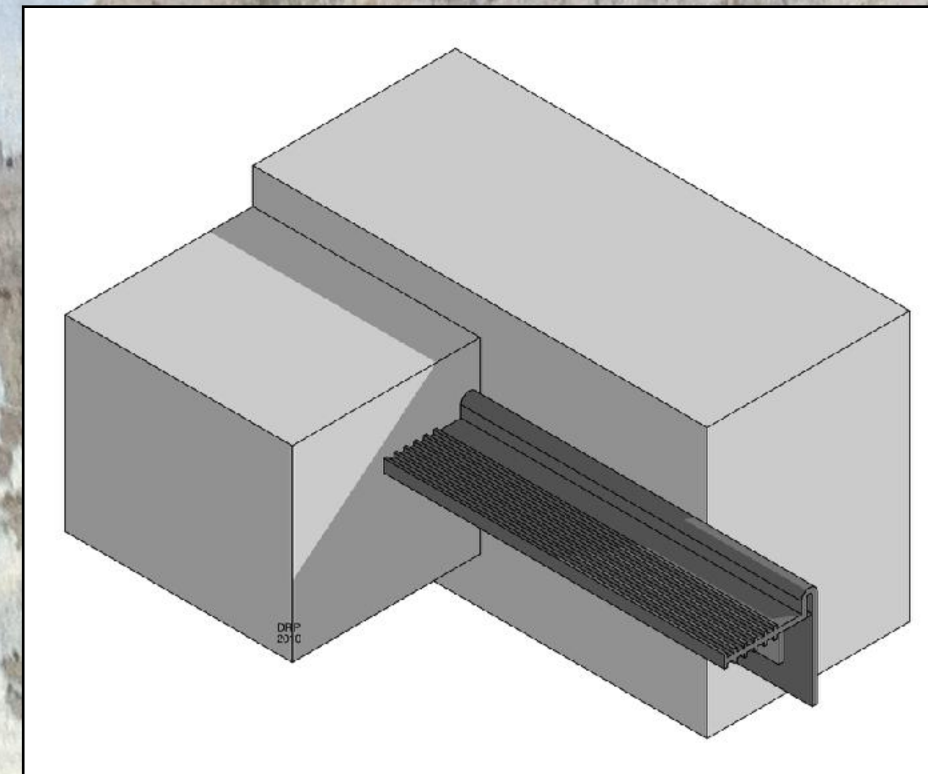
9. Repeat all steps for the second pour.

Movie 7.1 Properly Vibrate the Concrete

Thoroughly and systematically vibrate concrete in the vicinity of the joint, and to maximized intimate contact between concrete and waterstop

Chapter 8

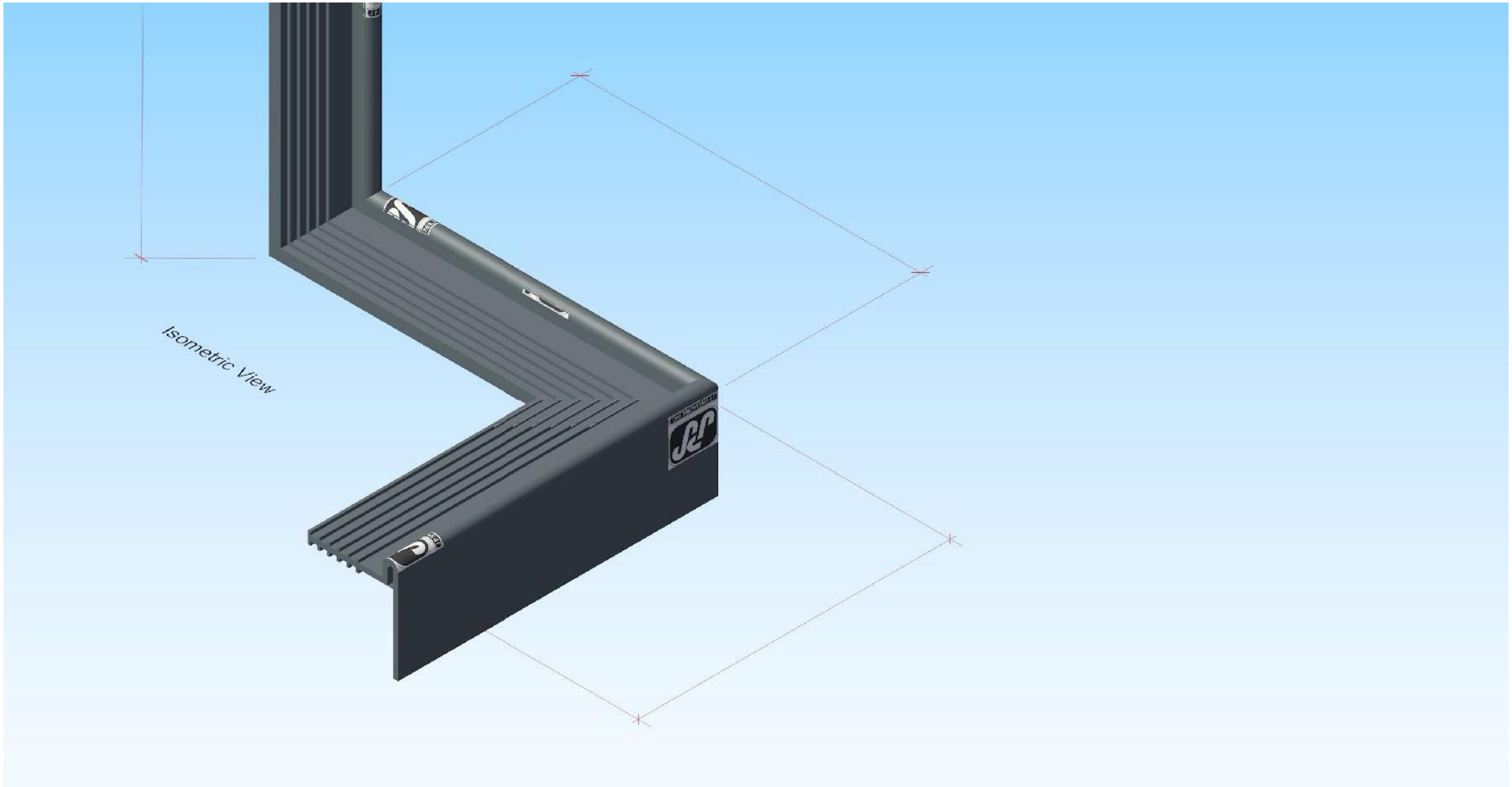
Retrofit Waterstop



Retrofit waterstop joins new concrete to existing construction. It is a versatile waterstop for many situations, including slab to wall, wall on slab, foundations, pilasters, columns, tank pads, containment curbs, others. Profiles are available for moving and non-moving joints.

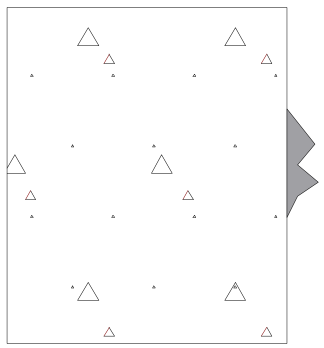
Retrofit waterstop provides a fluid-tight seal between existing and new concrete construction, without resorting to the labor-intensive and structurally destructive saw-cut-and-grout method. It is ideal for constructing a new containment curb or wall to an existing slab or joining a new slab to an existing wall. Unique profile fabrications are available for columns and pipe penetrations. All of our retrofit waterstops are sold as a complete system and include all the necessary stainless steel bars and bolts. We also offer a high-quality chemical resistant novolac epoxy — VEN 1000. Earth Shield retrofit waterstops are manufactured with our proprietary thermoplastic vulcanizate compound, which provides for unsurpassed chemical resistance. Like all our thermoplastic vulcanizate waterstops, Earth Shield retrofit waterstop can be heat-welded using a standard waterstop splicing iron. This profile allows for easy field fabrications and allows the waterstop to function as a continuous, homogeneous, fluid-tight diaphragm.

Gallery 8.1 Retrofit Waterstop Typical Fittings

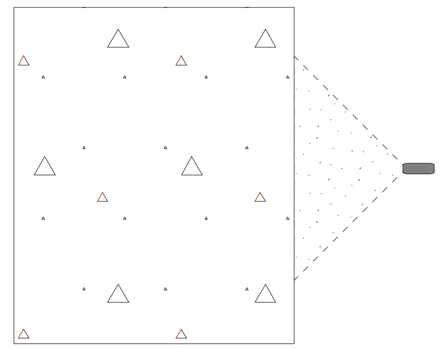


A variety of Earth Shield® Retrofit Waterstop fittings and photos.

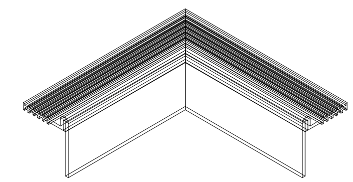
Typical Retrofit Waterstop Installation



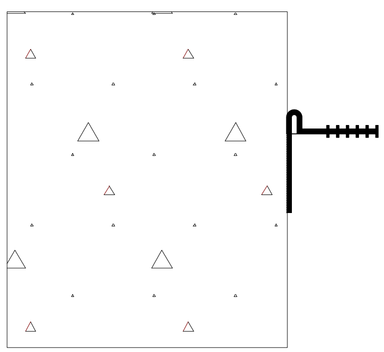
1) Prepare existing concrete by grinding away any irregularities.



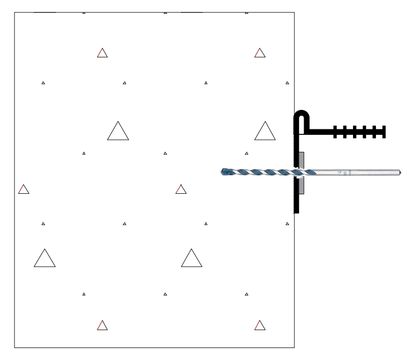
2) Thoroughly clean existing concrete using a wire brush, high pressure waterblast, or sand blast.



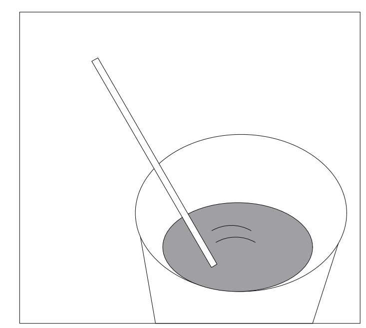
3) Heat weld waterstop profile to appropriate length and directional changes to fit concrete surface.



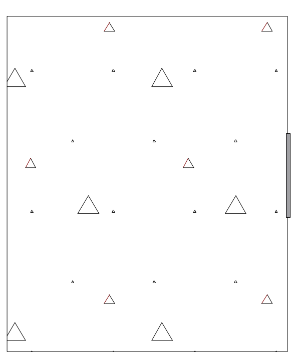
4) Check heat welded waterstop for proper location, orientation and fit.



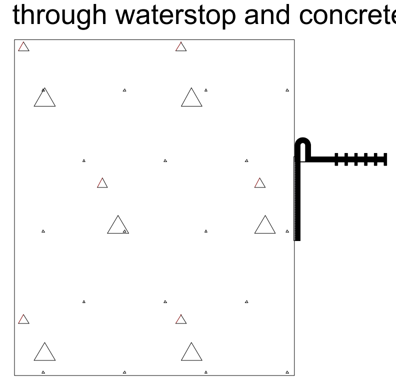
5) Using the prepunched stainless steel batten bar as a template, drill 1/4" holes 2-3/4" deep through waterstop and concrete. Clean out holes.



6) Mix appropriate amount of epoxy per mixing instructions on epoxy can.



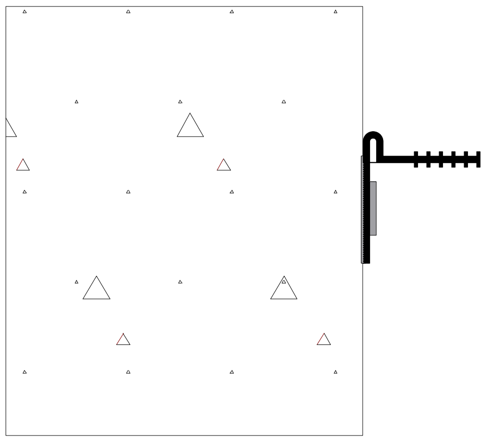
7) Place epoxy strip 1/8" thick by 3" wide on concrete surface.



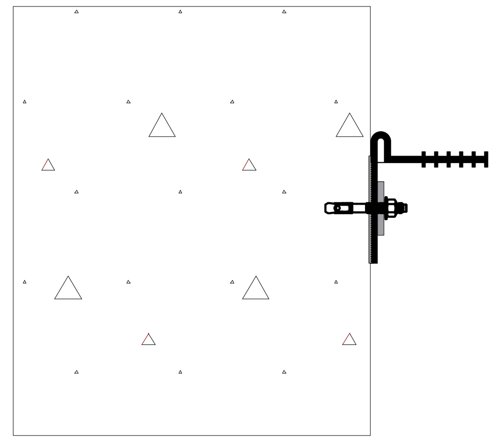
8) Embed waterstop into strip of uncured epoxy.

J P Specialties, Inc. / Earth Shield® Waterstop
25811 Jefferson Avenue, Murrieta, CA 92562
951-763-7077 · www.jpspecialties.com

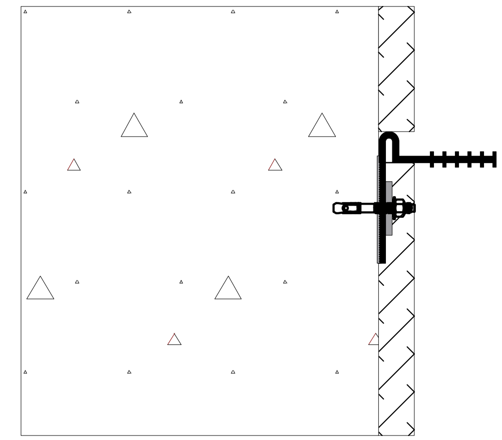
TITLE		
L-Shaped Retrofit Install		
PART NUMBER	DRAWN BY DRP	DATE 09/18
CAD FILE NAME L-Shaped Retrofit Install	APPROVALS	SIZE A



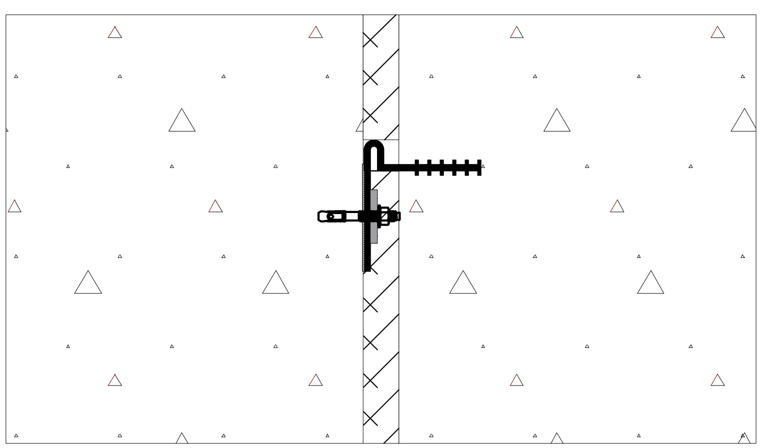
9) Place stainless steel batten bar against flat leg of waterstop.



10) Hammer stainless steel wedge anchors into drilled holes, passing anchor through batten bar, waterstop and epoxy gel bed. Repeat for all holes. Tighten anchor bolts.

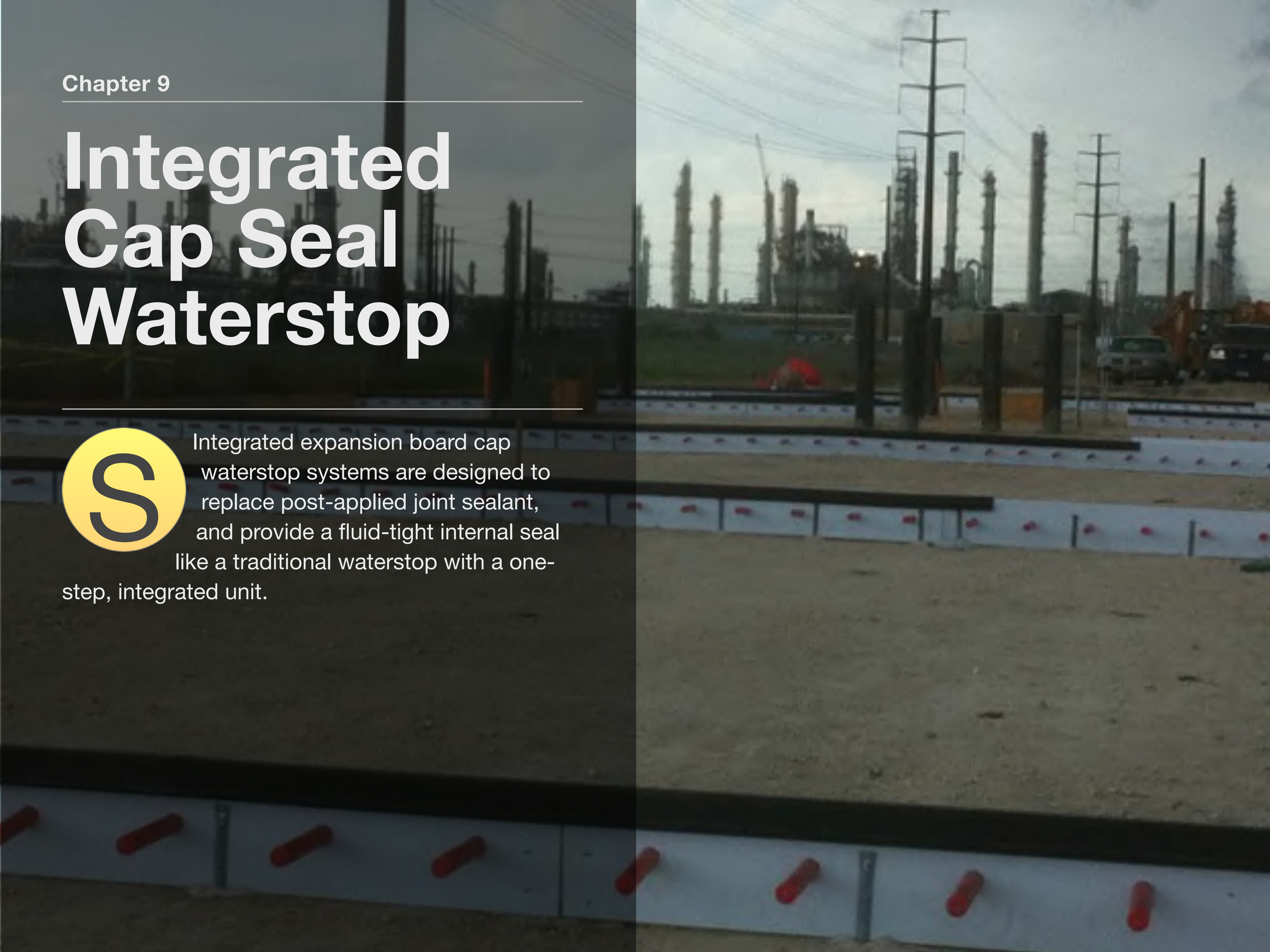


11) If expansion joint install expansion joint filler above and beneath waterstop embedment leg.



12) Allow installed retrofit waterstop system to cure for 24 hours before placing the second pour of concrete.

For welding, fabrication, placement, execution, and quality assurance please follow all procedures stated in Earth Shield® Master Specification Section 03250.



Chapter 9

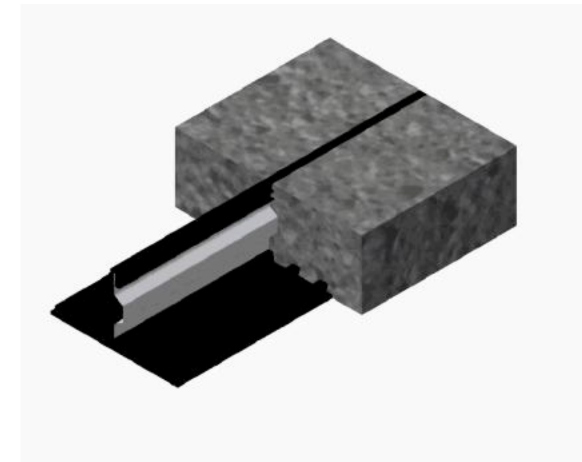
Integrated Cap Seal Waterstop

S

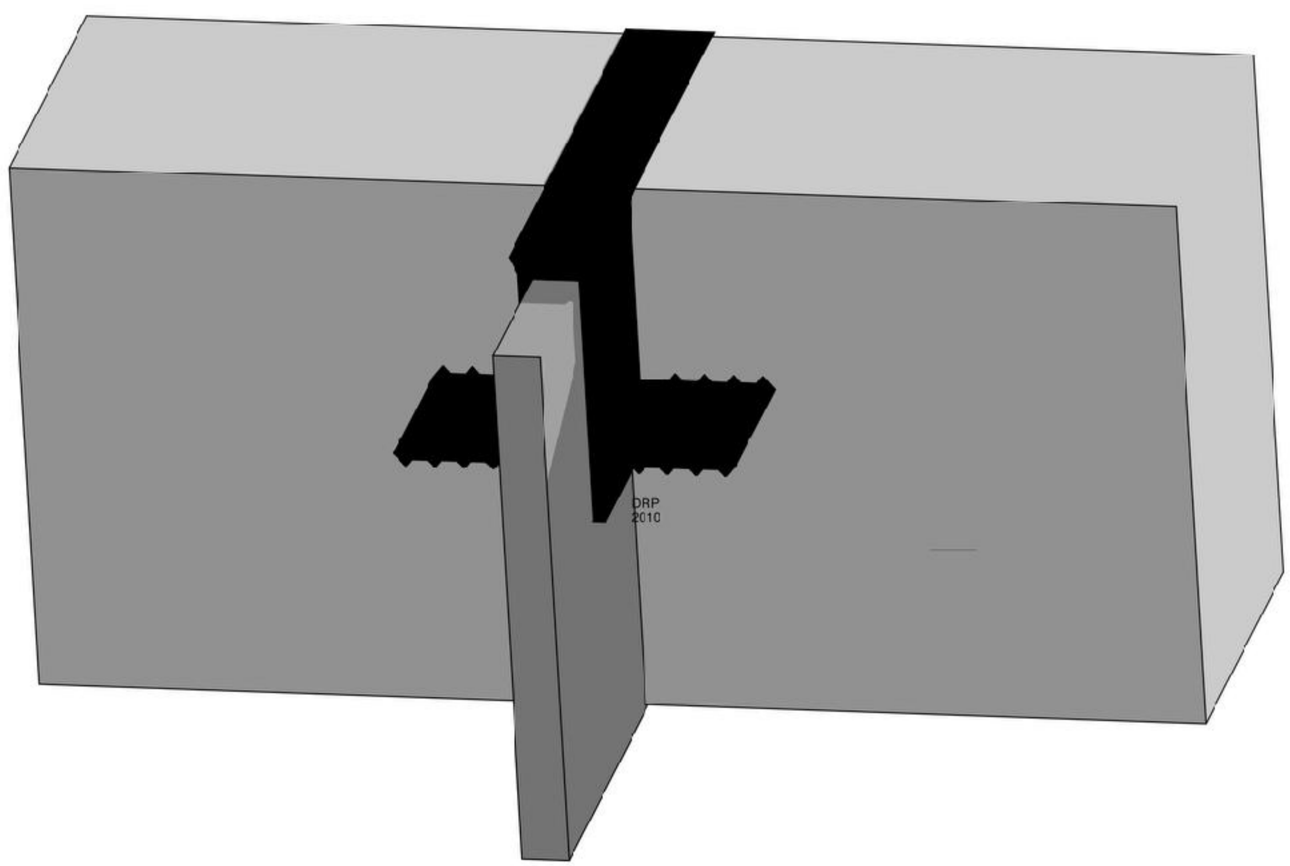
Integrated expansion board cap waterstop systems are designed to replace post-applied joint sealant, and provide a fluid-tight internal seal like a traditional waterstop with a one-step, integrated unit.

Earth Shield expansion board cap waterstop installs on top of conventional expansion board filler or Earth Shield's chemical resistant, plastic expansion board. The expansion board acts as the form; therefore, no form splitting is necessary. This installation dramatically accelerates the project schedule and provides a long-lasting, attractive finished concrete joint. Earth Shield screed key cap slides over the top of the metal screed key, eliminating the need for sealant. Like all our thermoplastic vulcanizate waterstops, Earth Shield integrated cap system waterstop can be heat-welded using a standard waterstop splicing iron. This allows for easy field fabrications and allows the waterstop to function as a continuous, homogeneous, fluid-tight diaphragm.

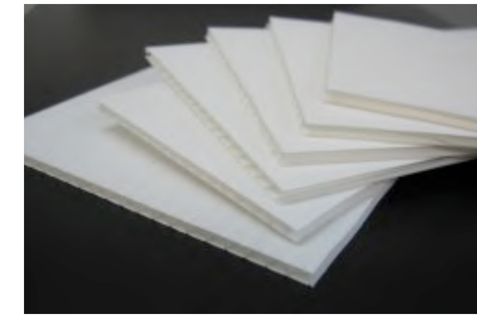
Movie 9.1 JP158 and JP211



JP158 creates the perfect sealant when installed in conjunction with metal keyway and JP211 base seal waterstop.

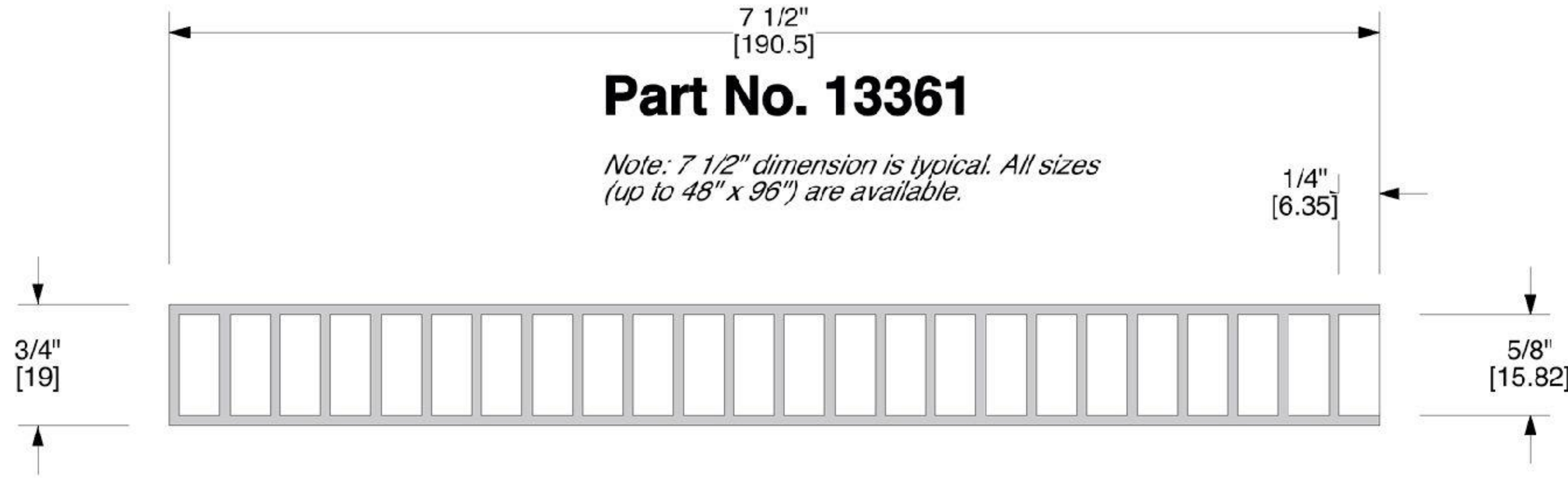


Earth Shield® Expansion Board Cap Waterstop is installed on top of conventional expansion board filler or Earth Shield's own chemical resistant, plastic expansion board. The expansion board acts as the form; therefore, no form splitting is necessary. This greatly accelerates the project schedule and provides a long lasting, attractive finished concrete joint.

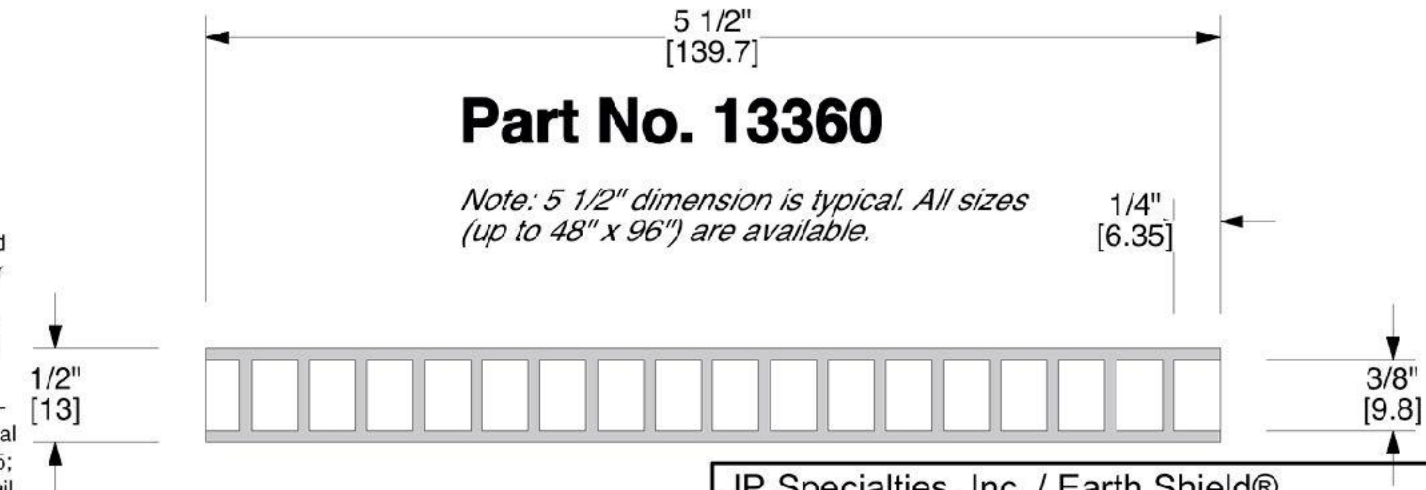


13360 — .50" x 48" x 96" board; factory cut to desired depth at no charge to customer

13361 — .75" x 48" x 96" board; factory cut to desired depth at no charge to customer



Density, g/cc ASTM-D782A-2	0.9
Notched Izod Impact (FT-lbs/in.) ASTM-D256-A @ 70 degrees F	3
Tensile Strength at Yield (psi units) ASTM-D638 2in/min.	4000
Elongation at yield (%)	10
Deflection Temp. degrees F 66psi	194
Water Absorption - 24 hrs, % ASTM-D570	0.02
Falling Weight Impact Strength @ -29degree F (ft.lbs.)	23



Suggested Short Form Spec

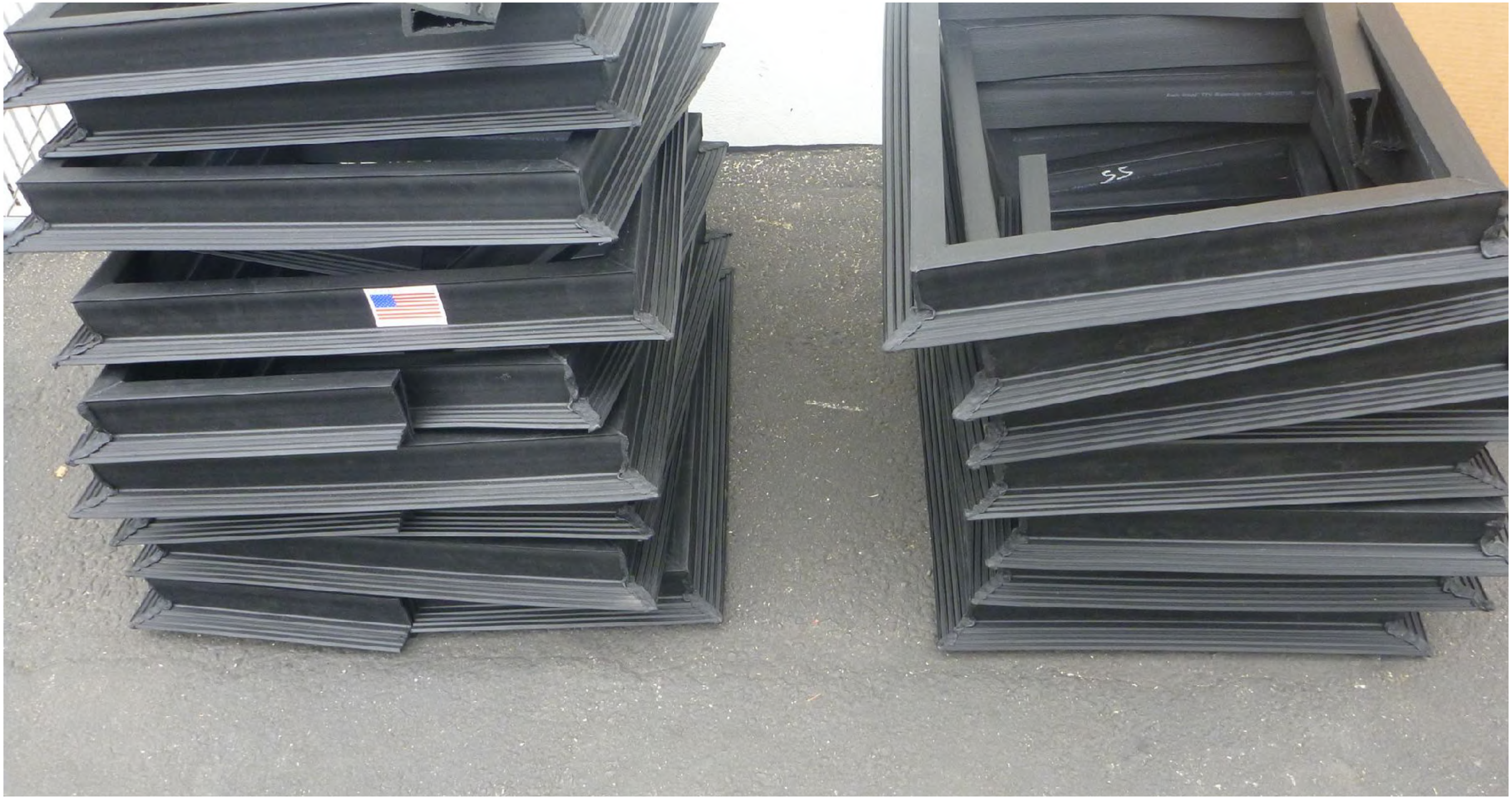
Chemical Resistant Plastic Expansion Board
Plastic expansion board indicated in drawings and specifications for expansion and joints to be Earth Shield® Polypropylene (PP) **Part No. ####** as manufactured by **JP Specialties, Inc.** - 551 Birch Street, Lake Elsinore, CA 92530 - Phone 888-836-5778; International 951-674-6869; Fax 951-674-1315; Web www.earthshield.com; E-mail davidp@earthshield.com

1. All material is certifed inert and hydrophobic (therefore it will not affect the pH level of the fluid it contacts).
2. Certified chemical resistance to acids, alkalies, salt solutions, solvents, alcohol, water, oil, fat, and detergents at room temperature.
3. No equals or substitutions allowed.

J P SPECIALTIES, INC.

JP Specialties, Inc. / Earth Shield®		
TITLE *Plastic Expansion Board*		
PART NUMBER 13360 & 13361	DRAWN BY DRP	DATE 11/07
CAD FILE NAME Plastic Expansion Board	APPROVALS	SIZE **A**

Gallery 9.1 Integrated Cap Seal Waterstop Typical Fittings

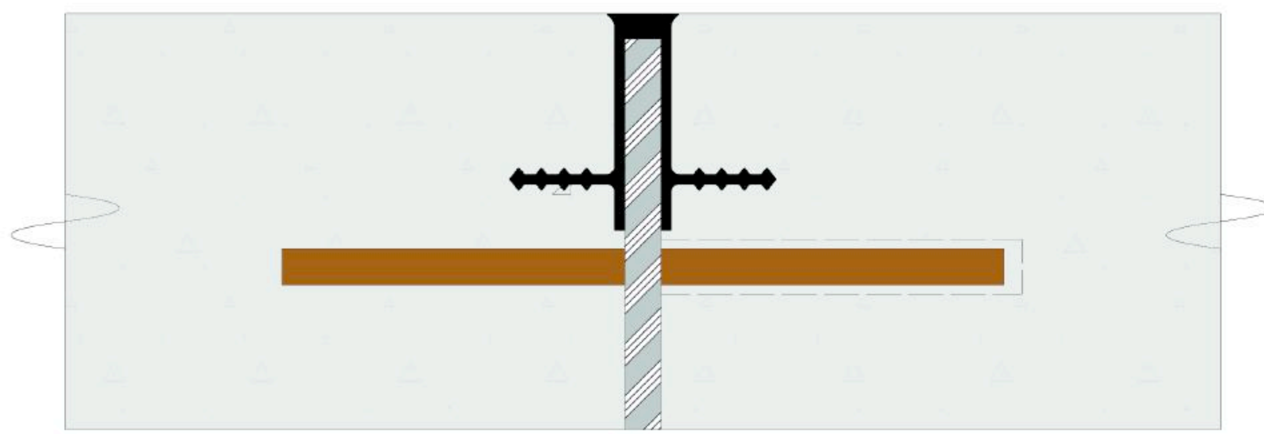


A variety of Earth Shield® Integrated Cap Seal Waterstop fittings and photos.

Integrated Cap Seal Waterstop Installation

Earth Shield® Expansion Board Cap Waterstop (JP EB350, JP EB375) Installation Guidelines

1. Place the JP EBCapstop over the top of the expansion board.
2. Securely fasten the JP EBCapstop the expansion board so that the JP EBCapstop is flat against the header board. Any kinks in the JP EBCapstop should be straightened out before it is fastened to the header board. The JP EBCapstop should be mechanically fastened (nails or staples) below the flange.
3. The fastening devices should be placed every 6" to 12" on center to maintain the alignment of the JP EBCapstop along the header board. For the best protection against liquid penetration, care should be taken to not tear or puncture the JP EBCapstop above the flange.
4. Pour the concrete and screed to the top of the JP EBCapstop. It is imperative that the concrete totally encapsulates the flange in order to eliminate any voids or honeycombing below the flange and to form a liquid tight barrier. Care should be taken if the concrete is vibrated or rodded to avoid damaging the JP EBCapstop.
5. The concrete should be vibrated, or thoroughly rodded, near the joints to insure proper consolidation around and under the flanges.

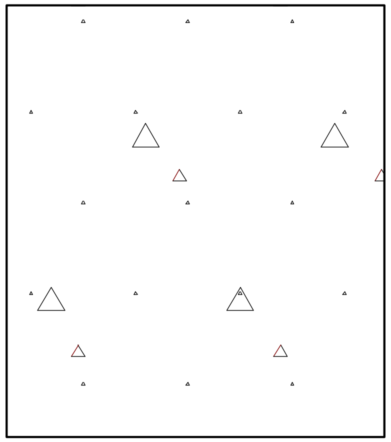


Note:

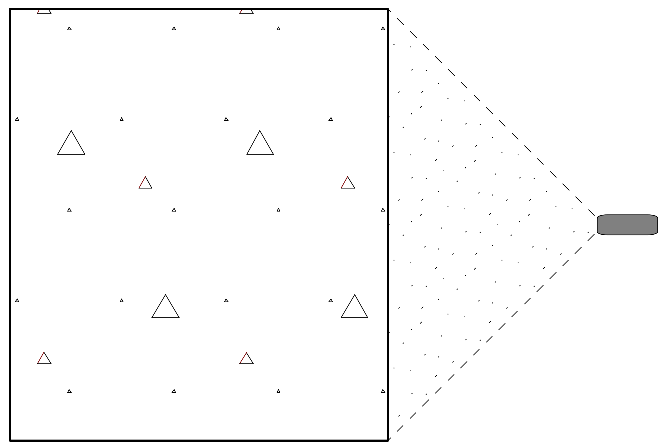
1. *It is imperative that the concrete not be subjected to loads until it has reached the rated strength per the design requirements (minimum 3,000-psi).*
2. *When pouring concrete in a checkerboard pattern the exposed edge of the expansion board must be protected from traffic and abuse. Driving over exposed header boards will initiate cracking. i.e. It is not good practice to drive over the header board onto or off of the poured slab. Doing so may cause cracking, even if the concrete has reached its design strength (3,000-psi minimum).*
3. *Loads that exceed the rated strength of the concrete shall not be allowed. If cranes are to be used for tilt-up construction, the weight of the crane must be considered in the concrete strength specification.*

For welding, fabrication, placement, execution, and quality assurance please follow all procedures stated in Earth Shield Master Specification Section 03250.

Integrated Cap Seal Retrofit Waterstop Installation

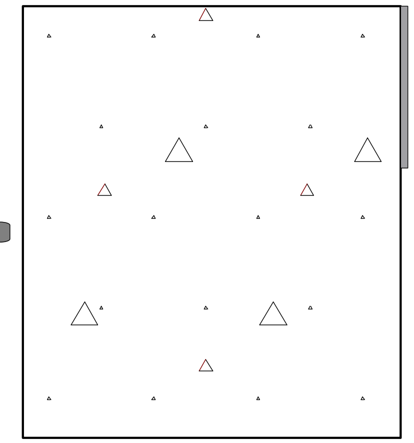


1) Existing Concrete — Prepare existing concrete by grinding away any irregularities.

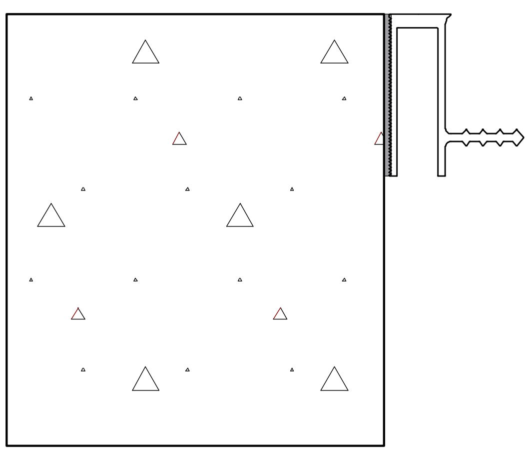


2) Thoroughly clean existing concrete using:

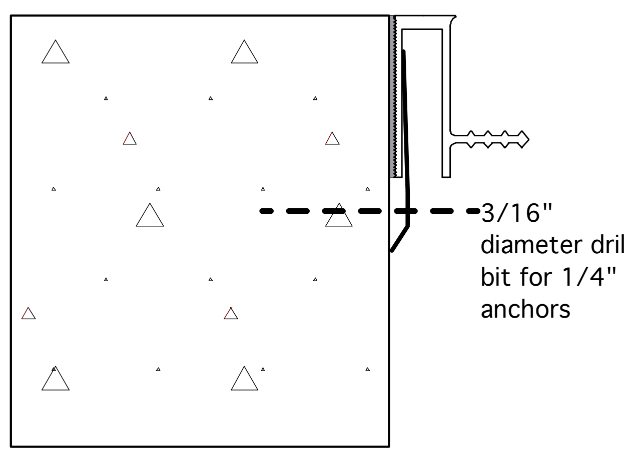
A. Wire brush or needle gun
B. High pressure water blast
C. Sand blast



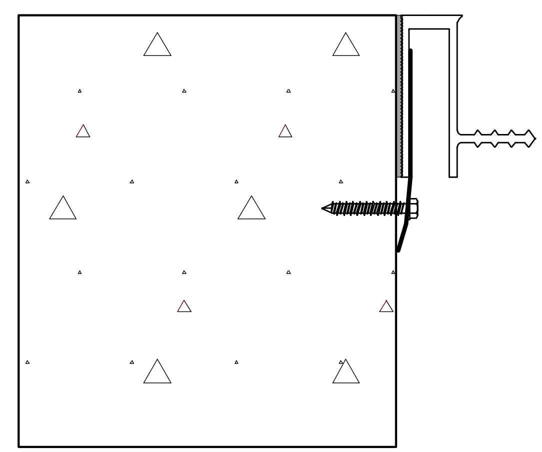
3) Place epoxy strip 1/8" thick by 3" wide on concrete surface.



4) Embed prefabricated retrof t waterstop into strip of uncured epoxy.



5) Drill fastener holes into concrete to appropriate depth, using stainless steel batten bar against retrof t waterstop as a template. Anchor holes should be drilled through every batten bar hole.



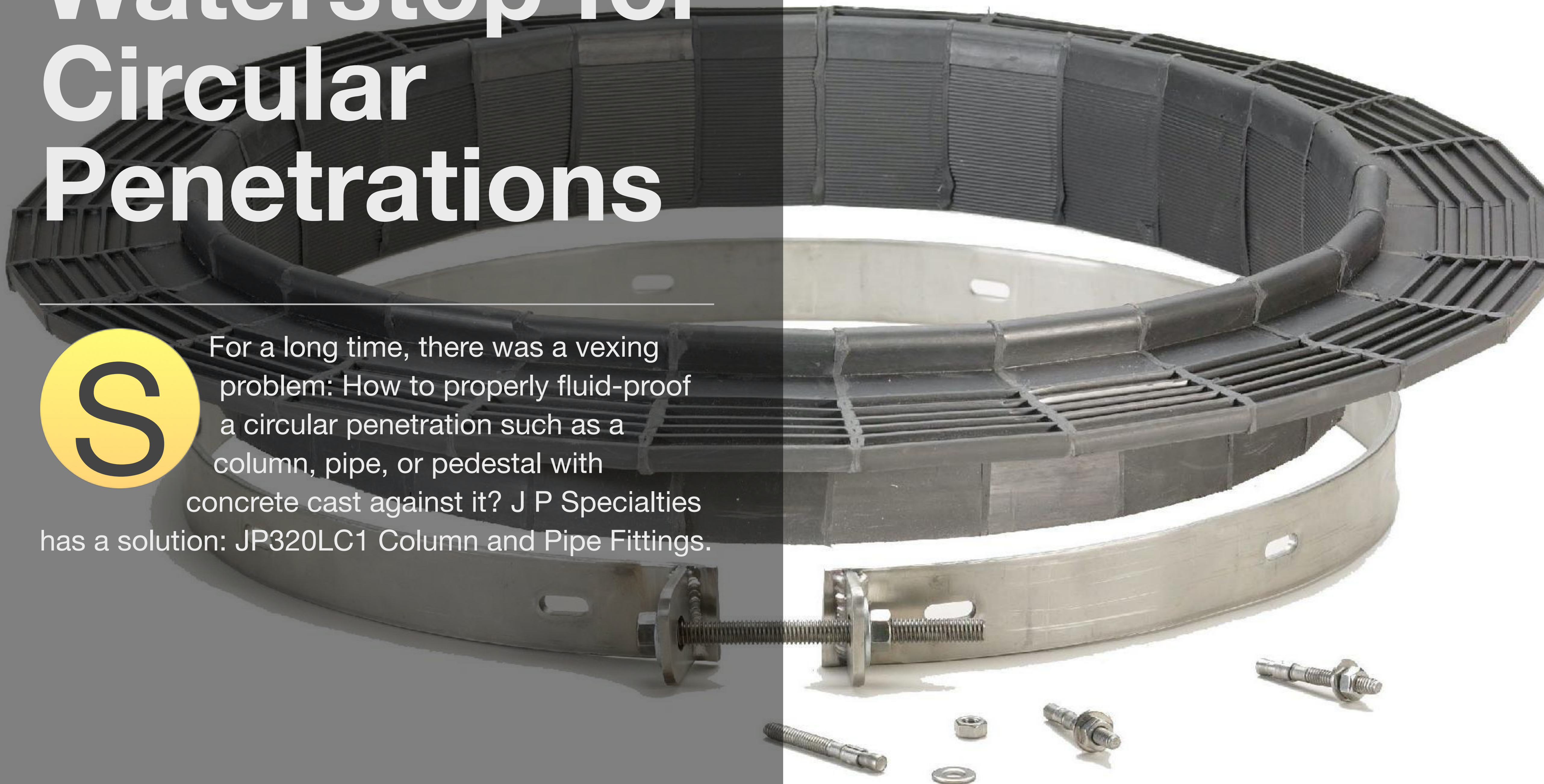
6) Apply fasteners through predrilled pilot holes in batten bar and tighten as required. (20 fasteners per 10 lft length of waterstop total.)

7) Allow installed system to cure 24 hours before placing new concrete.

JPEB375R Retrof t Installation
Scale: 3" = 1'-0"
1

Chapter 10

Waterstop for Circular Penetrations



S

For a long time, there was a vexing problem: How to properly fluid-proof a circular penetration such as a column, pipe, or pedestal with concrete cast against it? J P Specialties has a solution: JP320LC1 Column and Pipe Fittings.

Earth Shield® has solved a long-standing problem for engineered concrete structures with circular protrusions, such as columns, pipes, piers, and pilasters. The problem: how to permanently seal the concrete joint when cast-in-place concrete forms against an existing circular member. The solution: Earth Shield® Column & Pipe Fitting (part no. JP320LC1.XX* [*XX is the diameter in inches]) manufactured with a flexible, chemical-resistant polymer and stainless steel anchoring hardware. A single laborer on the job site can quickly install the column fitting and its associated hardware. Just apply an epoxy gel bed to the existing surface; place the polymer ring into the epoxy gel bed; heat weld the single opening on the polymer ring using a waterstop splicing iron; and finally, complete the system with the stainless steel closure ring.

The Earth Shield® system functions as an internal dam, centrally located within the cast concrete, to stop aggressive chemicals, solvents, and hot petroleum oils from penetrating the joint. By preventing the passage of hazardous liquids, the Earth Shield® Column Fitting provides facility owners, engineers, and contractors with the necessary EPA-mandated containment compliance (EPA Title 40 CFR 265.193). Of course, the system prevents the passage of water as well. The mechanical properties of the polymer, plus the tear-web design of the JP320L profile, enable the column fitting to function equally well in expansion (isolation) joints and construction joints.

Earth Shield® Column and Pipe Fitting Waterstop is available in many standard shapes and sizes.

1. Column and Pipe Fitting Literature (PDF)

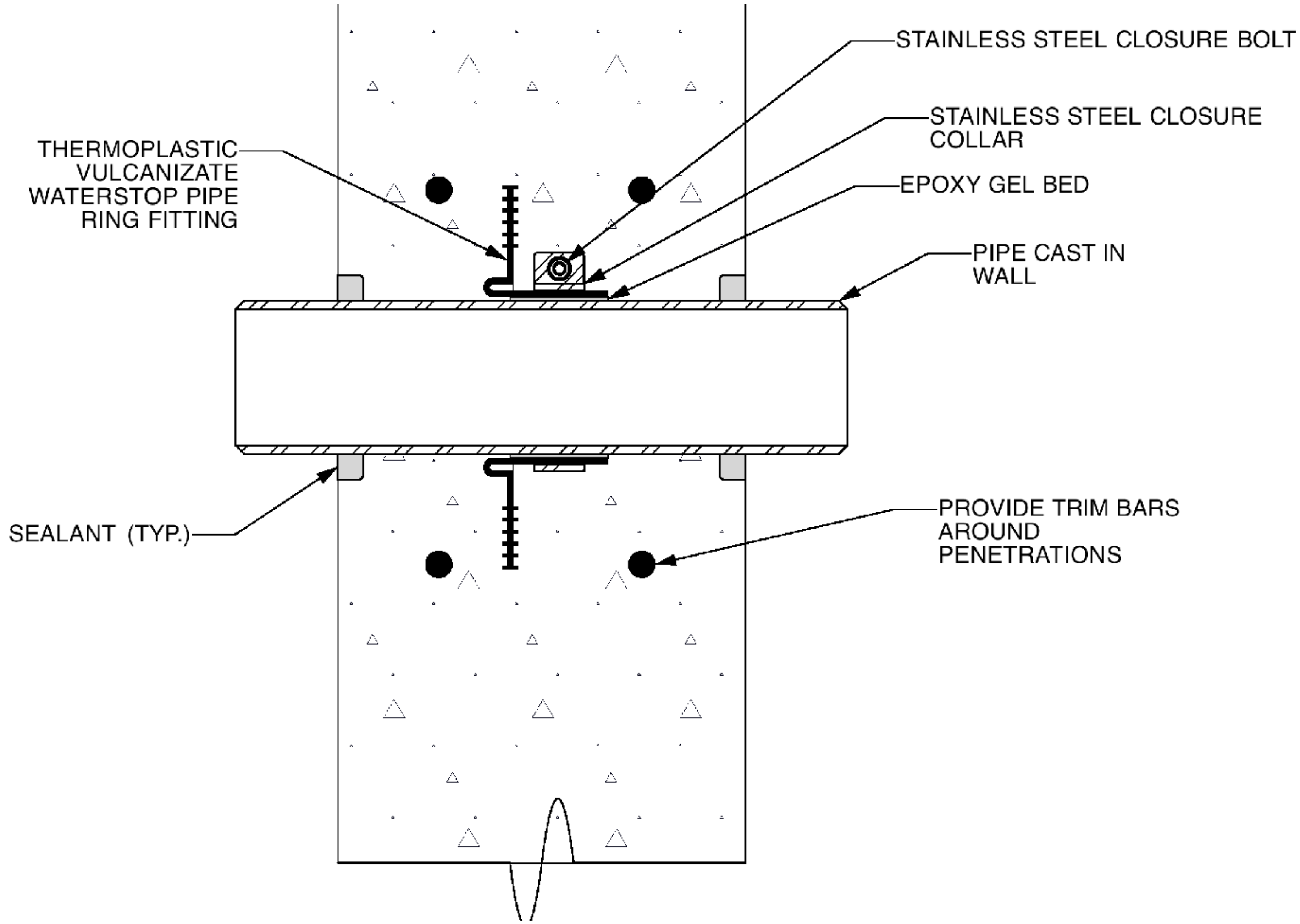
Standard 3-part Specifications are available at our website in Microsoft Word and Adobe PDF format, and upon request in printed and a variety of computer word processor formats. Call our Technical Sales Staff for additional help with your specification.

Suggested Proprietary Short Form Specification

Waterstop indicated in drawings and specifications for circular expansion and construction joints shall be Earth Shield® TPV Chemical Resistant Column and Pipe Fitting Waterstop Part No. JP320LC1.XX [Designer replace XX with outer diameter in inches] as manufactured by J P Specialties, Inc.; 25811 Jefferson Avenue, Murrieta, CA 92562; Phone 951-763-7077

1. Thermoplastic Vulcanizate (TPV) Waterstop shall conform to EPA Title 40 CFR Section 265.193. The suitability of the waterstop for a specific application should be determined by specific testing for that particular requirement per ASTM D471. Project-specific certification to be provided by the manufacturer.
2. Thermoplastic Vulcanizate (TPV) Waterstop shall be independently certified for use in potable water per NSF/ANSI Standard 61. Third-party certified documentation to be provided by the manufacturer.
3. No equals or substitutions allowed

Gallery 10.1 JP320LC1 Column and Pipe Fitting

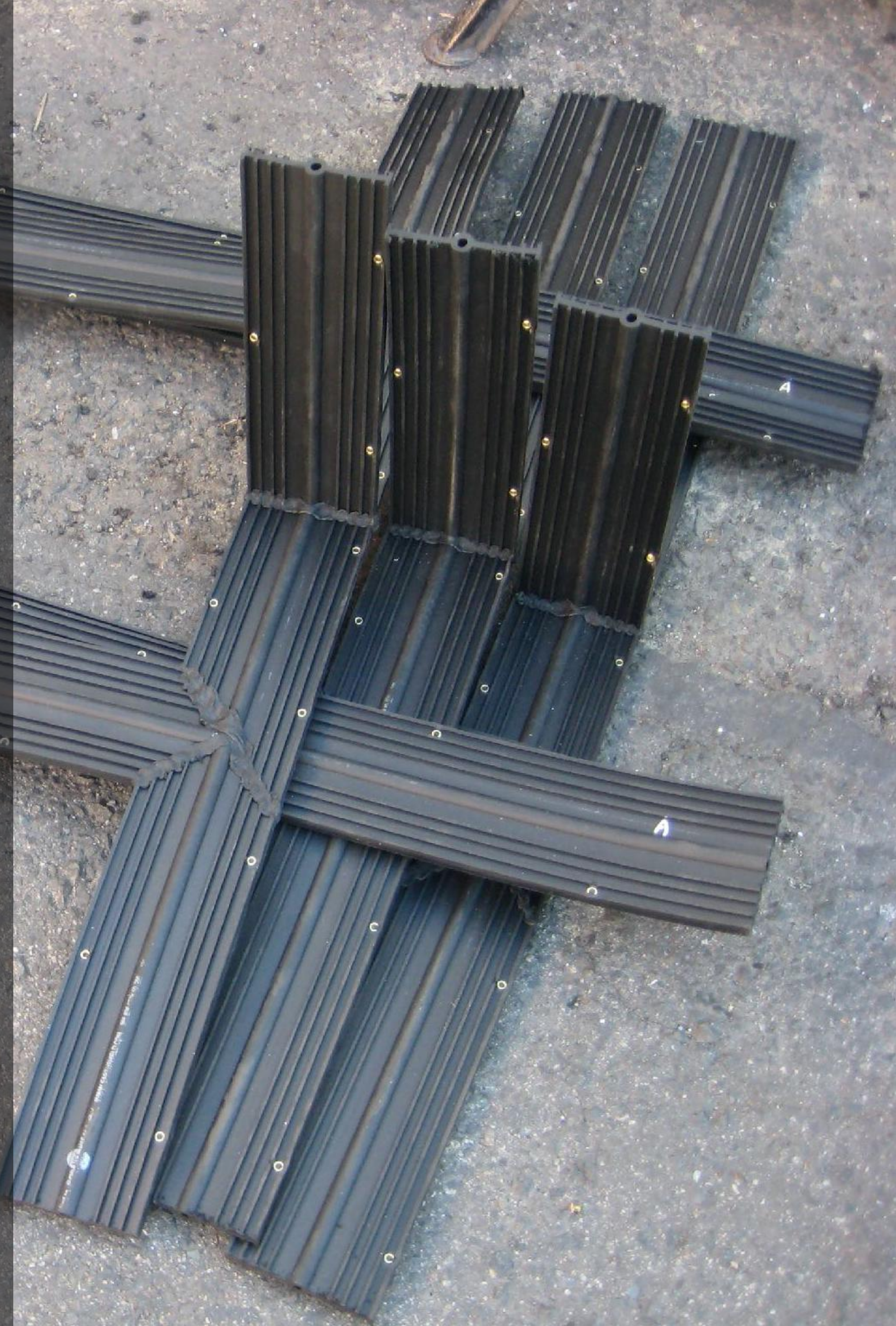


The current revision of the American Concrete Institute ACI 350 2R will include this detail when published later this year.

Chapter 11

Waterstop Fittings

Waterstop Fittings help ensure that environmental engineered concrete structures (such as locks, dams, water, and wastewater treatment plants, *et al.*) remain fluid tight at the most vulnerable location: the concrete joint. Difficult changes of direction Waterstop Fittings are best manufactured at the factory, leaving only simple butt-splicing for the Contractor in the field.



Section 1

What are Waterstop “Shop Made” Fittings?

WATERSTOP FITTINGS

1. **Any change of direction of the concrete joint, also requires a change of direction of the embedded waterstop installed in and along the joint.**
2. **These change of directions are known in the trade as:**
   - **A. Fittings**
   - **B. Shop Made Fittings**
   - **C. Factory Made Fittings**
   - **D. Factory Fabrications**
   - **E. Waterstop Fittings**
   - **F. “Fabs”**

Gallery 11.1 Typical Waterstop Fittings

A prefabricated sump module constructed with JP320L.

Because concrete joints are rarely in a simple straight line and include many turns and changes of directions, the waterstop must follow this path and mirror all the joints’ twists and turns. These changes of directions are known throughout the waterstop industry as “Waterstop Fittings” and this is the sole subject of this chapter. Due to the inherent difficulty of fabrication and the special tools and templates required, I believe that waterstop fittings should be pre-manufactured and shipped to the job site with the bulk waterstop material from the waterstop manufacturer. The weakest link in the waterstop chain is always the waterstop fittings. Shop made fittings can eliminate or significantly reduce this problem as the waterstop manufacturer has the specialized tools and templates unavailable to the contractor in the field. Regardless of polymer, brand, or waterstop configuration, specifiers in the know always call out factory-fabricated fittings alongside their preferred brand of waterstop.

This chapter is based upon CAD details, illustrations, and photographs produced during my nearly 30 years as a waterstop manufacturer. Some of the drawings produced early in my career are not quite as good as some of the later works, primarily due to CAD software's inherent learning curve. Still, I do believe they all accurately illustrate the waterstop changes of direction as intended. Each photo or illustration also includes brief commentary explaining the basic properties of the various waterstop profiles presented.

My goal with this chapter is to illustrate many of the conditions that an engineer or contractor may encounter with waterstops change of directions. Even though there are hundreds of details and drawings throughout this book, there will still be numerous possibilities and combinations of unillustrated products. If you are an Earth Shield® Waterstop specifier, contact me during the design phase of your project. We will supply isometric CAD details to your exact design, all free of charge (we only ask for your project specification).

Gallery 11.2 Waterstop Field Made Fitting Failures

A multitude of problems awaits the construction project that does not require Shop Made Fittings. Waterstop change of directions are the leading cause of leaks at the joint in environmental engineered concrete structures.

Why Specify Shop Made Fittings?

Shop made fittings are recognized and specified worldwide by major engineering firms. The U.S. Army Corps of Engineers also specifies Shop Made Fittings in the July, 1995 revision of CEGS Section 03250. Shop Made Fittings are specified because they work. Edge welding waterstop seriously compromises the integrity of any project. The limited movement of concrete during the coefficient of expansion and contraction can be too much for edge welded waterstop. The edge welded waterstop lacks the proper tensile strength and does not maintain the characteristics of the parent material (bulb or rib continuity).

Consequently, the waterstop often tears at the most critical junction: the change of direction. Since all waterstops act as a continuous, fluid-tight diaphragm in which fluids (generally water) traverse, the structure that uses edge welded waterstop will naturally leak, as fluids migrate to any deficiencies in the weld and pass through to the other side of the joint. Structures that use Shop Made Fittings will significantly reduce these waterstop failures. The tensile strength of the weld will be at least 80% of the parent material. Continuity of the bulbs and ribs are maintained across the weld. In other words, the waterstop will perform as intended and last the life of the structure.

Testing has shown that the majority of waterstop failures occur when the waterstop must make directional changes. Because directional changes, or fittings as they are commonly known, require specialized tools and skills that are not generally required for welding the straight edges of waterstops. Consequently, the fittings are either made wrong (edge welding); there is no tensile strength in the welds; the material is charred, burnt or otherwise contaminated, or the worker's lack of experience causes weak welds. The fittings produced by J P Specialties, Inc. are machine welded using an XLT-2000 Waterstop Splicing Table. My company — JP Specialties, Inc. — invented the XLT-2000 (and its portable sibling the ST-10®) and retained the patent on the technology. The XLT-2000 applies force evenly, creating consistent, homogeneous, and contaminant-free welds.

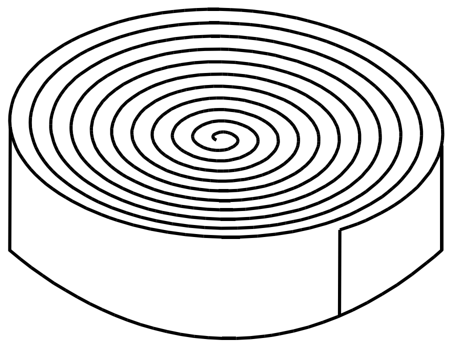
CAD and Shop Drawings
J P Specialties has a large library of CAD drawings that illustrate the many uses of various shop made fittings and explain waterstop's role in creating a fluid-tight structure. Additionally, J P Specialties can provide shop drawings for contractor submittal, **all at no charge**.

Why Use Shop Made Fittings?
J P Specialties certified welding crew can efficiently manufacture large quantities of top-quality Shop Made Fittings on our exclusive XLT-2000 Waterstop Splicing Tables. Therefore, we can pass the savings on to the contractor. Besides saving money, the contractor who uses Shop Made Fittings will save time. A standard flat cross has twelve cuts and seven welds. By using Shop Made Fittings, all of the cuts and three of the welds are eliminated. The number of welds can be further reduced by using modules.

What are Shop Made Fitting Modules?
Modules are custom shop made fittings that are delivered to the job-site as a complete unit, rather than a collection of parts. For example, a box culvert with a longitudinal joint would typically require four vertical ells and two flat crosses. Even with Shop Made Fittings, this would be sixteen butt welds (straight edge to straight edge) for the contractor in the field. With proper dimensions from building plans, J P Specialties will manufacture entire box culvert modules in fit-to-print dimensions. In the box culvert example conveyed above, using modules, only four butt welds remain to be done in the field. Modules work best when the engineer specifies them during the design phase of the project. They can also be used effectively during the construction phase with close collaboration between the manufacturer and contractor.

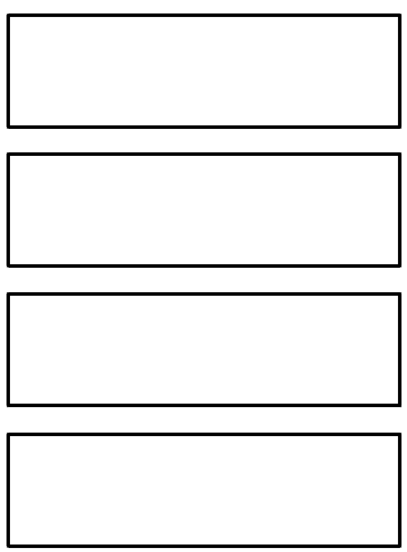
How Much Do Shop Made Fittings Cost?
Shop Made Fittings offer cost savings to the contractor on most jobs compared to the time and labor necessary to fabricate the waterstop in the field. Shop Made Fittings will be more cost-effective and will ensure a timely installation, thus saving costly delays. Also, Shop Made Fittings will enhance your ability to meet stringent hydraulic tests often required by engineers and project owners.

The true cost of a Flat Cross in the field.



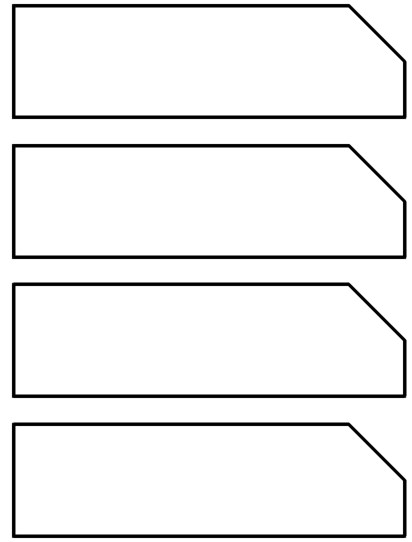
Waterstop starts out in roll form. Uncoil rolls to prepare to cut. 2 minutes.

1



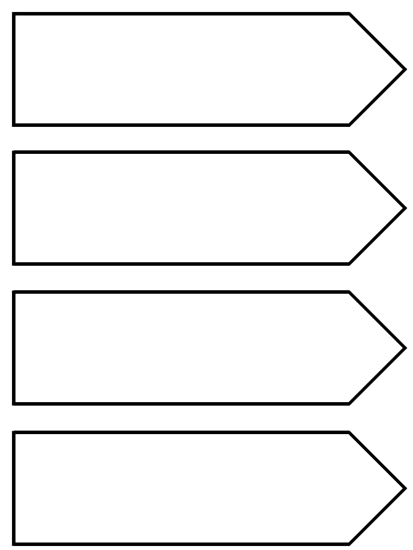
Cut waterstop into 4 equal pieces with radial arm saw. 4 cuts at 30 seconds each.

2



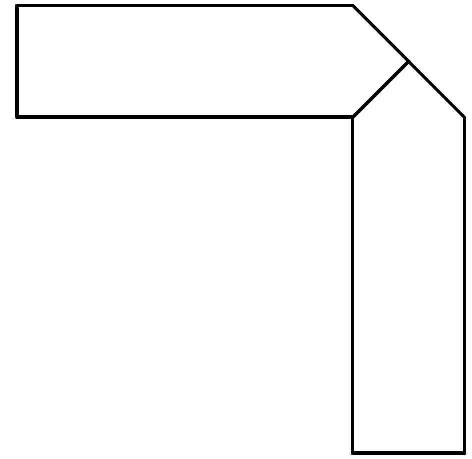
Cut 45° miter across one half the waterstop width. 4 cuts at 30 seconds each.

3



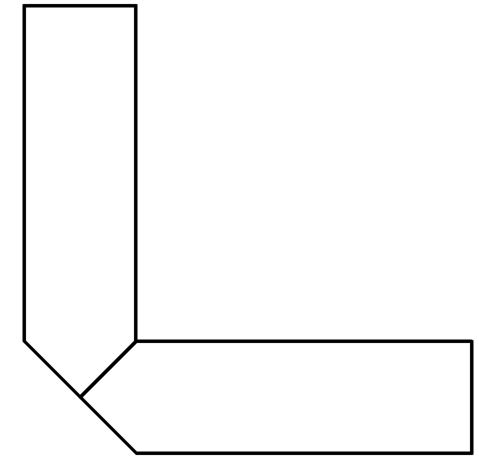
Miter cut 45° across the other side of the waterstop, forming a point. 4 cuts at 30 seconds each.

4



Weld two of the pieces together, point to point. 6 minutes to 12 minutes per weld, depending upon workers' skill level.

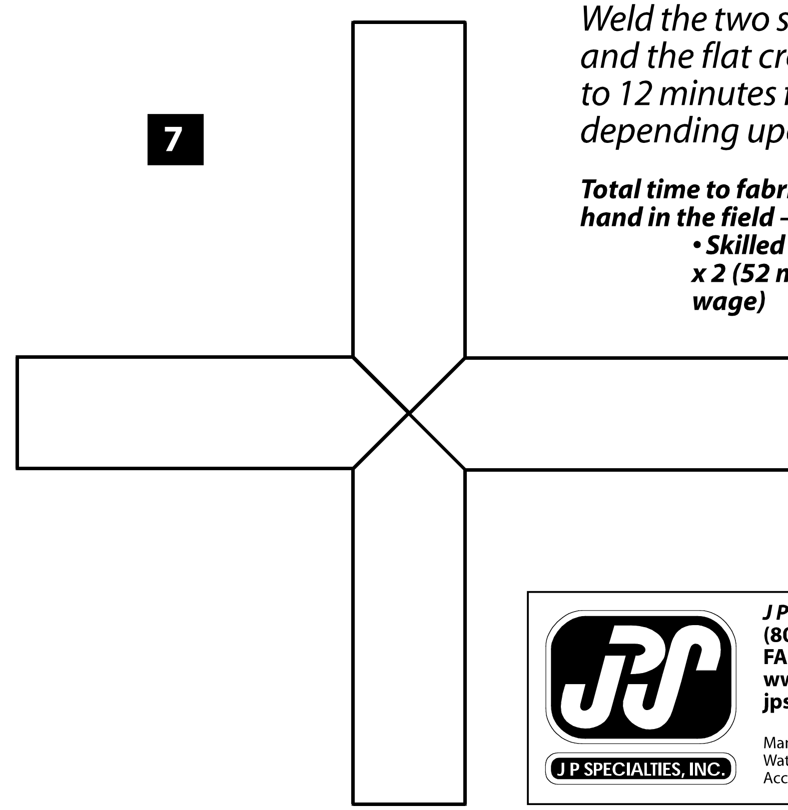
5



Weld the remaining two pieces together, point to point. 6 minutes to 12 minutes per weld, depending upon workers' skill level.

6

7



Weld the two sections together and the flat cross is finished. 6 to 12 minutes for the final weld depending upon workers' skill.

Total time to fabricate flat cross by hand in the field —

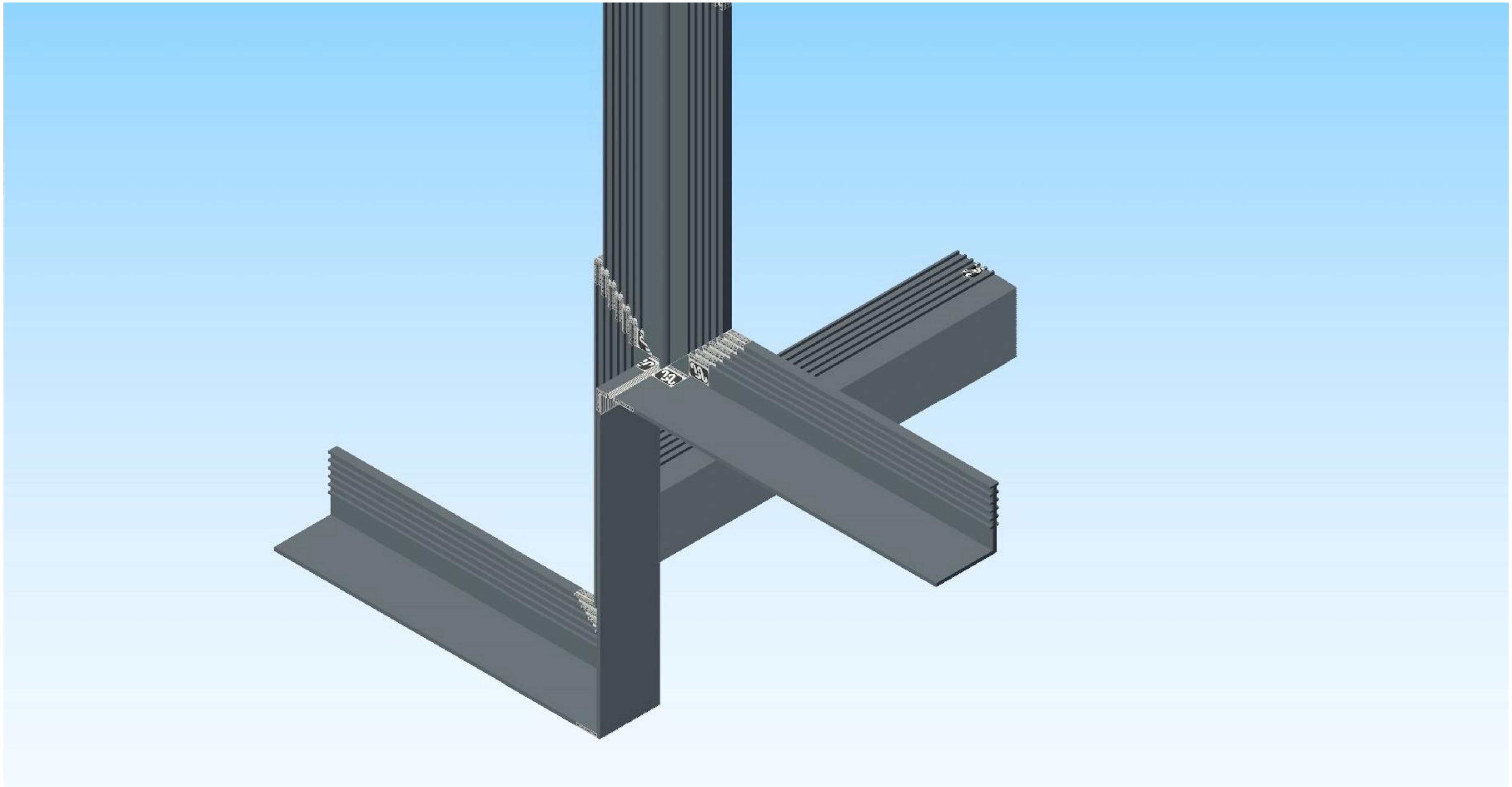
- ***Skilled workers: 26 minutes x 2 (52 minutes x workers' wage)***
- ***Unskilled workers: 44 minutes x 2 (1 hour, 28 minutes x workers' wage)***

J P Specialties, Inc.
(800) 821-3859
FAX (951) 674-1315
www.jpspecialties.com
jpspec@jpspecialties.com

J P SPECIALTIES, INC.

Manufacturers of Quality Waterstop, Waterstop Splicing Equipment, and Accessories Since 1954

Gallery 11.3 A Collection of Various Shop Made Fitting Modules and Fittings made with Earth Shield® TPV Waterstop

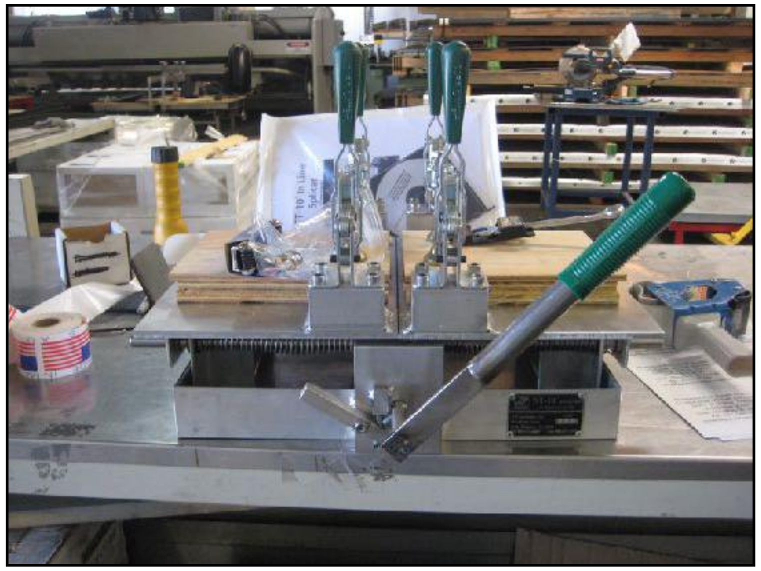


Shop Made Fittings and Modules are factory-fabricated change of direction waterstops.

Chapter 12

Waterstop Tools for Installation

The use of the proper tools predicates proper waterstop installation. This chapter describes typical waterstop tools and accessories and their use and function.



The ST-10® In-Line Waterstop Splicing Table

The ST-10® was designed and patented by J P Specialties as the perfect solution for producing high-tensile strength, leakproof welds on thermoplastic waterstops such as PVC, HDPE, LDPE, TPER, and TPV. New quality assurance standards in today's waterstop specifications mandate tensile testing across field welded joints, usually requiring tensile strength 80% or better of the parent material. Waterstops welded with the ST-10 assure the Contractor that their workmanship will yield results conducive to these rigorous requirements. The ST-10 is also an extreme labor saver, taking a two man job — welding waterstop — and taking it down to just one man.

- *Easy to use*
- *Aligns the waterstop*
- *Portable, lightweight*
- *Weather resistant*
- *Minimizes fumes (maximizes safety)*
- *High tensile welds*
- *Welds under pressure, eliminating air bubbles*

Waterstop Splicing Irons

JPS Standard Irons are specifically designed for welding waterstops and other thermoplastic extruded profiles (expansion joints, seals, etc.). The temperature control can be adjusted from 250°F to 500°F to accommodate various ambient conditions and different polymers. All JPS Standard Irons are constructed with the highest quality components.

Peel and Stick Teflon® Covers

We factory cut our high-quality Teflon® replacement covers, so all you have to do is peel off the release paper and adhere it to the warm iron. No trimming is required.12213 part number fits JP214 iron.

Large Waterstop Splicing Irons

Large waterstop irons for large profiles.

Small Waterstop Splicing Iron

Our most popular waterstop splicing iron. The JP214 is small and lightweight, and capable of welding all but the largest waterstop profiles.

JPS Pro Series Waterstop Splicing Irons

Designed for the waterstop pro! Our Pro Series irons feature all the same attributes as our regular irons plus built-in thermometer, temperature control knob, outdoor-use power cord (UL and CSA approved), analog thermometer, ergonomic vinyl grip, sealed elements, and a Silverstone coating that doesn't require covers.

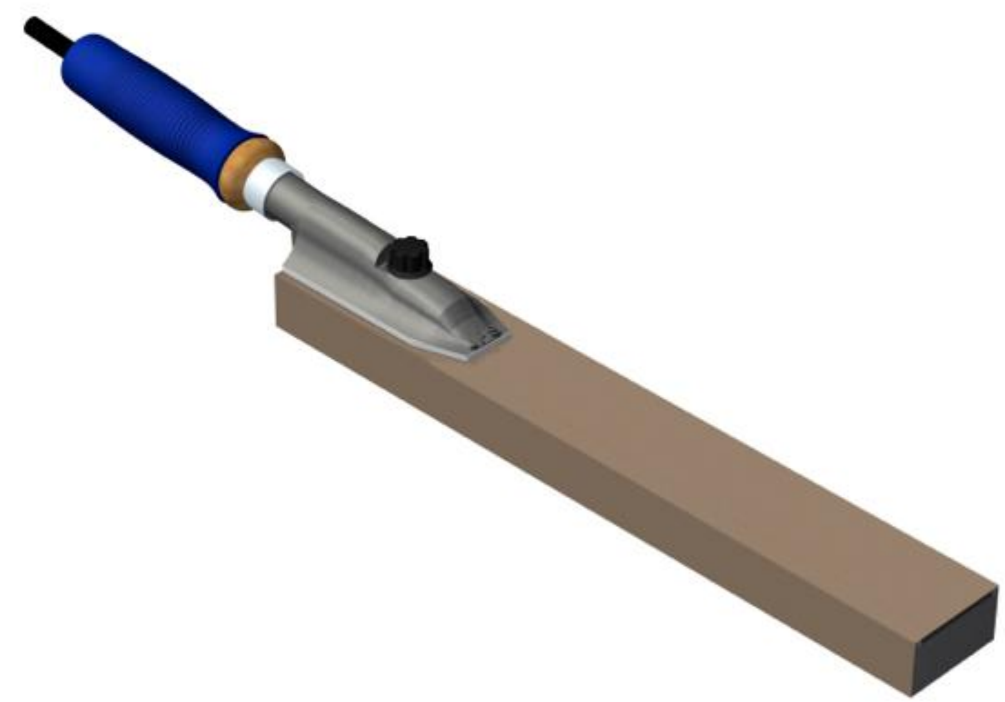
ElectroTest Spark Tester

The ElectroTest is a portable, high frequency generator used for the detection of pinholes in field welds of waterstop.

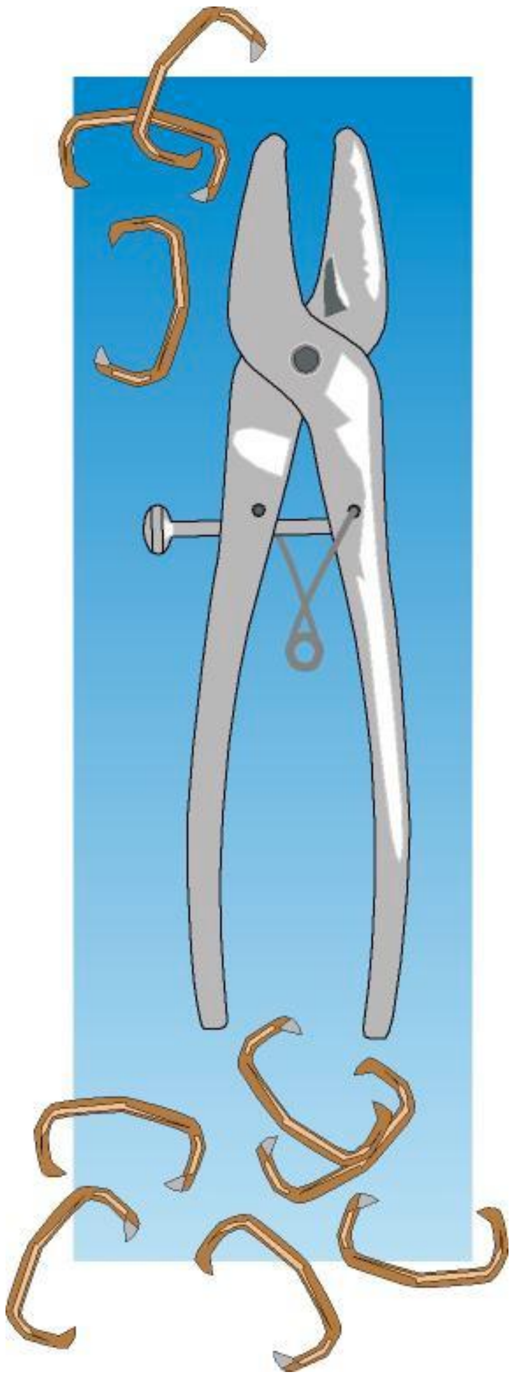
Waterstop Hog Ring Pliers

A durable, lightweight tool with unique torsion spring for ease of use and set screw to ensure perfect hog ring closure every time.

Gallery 12.1 Waterstop Splicing Irons and Tools



A JP214 Waterstop Splicing Iron is small and light and perfect for working in tight conditions.

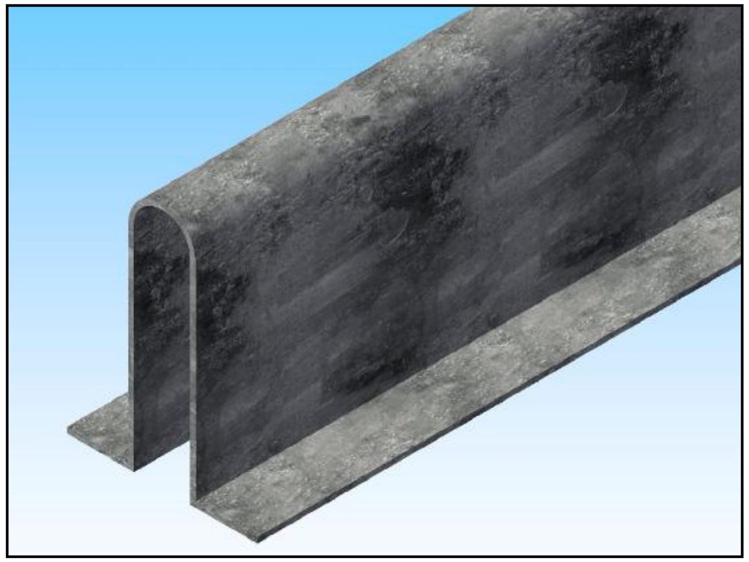


Waterstop Hog Rings

Copper-clad, hill-shaped, size #3 hog rings fits every [Earth Shield® TPV Waterstop]() profiles (as well as most other brands) with equal ease. Used to lash waterstop to the reinforcing steel during installation.

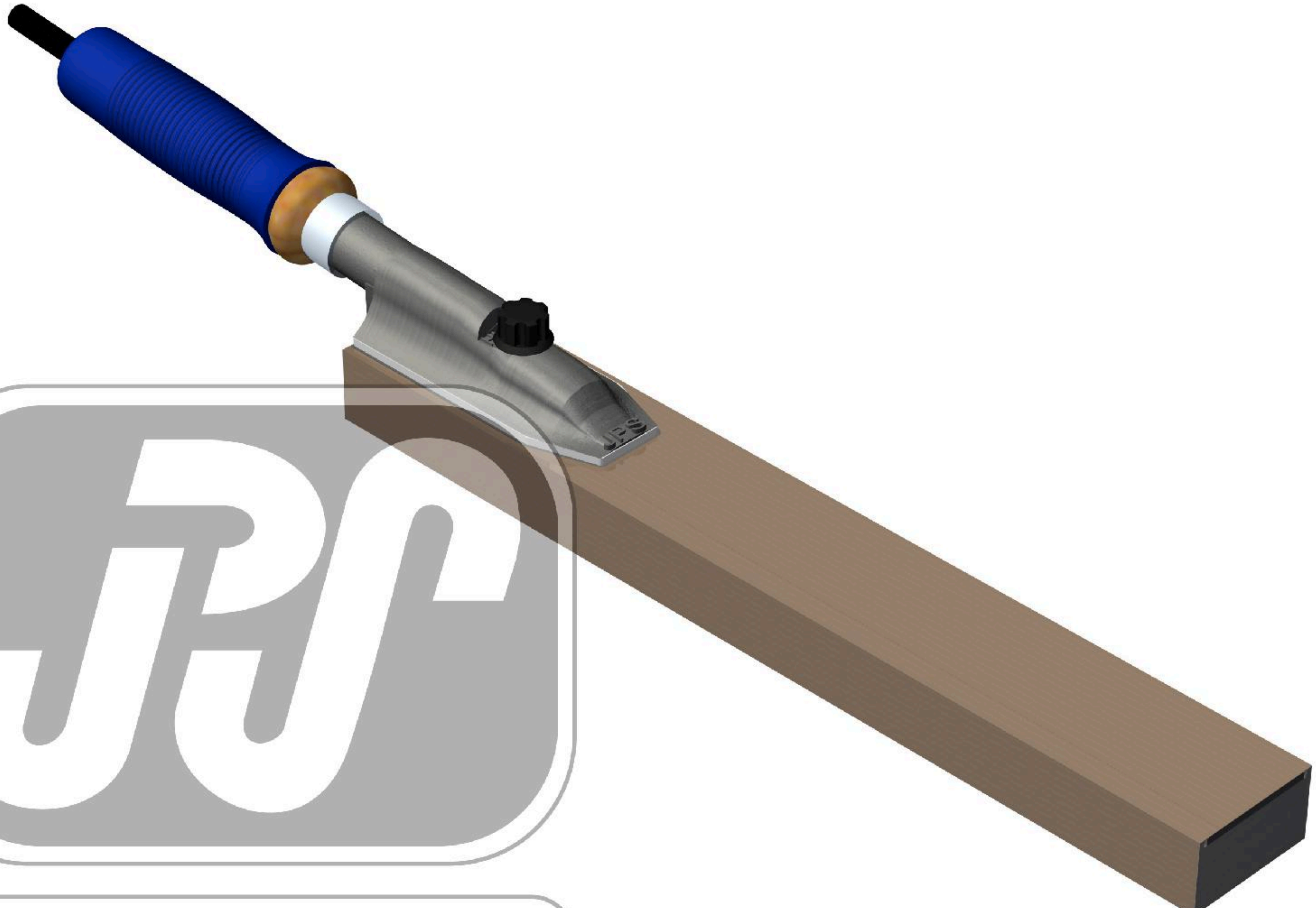
Factory Installed Eyelets

Secure your waterstop 12” on-center with factory-installed brass eyelets. Eliminates all of the labor associated with hog rings.



Waterstop Protector

Waterstop Protector is used to protect embedded waterstop for extended periods of time. Fits most [waterstop profiles](). Constructed with heavy-duty, 20 gauge, electro-galvanized steel. Other grades, gauges, and metals are available, including for CH2M Hill specification.



J P SPECIALTIES, INC.

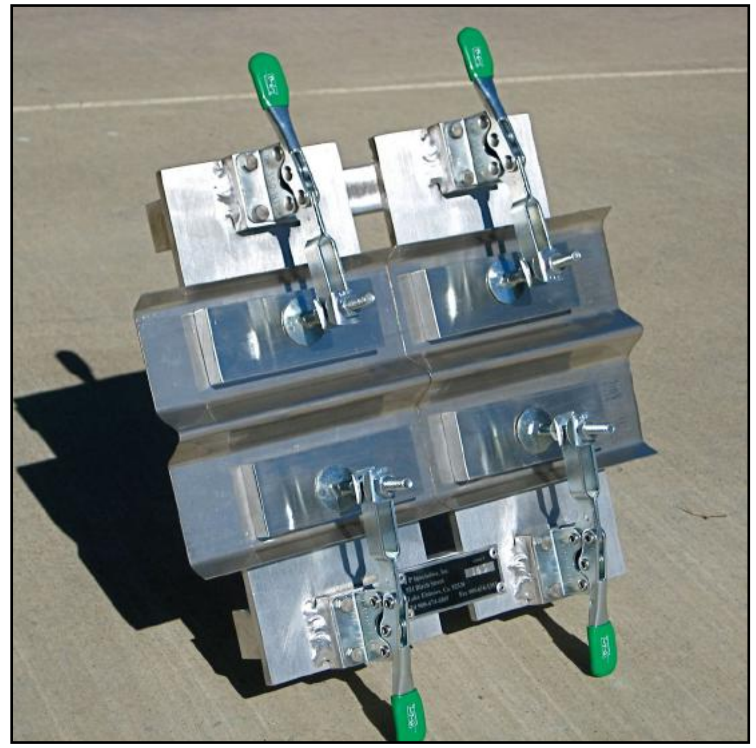
MixRite Jr Epoxy Mixing Paddle

The perfect paddle for mixing VEN 500 and 1000 Novolac Epoxies by Earth Shield®. Fits standard drill and one gallon bucket.

Condrive 1000 Tapcon® Tool

Used for installing Tapcon® fasteners with various Earth Shield® Retrofit Waterstop Systems.

11120 part number



Stainless Steel Waterstop Welding Jig

Our stainless steel waterstop welding jig is designed to perfectly align the straight lengths of Earth Shield® Stainless Steel Waterstop for field fabrication. Includes copper cool bar for heat sink.

Earth Shield® Waterstop Primer

Waterstop primer is used to adhere Earth Shield® Strip-Applied Hydrophilic and Mastic Waterstops to concrete. Solvent-based primer in one-gallon can. Each gallon can be used to install approximately 900 lineal feet of strip-applied waterstop.

Plastic Joint Former Expansion Joint Filler

Earth Shield® Expansion Board Cap Waterstop is installed on top of conventional expansion board filler or Earth Shield's own chemical resistant, plastic expansion board. The expansion board acts as the form; therefore, no form splitting is necessary. This greatly accelerates the project schedule and provides a long lasting, attractive finished concrete joint.

VEN 500 and VEN 1000 Chemical Resistant Novolac Epoxies

VEN 1000 and VEN 500 are trowel grade novolac epoxy gels designed to adhere Earth Shield® Retrofit Waterstops to existing concrete surfaces, as well as a variety of maintenance and bonding applications requiring extreme chemical resistance

Chapter 13

Plastic Waterstop Installation

You will find the step-by-step directions needed to properly install thermoplastic waterstop (such as PVC or TPV).

Preparation

1. Uncoil waterstop 24 hours prior to installation for ease of handling and fabrication.

2. Position waterstop to ensure proper distance from steel reinforcing bars to prevent rock pockets and honeycomb (see Gallery 13.1).

3. Protect waterstop from damage during progress of work (see Gallery 13.1). A Waterstop Protector can be used to accomplish this.

4. Clean concrete joint after first pour to remove debris and dirt.

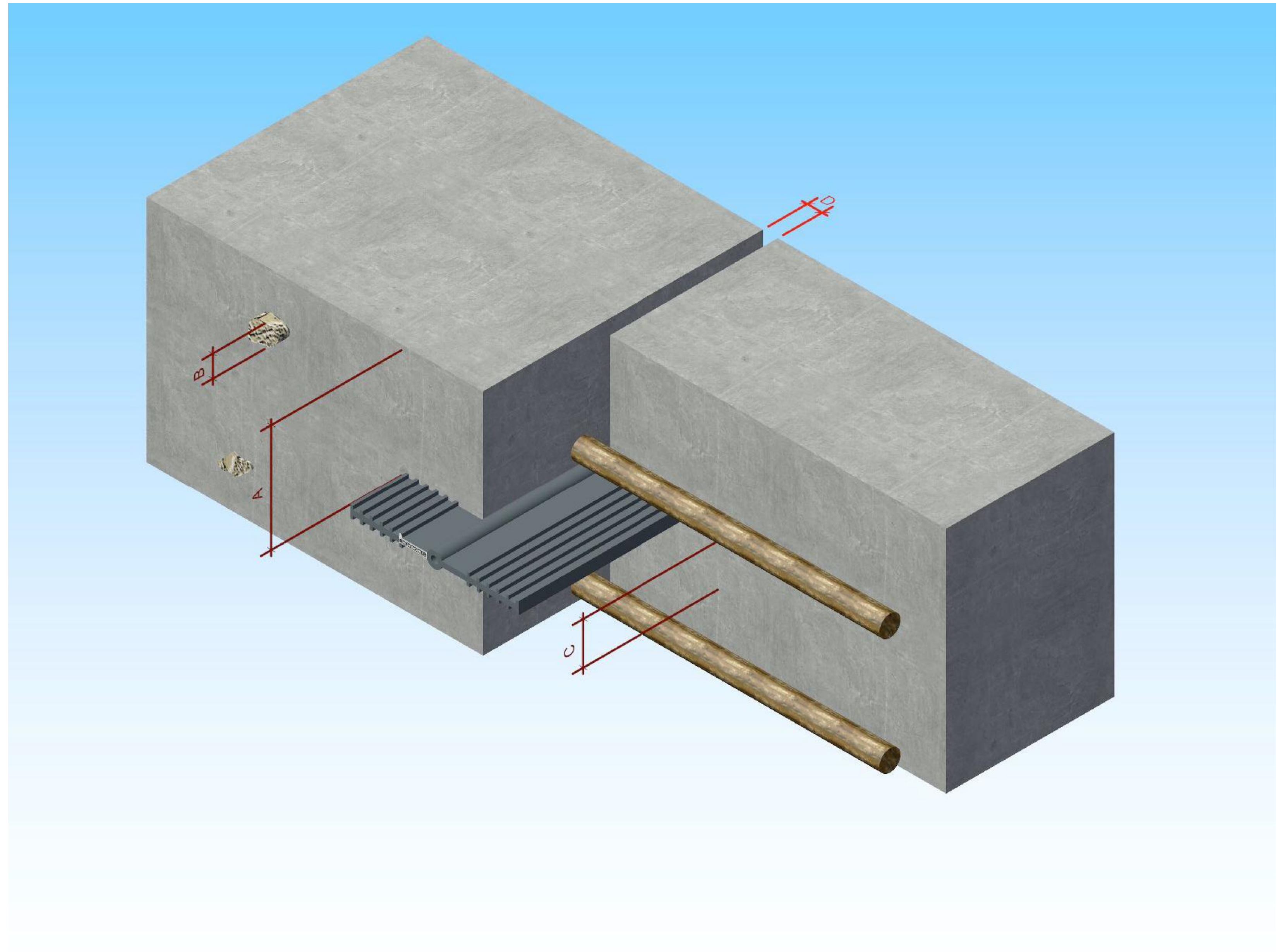
Examination/Inspection

1. Prior to placement of concrete notify engineer for field inspection approval.

2. Inspect waterstop and field splices for defects and conformance to Quality Assurance Standard.

3. Upon inspection of waterstop installation, replace any damaged or unacceptable waterstop and dispose of defective material.

Gallery 13.1 Waterstop Installation



A = Waterstop Concrete Coverage — Not less than half waterstop width B = Largest Aggregate Size C = Waterstop Distance from Reinforcing Steel — Not less than two B D = Joint Opening — Waterstop centerbulb diameter or greater if an expansion joint (can be zero if construction joint)

Installation

1. Position waterstop in joint as indicated on drawings.

2. Center waterstop on joint, with approximately one-half of waterstop width to be embedded in concrete on each side of the joint.

3. Allow clearance between waterstop and reinforcing steel of a minimum two times the largest aggregate size. Prevent rock pockets and air voids caused by aggregate bridging (see Gallery 12.1).

4. Ensure centerbulb is not embedded at expansion joints.

5. Secure waterstop in correct position using optional factory-installed brass eyelets (or JPS hog rings crimped between last two ribs on 12 inch maximum centers), and wire tie to adjacent reinforcing steel. Center-to-center spacing may be increased upon written request and approval from ENGINEER.

6. Carefully place concrete without displacing waterstop from proper position.

7. Thoroughly and systematically vibrate concrete in the vicinity of the joint, and to maximized intimate contact between concrete and waterstop.

8. After first pour, clean unembedded waterstop leg to ensure full contact of second concrete pour. Remove laitance, spillage, form oil and dirt.

Quality Assurance

1. Edge welding will not be permitted. Centerbulbs shall be compressed or closed when welding to non-centerbulb type. Waterstop splicing defects which are unacceptable include, but are not limited to the following:

2. Tensile strength not less than 60 percent of parent sections.

3. Free lap joints.

4. Misalignment of centerbulb, ribs, and end bulbs greater than 1/16 inch.

5. Misalignment which reduces waterstop cross section ore than 15 percent.

6. Bond failure at joint deeper than 1/16 inch or 15 percent of material thickness.

7. Misalignment of waterstop splice resulting in misalignment of waterstop in excess of 1/2 inch in 10 feet.

8. Visible porosity in the weld.

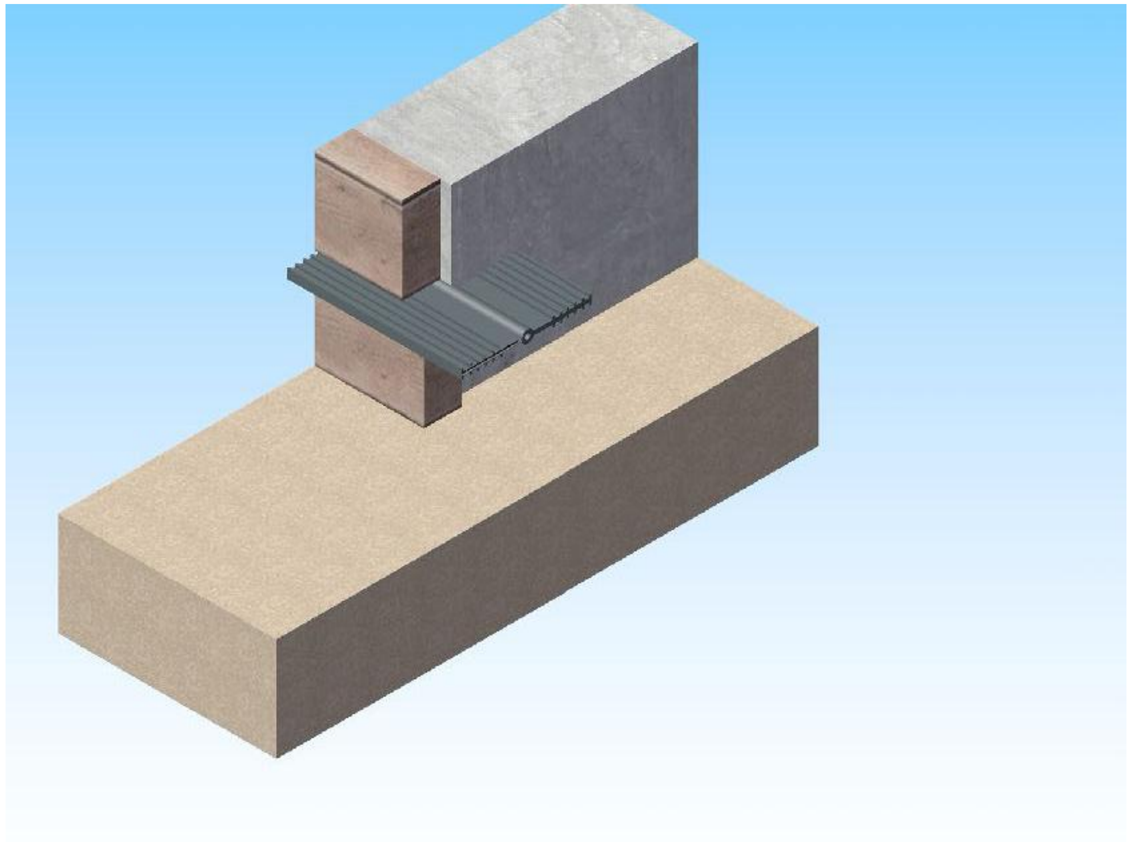
9. Charred or burnt material.

10. Bubbles or inadequate bonding.

11. Visible signs of splice separation when cooled splice (24 hours or greater) is bent by hand at sharp angle.

For examples of waterstop installation failures, see this gallery.

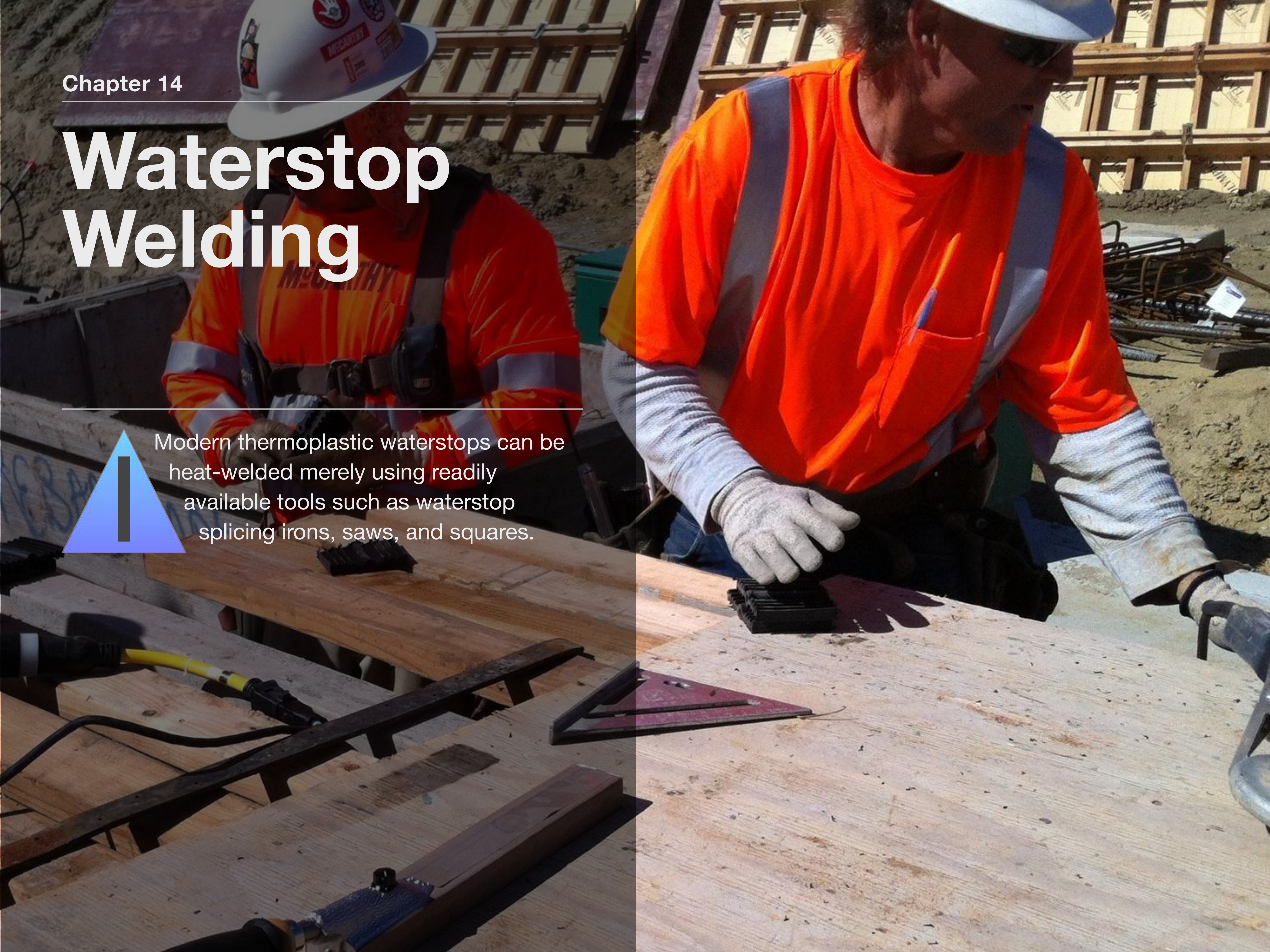
Gallery 13.2 Split Forming Waterstop



Lumber is frequently used to provide the "split forming" necessary to properly install waterstop.

Chapter 14

Waterstop Welding



Modern thermoplastic waterstops can be heat-welded merely using readily available tools such as waterstop splicing irons, saws, and squares.

Waterstop Splicing Iron Job Site Installation User Guide

Follow all of the instructions contained in this book to ensure a safe procedure and structurally sound waterstop welds.

A minimum warm up time of 15 minutes is <u>required</u> to set the waterstop splicing iron to the required temperature. Preheat waterstop splicing iron to the following temperature:

•For **TPV** Waterstop: 410 to 430°F

•For **PVC** Waterstop: 350 to 380°F

It is recommended to verify temperature using an external thermometer.

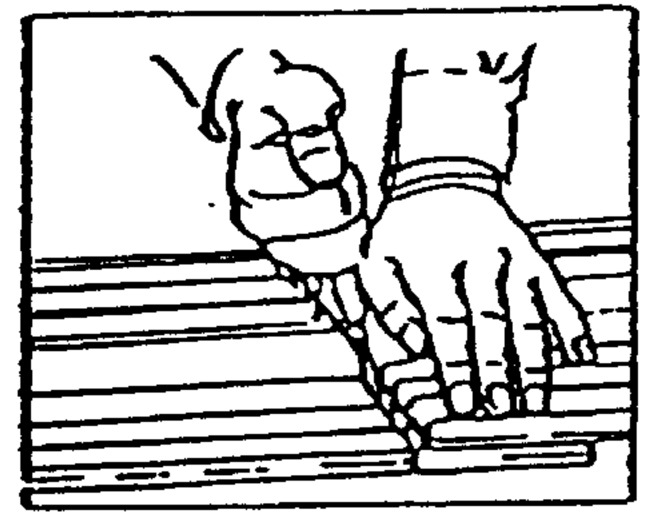
NOTE: The **Peel and Stick Teflon® Cover** is to remain on the iron during the welding process. **DO NOT REMOVE.**

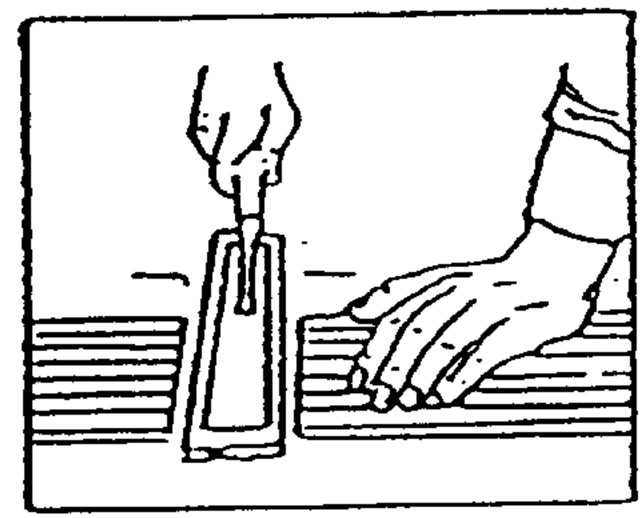
CAUTION: Too high of a temperature will result in damage to waterstop welds, splicing iron cover, and possibly splicing iron.

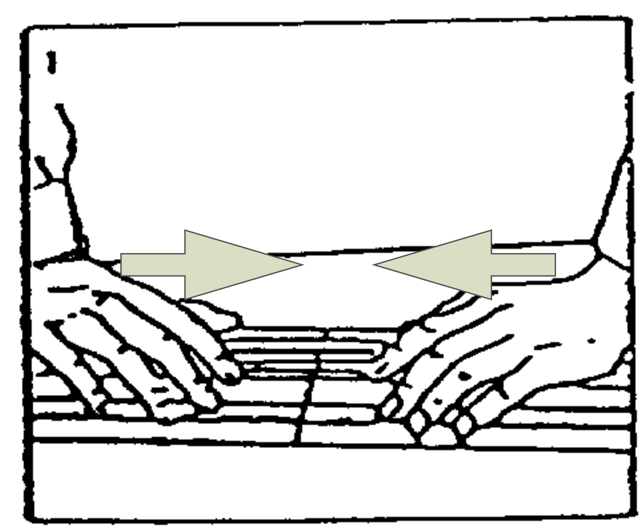
1. Always cut square ends before welding waterstops. Never weld to extruded ends. Use flat work table to create field splices. Work area should be solid and have access to power supply and have jigs and fixtures to aid splicing.

2. Cut ends square, using a razor knife or circular saw equipped with a carbide tipped blade (10” diameters with 40 teeth) to ensure matching edges.

3. Preheat the iron to the desired temperature ranges. Place iron between butt ends. Keep waterstops in place until approximately 3/16” bead forms on each side of waterstops. Quickly remove splicing iron and gently press waterstops ends together until they bond (approximately 3 to 5 minutes or cool to touch). Cold water may be sprayed on waterstops to expedite the bond.





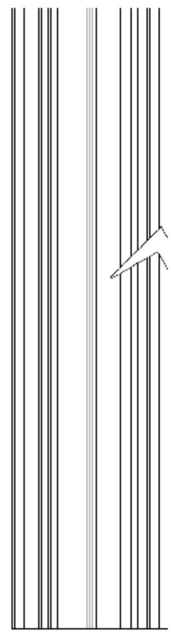


NOTE: When welding TPV/TPER, if you do not join ends quickly, the melted material will skin over, resulting in an inadequate bond.

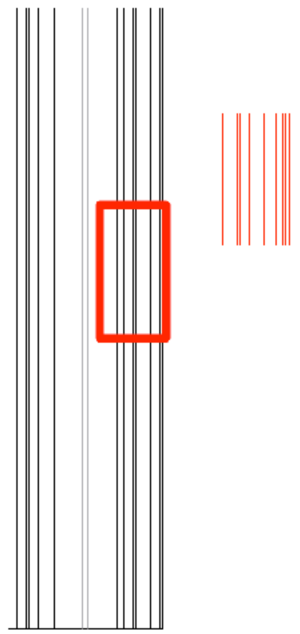
Movie 14.1 Waterstop Welding with the ST-10® Waterstop Splicing Table

The ST-10® makes waterstop welding in the field an one-man operation.

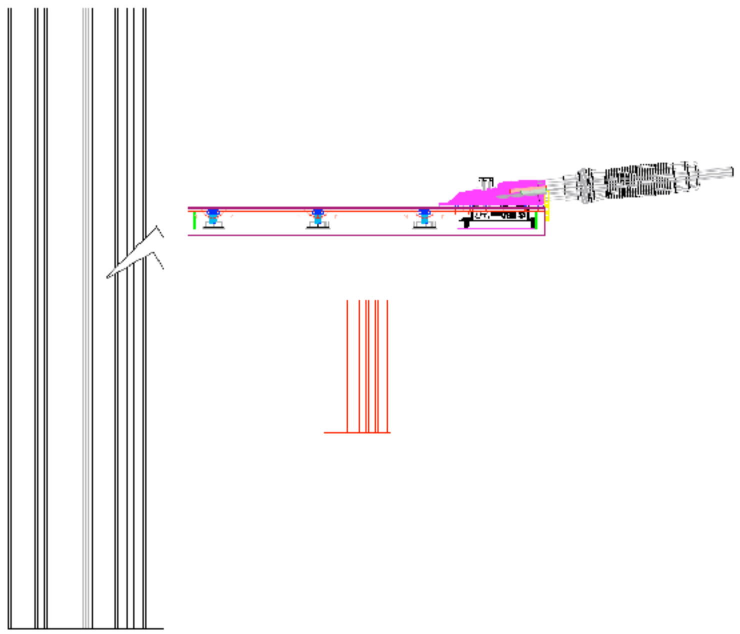
A Simple Repair Method for Damaged Thermoplastic* Waterstops by David R. Poole



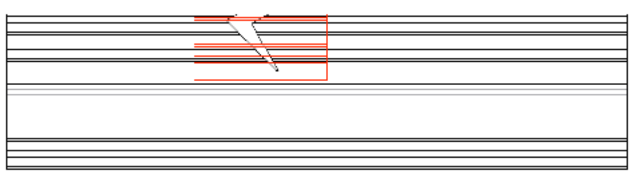
1) Thoroughly clean damaged area. Remove all dust, dirt, oil, etc.



2) Cut a patch out of undamaged waterstop material. The patch should be slightly larger than the damaged area.



3) Using a JP Specialties Waterstop Welding Iron, simultaneously heat both the patch and the damaged area, allowing the plastic to become molten and sticky.

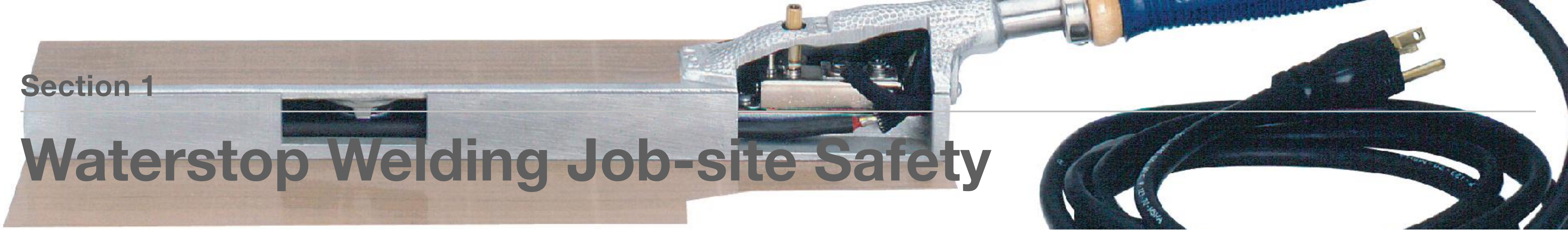


4) Apply the hot, sticky patch over the affected area. Allow to cool. the repair is now complete.

**Thermoplastic waterstops include PVC, TPER/TPV, and PE*

JP Specialties, Inc. / Earth Shield®
551 Birch Street • Lake Elsinore, CA 92530 www.jpspecialties.com
phone 800-821-3859 • international 951-674-6869 • fax 951-674-1315

TITLE		
Simple Waterstop Repair		
PART NUMBER	DRAWN BY DRP	DATE 04/13
CAD FILE NAME Waterstop Repair	APPROVALS	SIZE A



Section 1

Waterstop Welding Job-site Safety

Waterstop welding involves high heats generated by electric currents. Therefore, proper safety measures are mandatory. Additionally, when welding PVC (polyvinyl chloride) waterstop, the contractor could inhale harmful fumes* if adequate precautions are not taken.

Operating Safety

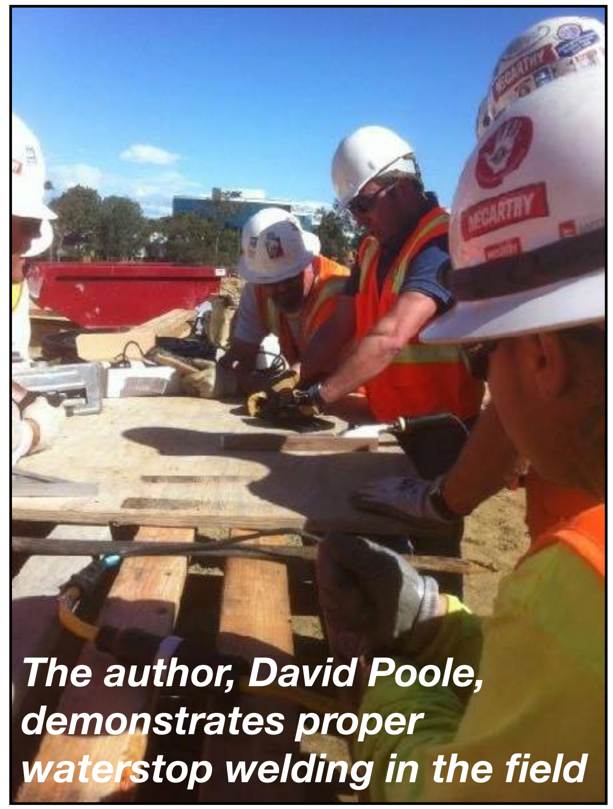
•Allow only one person to work on waterstop splicing iron at a time.

•Only qualified personnel should operate splicing iron.

•Keep children, bystanders, and animals at least twenty (20) feet away from the work area.

•Do not operate under the influence of alcohol or drugs.

•Always unplug the iron when not in use.



The author, David Poole, demonstrates proper waterstop welding in the field

•Never operate under the influence of medications, drugs or alcohol.

•Iron operates at very high temperature and can burn flesh or cause ignition, even after being unplugged (until cool).

Never, under any circumstances, alter your splicing iron. Altering the equipment, or using the equipment in such a way as to change its design capabilities and capacities, could result in serious or fatal injury and WILL VOID THE WARRANTY.

Personal Protection

•Always wear protective gear including but not limited to:

1. Temperature resistant gloves
2. Safety goggles
3. Protective shoes/boots
4. Respirator* in indoor confined spaces

•Ensure all electrical connections are in good working order prior to plugging in Splicing Iron.

Worksite Safety

•Never use splicing iron on slippery, wet, or muddy surfaces. The location should be flat, dry, and free from any tall grass, brush, or ignitable objects.

•Welding should be done in a well ventilated area. In confined areas, a respirator should be worn as melting plastic waterstop fumes (*especially PVC**) may be harmful to your health.

•Never use your splicing iron at night.

Electrical Safety and Standards

•Ensure appropriate electrical connections are in good working order.

•Do not alter the tool in any way. Doing so could be a hazard and void the warranty.

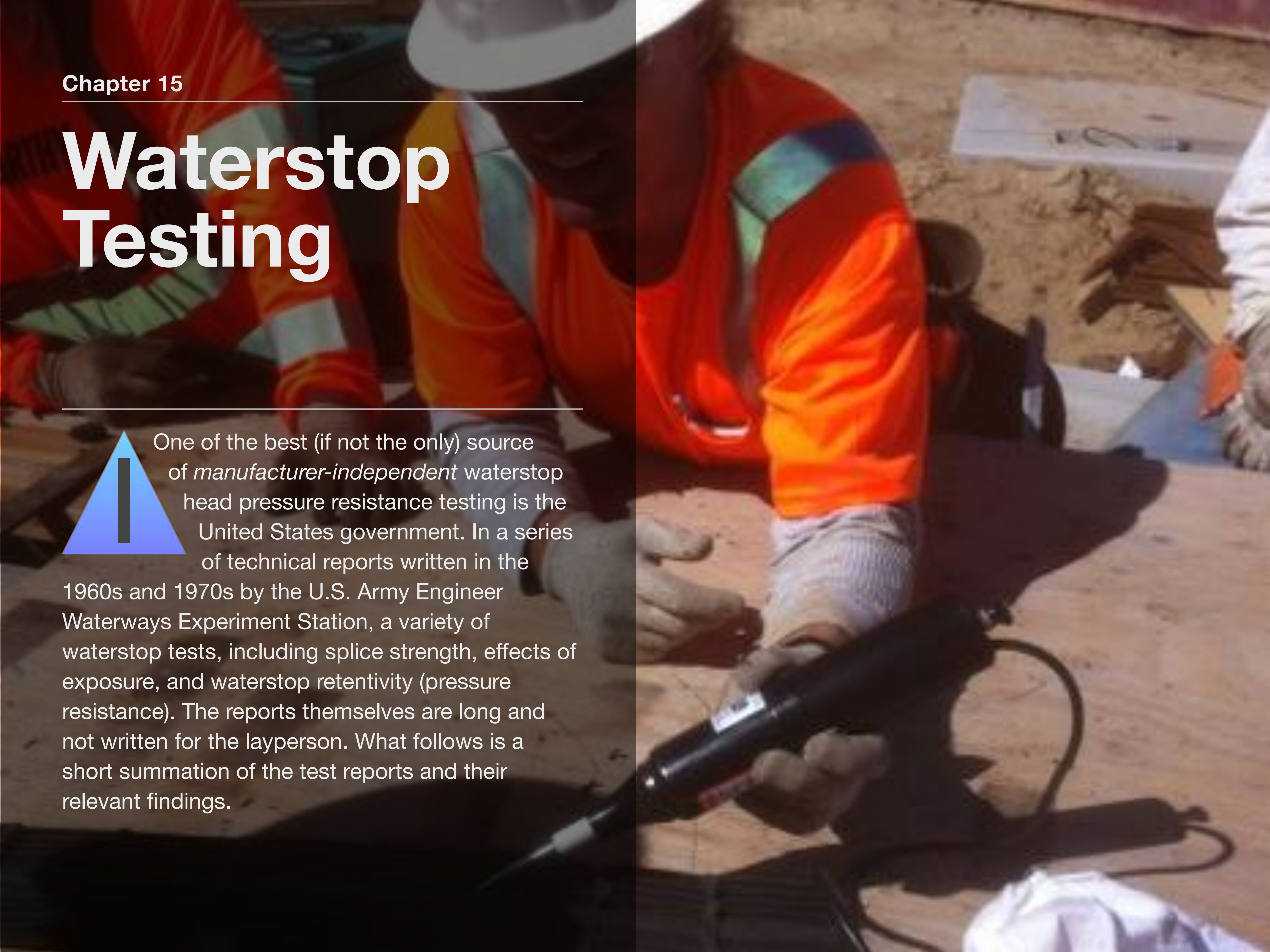
•Keep iron away from water and never operate with wet hands.

•Do not use the Splicing Iron with a damaged cord.

•Never use the Splicing Iron with non-regulated voltages.

•Understand all of the above requirements before plugging in the splicing iron.

***PVC (Polyvinyl Chloride) waterstop fumes can be harmful to the welder/ operator's health.** At high temperatures (like those used to weld waterstop), PVC waterstop can form hydrogen chloride (HCl) fumes; the chlorine serves to scavenge free radicals and is the source of the material's fire resistance. While HCl fumes can also pose a health hazard in their own right, HCl dissolves in moisture and breaks down into fuming hydrochloric acid, particularly in areas where the air is cool enough to breathe, and is not available for inhalation. Frequently in applications where smoke is a major hazard (notably in tunnels and communal areas) PVC-free waterstop (such as TPV) is preferred.*



Chapter 15

Waterstop Testing

One of the best (if not the only) source of *manufacturer-independent* waterstop head pressure resistance testing is the United States government. In a series of technical reports written in the 1960s and 1970s by the U.S. Army Engineer Waterways Experiment Station, a variety of waterstop tests, including splice strength, effects of exposure, and waterstop retentivity (pressure resistance). The reports themselves are long and not written for the layperson. What follows is a short summation of the test reports and their relevant findings.

Section 1

Water Retentivity and Tensile Strength of Splices

Published in 1965 by U.S. Army Corps of Engineers in Vicksburg, Mississippi, Investigation of Nonmetallic Waterstops — Water Retentivity and Tensile Strength of Splices (Technical Report No. 6-546) is likely the most comprehensive study ever undertaken by any singular entity on the effectiveness and performance of various waterstop.

Initiated in 1958 in a letter dated November 25th, 1958, from the U.S. Army Engineer Waterways Experiment Station, the purpose of this report (and others from the same series) was to evaluate and test the “new” plastic waterstop products which were coming to market. Before this report, USCOE projects all used thermoset rubber waterstops or metallics.

The following tables present the raw data I obtained from the report, and after the tables, I have included the report’s summary verbatim.

Table 1

Water Retentivity of PVC-11. -13, and -14. and NR-3

			PVC-11		PVC-13	PVC-14		
Joint Condition	**Water Pressure PSI**	**Simulated Head of Water, ft**	**Ribs not Reformed Across Splice**	**Ribs Reformed Across Splice**	**Ribs Not Reformed**	**Ribs not Reformed Across Splice**	**Ribs Reformed Across Splice**	**NR-3 Dumbbell**
Closed	50	116	0.0027	0.0012	0.0051	0.0066	0	0.0051
	100	231	0.0357	0.0099	0.072	0.0165	0.0027	0.0543
	150	347	0.0492	0.0447	0.0966	0.0165	0.0045	0.0714
	200	462	0.06	0.0468	0.0864	--	--	0.0834
Open 1/2 in	50	116	0.0306	0.0057	0.024	0.018	0.0006	0.0099
	100	231	0.0612	0.0207	0.0396	0.0477	0.0021	0.0047
	150	347	0.0864	0.0306	0.0537	0.078	0.0039	0.0696
	200	462	0.0942	0.0423	0.0609	--	--	0.0864
Open 1 in	50	116	0.0183	0.0117	0.0201	0.0171	0.0006	0.0195
	100	231	0.0753	0.0234	0.0387	Ruptured at splice	0.0012	0.0417
	150	347	0.0612	0.03	0.0558	--	0.0021	0.0657
	200	462	0.0786	0.0279	0.0609	--	--	0.0678
Open 1 1/2in	50	116	0.0333	0.0081	0.0267	--	0	0.016
	100	231	0.0696	Ruptured, not at splice	0.0636	--	0.0012	0.0336
	150	347	Ruptured, not at splice	--	0.0564	--	0.0018	0.0543
	200	462	--	--	0.0759	--	--	0.0876
Reclosed	50	116	--	--	0.0186	--	0	0.0072
	100	231	--	--	0.0318	--	0.0012	0.0588
	150	347	--	--	0.0408	--	0.0018	0.0597
	200	462	--	--	0.048	--	--	0.0702
Open 1 in and torque applied	50	116	--	--	0.0183	--	0.0006	0.0162
	100	231	--	--	0.0384	--	0.0006	0.0357
	150	347	--	--	0.0525	--	0.0018	0.0588
	200	462	--	--	0.0636	--	--	0.0678
	Note: PVC-14 was 6 in. wide; other waterstops were 9 in. wide							

Table 2

Tensile Strength of Elongation of Splices (Dumbbells)

		Tensile Strength of Splices			Elongation of Splices		
Waterstop	**Tensile Strength of Unspliced Material psi**	**PSI**	**% of Strength of Un-spliced Material**	**Elongation of Un-spliced Material, %**	**%**	**% of Elongation of Un-spliced Material**	**Method of Preparation of Dumbbells**
PVC-2(2)	1030	950	92	250	225	90	Ground
PVC-2A(2)*	1200	1130	94	200	175	88	Ground
PVC-3(2)	1110	960	86	225	225	100	Ground
PVC-4	950	860	91	250	225	90	Ground
PVC-3A(2)	1360	1310	96	250	225	90	Ground
PVC-5	1160	950	82	350	250	71	Ground
PVC-7(2)	2020	1480	73	300	200	67	Ground
PVC-14	2460	1380	56	350	100	29	Sliced
PVC-9A(4)	1820	1340	74	410	270	66	Sliced**
NEOR-1	2570	1070	42	470	280	60	Sliced**
NEOR-2	2800	1460	52	370	230	62	Sliced**
NR-1	2350	1430	61	500	330	66	Ground
NR-2(2)	2880	1270	44	490	280	57	Sliced**
SR-1	2170	580	27	320	130	41	Sliced**
SR-2	1800	790	44	280	150	54	Sliced**
SR-3	2100	370	18	330	125	38	Ground
PVC-15(2)	2060	1720	83	405	345	85	Sliced

* Material too thin to prepare regulation dumbbells

** All specimens of the unspliced material were ground down, but all specimen of the spliced material were sliced.

Table 3

Results Obtained by Testing Entire Splices in Tension

			Tensile Strength of Dumbbells Across Splice		Tensile Strength of Total Splice (median of 5)		
Waterstop	**Manufacturer**	**Tensile Strength of Dumbbells from Finished Waterstop PSI**	**PSI**	**% of Unspliced Strength**	**%**	**% of Elongation of Unspliced Material**	**Method of Preparation of Dumbbells**
NR-1	B	2350	1430	61	575	24	40
NR-1(2)	B	3275	1430	44	180	5	13
NR-1(2)A	B	3315	1080	33	260	8	24
NR-2(2)	D	2880	1270	44	1000	35	79
NR-4	H	2720			495*	18	68
NR-4A	H	3120			320*	10	42
SR-2	D	1800	790	44	315	18	40
SR-3	D	2100	370	18	380	18	103
NEOR-2	D	2800	1460	52	445	16	30
PVC-15(2)**	F	2060	1720	83	890	43	52

* Splices were made using raw materials and vulcanizer from manufacturer B. The strength results probably would have been greater had raw materials and equipment from manufacturer H been used.

**Polyvinyl chloride, factory-made splices; all other samples were rubber, with splices vulcanized at WES

Table 4

Results Obtained by Testing Entire Splices in Tension

				Standard Dumbbells			Strips		Full Size		
										Splice Glued into Sleeves (Median	
Manufacturer	**Water-stop**	**Treatment Before Test***	**Tensile Strength of Unspliced Material PSI**	**Splice Vulcanized (Median of 3)**	**Splice Glued** 45 degree angle (Median of 3)**	**Splice Reglued** 45 degree angle (Median of 3)**	**Splice Vulcanized (Median of 3)**	**Splice Glued** 45 degree angle (Median of 3)**	**Splice Vulcanized (Median of 5)**	**Original Glue*****	**New Glue******
B	NR-1(2)	A	3185	711	545	620	1140	325			
B	NR-1(2)A		3380	935	790	660	960	540			
H	NR-4		2910	545	210	1020	585	170			
H	NR-4A		3120	635		405	755	200			
B	NR-1(2)	B	3185	1120	275	590	1590	270	165	300	300
B	NR-1(2)A		3380	1080	1115	590	1455	330	260	245	350
H	NR-4		2910	725	555	585	1300	235	495		
H	NR-4A		3120	770		585	1100	200	325		
B	NR-1(2)	C	3185	1120	525		1130	305			
B	NR-1(2)A		3380	1205	465		1225	410			
H	NR-4		2910	695	705		985	280			
H	NR-4A		3120	675	135		1195	300			
B	NR-1(2)	D	3185	1060	445	407	1350	250			
B	NR-1(2)A		3380	1105	270	540	920	395			
H	NR-4		2910	550	320	570	1295	160			
H	NR-4A		3120	970	Broken	300	1125	180			
B	NR-1(2)	E	3185	1075	665	490	1525	450			
B	NR-1(2)A		3380	1070	420	525	1165	200			
H	NR-4		2910	575	440	735	1260	135			
H	NR-4A		3120	725		385	945	165			

* A= tested 24 hr after splicing, B= tested 7 days storage at 72F, C= tested after 48 hr storage in oxygen at 300psi and 70F, D=tested after 7 days storage at 100F, and E= tested after 7 days storage at 35F

** A glue especially formulated for splicing rubber waterstops and marked by manufacturer E was used. Samples NR-4 AND -4A are from the same manufacturer

*** Original glue furnished by manufacturer B to be used when their splicing sleeves were used

**** New glue, 5318-3M(EC-870), furnished by manufacturer B

Table 5

Total Loads Required to Break Various Splices, 1lb

					Full-Size Loops			
		Strips				Glued Sleeve		
Waterstop	**Treatment Before Test**	**Vulcanized**	**45° Glued**	**Glued Lapped**	**Vulcanized**	**Original Glue**	**New Glue**	**Glue Lapped**
NR-1(2)	A	330	75	85				
NR-1(2)A		265	140	85				
NR-4		170	50	80				
NR-4A		150	40	40				
NR-1(2)	B	465	70	80	450	760	760	
NR-1(2)A		400	90	70	740	700	1000	
NR-4		370	70	85	1390			380
NR-4A		220	35	50	710			280
NR-1(2)	C	320	80	80				
NR-1(2)A		330	115	85				
NR-4		310	80	85				
NR-4A		245	40	55				
NR-1(2)	D	390	70	80				
NR-1(2)A		260	110	80				
NR-4		400	50	85				
NR-4A		240	35	60				
NR-1(2)	E	440	120	80				
NR-1(2)A		325	55	85				
NR-4		385	40	85				
NR-4A		195	35	50				

Note: Each test value is a median of 3 values

* A= tested 24 hr after splicing, B= tested after 7 days storage at 72F , C= tested after 48 hr storage in oxygen at 300 psi and 70F, D= tested after 7 days storage at 100 F, and E= tested after 7 days storage at 35F

Table 6									
Results of Tests as Required by Corps of Engineers Specifications for Rubber Waterstops									
							Tensile Strength of Dumbbells		
Manufacturer	**Waterstop**	**Source**	**Ultimate Elonga-tion* %**	**Shore Hard-ness**	**Water Absorp-tion, %**	**Compression Saturation, %**	**PSI**	**% of Original Strength After Aging**	**Tensile Strength of Spliced Waterstop, % of Strength of Unspliced Material**
B	NR-1(2)	Sheets	555	61		23.7	3885	8	
B	NR-1(2)A	Sheets	555	61		23.7	3885	88	
H	NR-4	Sheets	550	66	2.2	25	3260	92	
H	NR-4A	Sheets	550	66	2.2	25	3260	92	
B	NR-1(2)	Finished Wa-terstop	510				3185		35
B	NR-1(2)A	Finished Wa-terstop	500				3380		32
H	NR-4	Finished Wa-terstop	495				2910		
H	NR-4A	Finished Wa-terstop	510				3120		

* Each test value is a median of 5 values

Summary (presented absolutely verbatim)

The results indicate the following:

1.Corrugated or ribbed-flange waterstops and dumbbell waterstops are both effective in retaining water when care is exercised in splicing and embedding them, with the former type being slightly more effective. It is necessary to re-form the continuity of the ribs across the splice for best results in retaining water.

2.The tensile strength of a fused splice, used in splicing PVC waterstops, will average nearer the strength of the unspliced material than will that of a vulcanized splice of either natural or neoprene rubber.

3.The method developed for testing the strength of an entire splice is satisfactory for comparing the strength of various types of splices; with the development of proper specification requirement limits, it probably would be satisfactory as a standard acceptance test for splices in waterstops.

4.The glued sleeve splices tested were stronger than the vulcanized splices of the same waterstop, whereas the glued lapped splices tested were not as strong as the vulcanized splices.

5.Apparently PVC is the best currently* available material for the production of plastic waterstops from the standpoints of both quality and economy; however, waterstops extruded from ethylene copolymer have recently been introduced and recommended for use where movement of less than 20% of the original joint opening is expected. This recommendation is made, not because the material does not possess the necessary elongation properties, but because recovery is minimal. The manufacturer states that the main advantages of this material are its rigidity and good chemical resistance.

6.Polyethylene has been extruded into a waterstop shape by one manufacturer for experimental purposes. The manufacturer states that this material is not suitable for waterstop production because it is not sufficiently flexible and it is difficult to splice. Aging characteristics of the polyethylene waterstop in its standard form are not good. Addition of carbon black improves the aging characteristics but also increases the production costs.

published in 1965

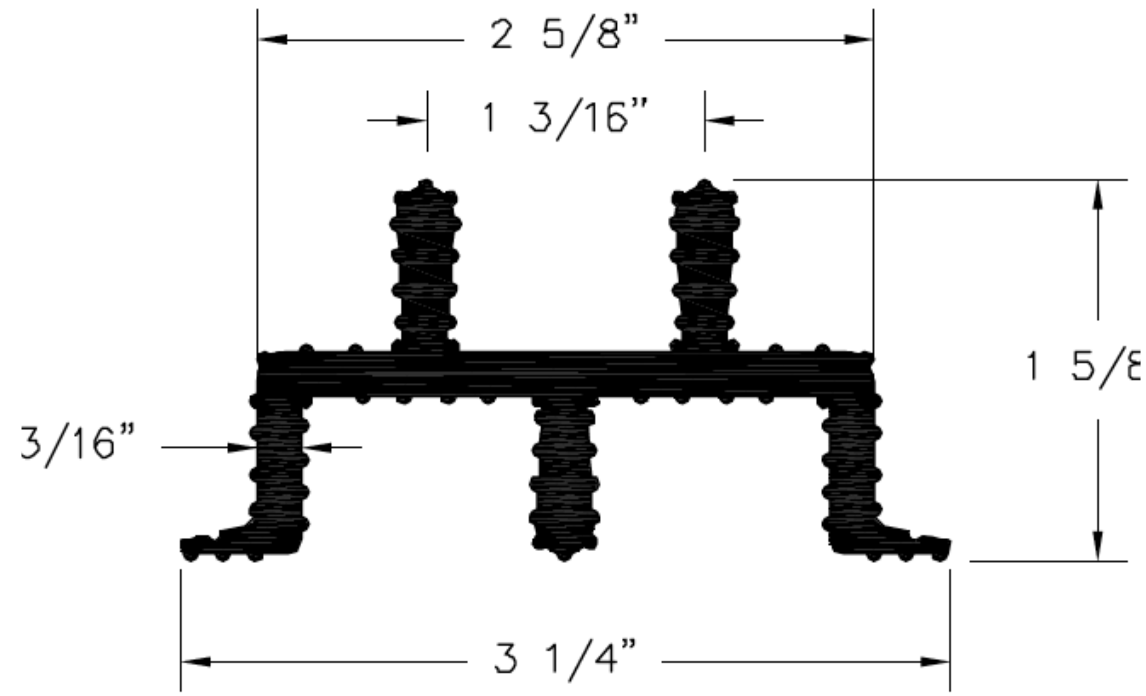
Water Retentivity of Labyrinth—Shaped Waterstops

This report was initiated on May 2nd, 1966, by the USACOE, and published in January 1971. The report's purpose was to evaluate and report on the effectiveness of a new style of waterstop being marketed as an alternative to the conventional dumbbell or ribbed profiles: Labyrinth waterstop.

Labyrinth waterstop, which by its design forms a keyed joint when installed correctly and mitigates the splitting of forms, tests quite well (as you can see in the following tables) in **closed joints**. However, it performs quite poorly as the joint opens up.

SM

Gallery 15.1 Labyrinth Waterstop



A typical labyrinth style waterstop design.

Table 1

Water Retentivity of Labyrinth Waterstops PVC-16B and PVC-16C

Joint Condition	Water Pressure psi	Simulated Head of Water, ft	PVC-16B			PVC-16C		
			Round 1	Round 2	Round 3	Round 1	Round 2	Round 3
Closed	50	116	*	0.007	0.015	0.002	*	0.001
	100	231	*	0.016	0.035	0.004	*	0.004
	150	347	*	0.035	0.035	0.008	*	0.006
	200	462	*	0.04	0.065	0.009	*	0.009
Open 1/4 in	50	116	*	3.543	11.809	0.378	*	0.59
	100	231	*	**	**	**	*	**
	150	347	*	**	**	**	*	**
	200	462	*	**	**	**	*	**
Reclosed	50	116	*	0.015	0.027	0.009	*	0.004
	100	231	*	0.088	0.03	0.013	*	0.026
	150	347	*	0.106	0.053	0.035	*	0.035
	200	462	*	0.119	0.074	0.044	*	0.047
Closed	50	116	0.018	--	--	0.009	--	--
	100	231	0.041	--	--	0.041	--	--
	150	347	0.05	--	--	0.062	--	--
	200	462	0.077	--	--	0.067	--	--
Open 1/8 in	50	116	0.018	--	--	0.009	--	--
	100	231	0.037	--	--	0.018	--	--
	150	347	0.304	--	--	0.089	--	--
	200	462	**	--	--	0.65	--	--
Reclosed	50	116	**	--	--	**	--	--
	100	231	**	--	--	**	--	--
	150	347	**	--	--	**	--	--
	200	462	**	--	--	**	--	--

* Data not included because excessive leakage was considered to be caused by factors other than waterstop shape

** Test discontinued because of excessive leakage

Table 2

Water Retentivity of Conventional and Labyrinth Waterstop Shapes

			PVC-11		**PVC-13**	**PVC-14**			PVC-16B		PVC-16C	
Joint Condition	**Water Pressure PSI**	**Simulated Head of Water, ft**	**Ribs not Reformed Across Splice**	**Ribs Reformed Across Splice**	**Ribs Not Reformed**	**Ribs not Reformed Across Splice**	**Ribs Reformed Across Splice**	**NR-3**	**First Series**	**Second Series**	**First Series**	**Second Series**
Closed	50	116	0.003	0.001	0.005	0.007	0	0.005	0.011	0.018	0.002	0.009
	100	231	0.035	0.01	0.072	0.016	0.003	0.054	0.026	0.041	0.004	0.047
	150	347	0.049	0.045	0.097	0.017	0.005	0.071	0.03	0.95	0.007	0.062
	200	462	0.06	0.047	0.086	--		0.083	0.053	0.077	0.009	0.067
Open 1/8 in	50	116	--	--	--	0.018	0.001	0.01	--	0.018	--	0.009
	100	231	--	--	--	0.048	0.002	0.045	--	0.037	--	0.018
	150	347	--	--	--	0.078	0.004	0.07	--	0.304	--	0.089
	200	462	--	--	--	--	--	0.086	--	Excessive leakage	--	0.65
Open 1/4 in	50	116	--	--	--	--	--	--	7.676	--	0.484	Excessive leakage
	100	231	--	--	--	--	--	--	Discontinued	--	Discontinued	Excessive leakage
	150	347	--	--	--	--	--	--	Discontinued	--	Discontinued	Excessive leakage
	200	462	--	--	--	--	--	--	Discontinued	--	Discontinued	Excessive leakage
Open 1/2 in	50	116	0.031	0.005	0.024	--	--	--	--	--	--	--
	100	231	0.061	0.021	0.04	--	--	--	--	--	--	--
	150	347	0.085	0.031	0.054	--	--	--	--	--	--	--
	200	462	0.094	0.042	0.061	--	--	--	--	--	--	--
Open 1 in	50	116	0.018	0.012	0.02	0.017	0.001	0.02	--	--	--	--
	100	231	0.075	0.023	0.039	Ruptured, not at splice	0.001	0.042	--	--	--	--
	150	347	0.061	0.03	0.056	--	0.002	0.065	--	--	--	--
	200	462	0.079	0.028	0.061	--	--	0.068	--	--	--	--
Open 1 1/2in	50	116	0.033	0.008	0.027	--	0	0.015	--	--	--	--
	100	231	0.07	Ruptured, not at splice	0.056	--	0.001	0.034	--	--	--	--
	150	347	Ruptured, not at splice	--	0.064	--	0.002	0.054	--	--	--	--
	200	462	--	--	0.076	--	--	0.088	--	--	--	--
Reclosed	50	116	--	--	0.019	--	0	0.007	0.021	Excessive leakage	0.006	Excessive leakage
	100	231	--	--	0.032	--	0.001	0.059	0.059	Excessive leakage	0.02	Excessive leakage
	150	347	--	--	0.041	--	0.002	0.06	0.08	Excessive leakage	???	Excessive leakage
	200	462	--	--	0.043	--	--	0.07	0.095	Excessive leakage	???	Excessive leakage

Final Report of Effect of Exposure

The following tables represent test samples exposed between 1957 to 1959. In March of 1966, two of the three exposed samples of each material at each condition of stress, were returned to the laboratory for evaluation.

Some of the samples were lost during exposure. The results of the field exposure and laboratory evaluation before 1966 were reported as Report 6 of the Technical Report No. 6-546 series. In 1973, the remaining sample from each exposure station, where one existed, was returned to the laboratory and evaluated. This report is an updating of Report 6. Of the rubber and synthetic rubber samples exposed, all were affected by exposure under most of the nine exposure conditions, with the more pronounced effect being on the specimens exposed in the hot sunlight (Jackson outdoors and St. Augustine) and in contaminated water (St. Louis and New Orleans). It appeared that, generally, neoprene best withstood most exposure conditions, with natural, butyl, and service rubber following, in that order. As with rubber, PVC was more affected by hot sunlight and air than by the other exposure conditions. Several samples lost plasticizer and became hard and brittle, especially at New Orleans in contaminated water. Both rubber and PVC samples were more affected by exposure when stressed than when unstressed and were less affected when embedded in concrete than when not embedded. Results indicate that PVC, neoprene, and natural rubber are all satisfactory materials for the production of nonmetallic waterstops. A good grade PVC would probably have a longer service life under most conditions. However, there is more danger of getting a poor grade material unless laboratory testing for compliance with rigid specifications is required.

	TABLE 1 — Summary of Condition of Specimens After Exposure as Determined by Visual Inspection									
				Jackson			St. Louis District		New Orleans District	
Specimen No.	Stream Condition	Treat Island	St. Augustine	Outdoors	Indoors	Sulfate	Cold Fresh Water	Cold Contaminated Water	Warm Fresh Water	Warm Contaminated Water
Butyl-1	Unstressed	Sound	Sound at 3 yr then lost	Sound	Sound	Sound	Sound at 5 yr	Crazing at 4 yr	Sound at 1 yr then lost	Sound
	Bent	Crazing at 5 yr	Sound at 3 yr then lost	Crazing at 1 yr, Cracked at 2 yr	Sound	Sound	Sound at 5 yr	Crazing at 2 yr	Sound at 4 yr then lost	Sound
	Embedded	Sound	Crazing at 3 yr	Sound	------	------	------	------		------
NEOR-1	Unstressed	Sound	Sound	Sound	Sound	Sound	Sound at 5 yr	Crazing at 3 yr	Sound	Sound
	Bent	Crazing at 12 yr then lost	ound at 3 yr then lo	Cracked at 1 yr	Sound	Sound	Sound at 5 yr	Crazing at 3 yr	Sound	Sound
	Embedded	Sound	Crazing at 4 yr	Sound	------	------	------	------	------	------
NEOR-2	Unstressed	Sound	Sound	Sound	Sound	Sound	Sound at 5 yr	Crazing at 3 yr	Sound at 1 yr then lost	Sound
	Bent	Sound	Cracked at 4 yr	Sound	Sound	Sound	Sound at 5 yr	Crazing at 2 yr	Sound at 2 yr then lost	Sound
	Embedded	Sound	Crazing at 4 yr	Crazing after 5 yr	------	------	------	------	------	------
NR-1	Unstressed	Crazing at 11 yr	Crazing at 4 yr	Crazing at 3 yr	Sound	Sound	Crazing at 1 yr	Crazing at 2 yr	Soft at 1 yr, crazing at 5 yr	Sound
	Bent	Crazing at 1 yr, cracked at 11 yr	Sound at 3 yr then lost	Crazing at 1 yr, Cracked at 2 yr	Sound	Sound	Crazing at 1 yr, Cracked at 5 yr	Crazing at 2 yr	Soft at 1 yr, crazing at 5 yr	Sound
	Embedded	Crazing at 3 yr	Crazing at 4 yr	Cracking at 3 yr	------	------	------	------	------	------
NR-2	Unstressed	Crazing at 11 yr	Crazing at 4 yr	Sound	Sound	Sound	Crazing at 1 yr	Crazing at 4 yr	Sound at 1 yr then lost	Sound
	Bent	Crazing at 1 yr, cracked at 11 yr	Sound at 3 yr then lost	Crazing at 2 yr	Sound	Sound	Crazing at 1 yr, cracked at 5 yr	Crazing at 2 yr	Sound at 4 yr then lost	Sound
	Embedded	Crazing at 4 yr	Crazing at 3 yr	Crazing at 3 yr	------	------	------	------	------	------
SR-1	Unstressed	Crazing at 11 yr	Crazing at 4 yr	Crazing at 5 yr	Sound	Sound	Crazing at 1 yr	Crazing at 3 yr	Sound	Sound
	Bent	Cracked at 2 yr, badly cracked at 5 yr	Sound at 3 yr then lost	Badly cracked at 2 yr	Sound	Sound	Crazing at 1 yr, Cracked after 4 yr	Crazing at 2 yr	Sound	Sound
	Embedded	Crazing at 3 yr	Crazing at 4 yr	Badly cracked at 2 yr, torn at 5 yr	------	------	------	------	------	------
SR-2	Unstressed	Crazing at 11 yr	Cracked at 4 yr	Sound	Sound	Sound	Crazing at 1 yr	Crazing at 3 yr	Sound at 7 yr then lost	Sound
	Bent	Cracked at 1 yr, badly cracked at 5 yr	Cracked at 3 yr	Cracked at 2 yr	Sound	Sound	Crazing at 1 yr, Cracked at 4 yr	Crazing at 3 yr, Cracked at 4 yr	Sound at 5 yr then lost	Sound
	Embedded	Crazing at 3 yr	Crazing at 3 yr	Completely torn at 1 yr	------	------	------	------	------	------
SR-3	Unstressed	Crazing at 11 yr	Cracked at 4 yr	Crazing at 3 yr	Sound	Sound	Crazing at 1 yr	Crazing at 3 yr	Sound	Sound
	Bent	Cracked at 2 yr, badly cracked at 5 yr	Cracked at 3 yr	Badly cracked at 2 yr	Sound	Sound	Cracked at 1 yr, cracked at 4 yr	Cracked at 2 yr, cracked at 5 yr	Sound at 1 yr then lost	Sound
	Embedded	Crazing at 3 yr	Crazing at 11 yr	Badly cracked at 2 yr	------	------	------	------	------	------
PVC-2	Unstressed	Curled at 10 yr	Sound at 6 yr then lost	Crazing at 3 yr	Sound	------	------	------	------	------
	Bent	Crazing at 11 yr	Sound at 2 yr then lost	Crazing at 2 yr, cracked at 16 yr	Sound	------	------	------	------	------
	Embedded	Sound	Crazing at 3 yr	Crazing at 6 yr	------	------	------	------	------	------
PVC-2(2)	Unstressed	------	------	------	------	Sound	Broken went bent at low temperature for inspection at 3 yr	Sound	Sound at 4 yr then lost	Sound
	Bent	------	------	------	------	Sound	Sound	Sound	Sound at 4 yr then lost	Sound
	Embedded	------	------	------	------	------	------	------	------	------

*Specimen conditions given without time limit are conditions after full exposure time

*All specimens lost after 5 yr exposure as a result of an ice jam.

	TABLE 1 (continued)									
				Jackson			St. Louis District		New Orleans District	
Specimen No.	Stream Condition	Treat Island	St. Augustine	Outdoors	Indoors	Sulfate	Cold Fresh Water	old Contaminated Wat	Warm Fresh Water	arm Contaminated Wa
PVC-2A	Unstressed	Sound	------	Sound	Sound	------	------	------	------	------
	Bent	Sound	------	Sound	Sound	------	------	------	------	------
	Embedded	Torn at 2 yr	------	Crazing at 13 yr	------	------	------	------	------	------
PVC-2A(2)	Unstressed	------	------	------	------	Sound	Broken when bent at low temperature for inspection at 3 yr	Broken when bent at low temperature for inspection at 2 yr	Sound at 4 yr, then lost	Sound
	Bent	------	------	------	------	Sound	Sound	Sound	Sound at 4 yr, then lost	Sound
	Embedded	------	------	------	------	------	------	------	------	------
PVC-3	Unstressed	Sound	Sound at 2 yr, then lost	Crazing at 9 yr	Sound	------	------	------	------	------
	Bent	Sound	Sound at 2 yr, then lost	Crazing at 8 yr	Sound	------	------	------	------	------
	Embedded	Concrete broken at 2 yr	Crazing at 5 yr	Crazing at 13 yr	------	------	------	------	------	------
PVC-3(2)	Unstressed	------	------	------	------	Sound	Sound	Sound	Sound at 4 yr, then lost	Sound
	Bent	------	------	------	------	Sound	Sound	Sound	Sound at 4 yr, then lost	Sound
	Embedded	------	------	------	------	------	------	------	------	------
PVC-3A	Unstressed	Sound	------	Sound	Sound	------	------	------	------	------
	Bent	Sound	------	Sound	Sound	------	------	------	------	------
	Embedded	Sound	------	Crazing at 13 yr	------	------	------	------	------	------
PVC-3A(2)	Unstressed	------	------	------	------	Sound	Sound	Sound, one cracked when bent at low temperature	Sound at 4 yr, then lost	Sound
	Bent	------	------	------	------	Sound	Sound	Sound	Sound at 4 yr, then lost	Sound
	Embedded	------	------	------	------	------	------	------	------	------
PVC-4	Unstressed	Discolored	Sound	Crazing at 1 yr	Sound	Sound	Sound	Sound	Sound	Sound
	Bent	Slight cracking at 16 yr	Sound at 2 yr, then lost	Crazing at 5 yr	Sound	Sound	Sound	Sound	Sound	Sound
	Embedded	Sound	Crazing at 5 yr	Crazing at 13 yr	------	------	------	------	------	------
PVC-5	Unstressed	Discolored	Sound	Crazing at 1 yr	Sound	Sound	Sound	Sound	Sound at 1 yr, then lost	Sound
	Bent	Slight cracking at 16 yr	Sound at 2 yr, then lost	Crazing at 5 yr	Sound	Sound	Sound	Sound	Sound at 4 yr, then lost	Sound
	Embedded	Sound	Crazing at 5 yr	Crazing at 13 yr	------	------	------	------	------	------
PVC-7(2)	Unstressed	------	------	------	------	Sound	Sound	Cracked at 5 yr	Sound	Sound
	Bent	------	------	------	------	Sound	Sound	Cracked at 4 yr	Sound at 4 yr, then lost	Sound
	Embedded	------	------	------	------	------	------	------	------	------
PVC-9A(4)	Unstressed	Shrunken at 16 yr	Sound at 2 yr, then lost	------	------	Sound	Sound	Sound	Sound	Sound
	Bent	Shrunken at 16 yr	Sound at 2 yr, then lost	------	------	Sound	Sound	Sound	Sound at 4 yr, then lost	Sound
	Embedded	Sound, sample lost 1965	Crazing at 5 yr	------	------	------	------	------	------	------

Additional Waterstop Testing Methods

Hydrostatic Head Pressure Testing
Because ASTM (American Society of Testing and Materials) or ISO (International Standards Organization) testing standards do not currently exist for the testing of waterstop, we have devised our testing methodologies to test waterstop for leakage (hydrostatic head pressure resistance).

The illustration on the next page and the accompanying sidebar text illustrates the JPS method, which is undoubtedly similar to other manufacturers who test their waterstop profiles*.

**It has been my experience that not all manufacturers can provide leakage test reports, but instead supply some form of federal report, such as the reports presented in Section 1 and 2 of this chapter.*

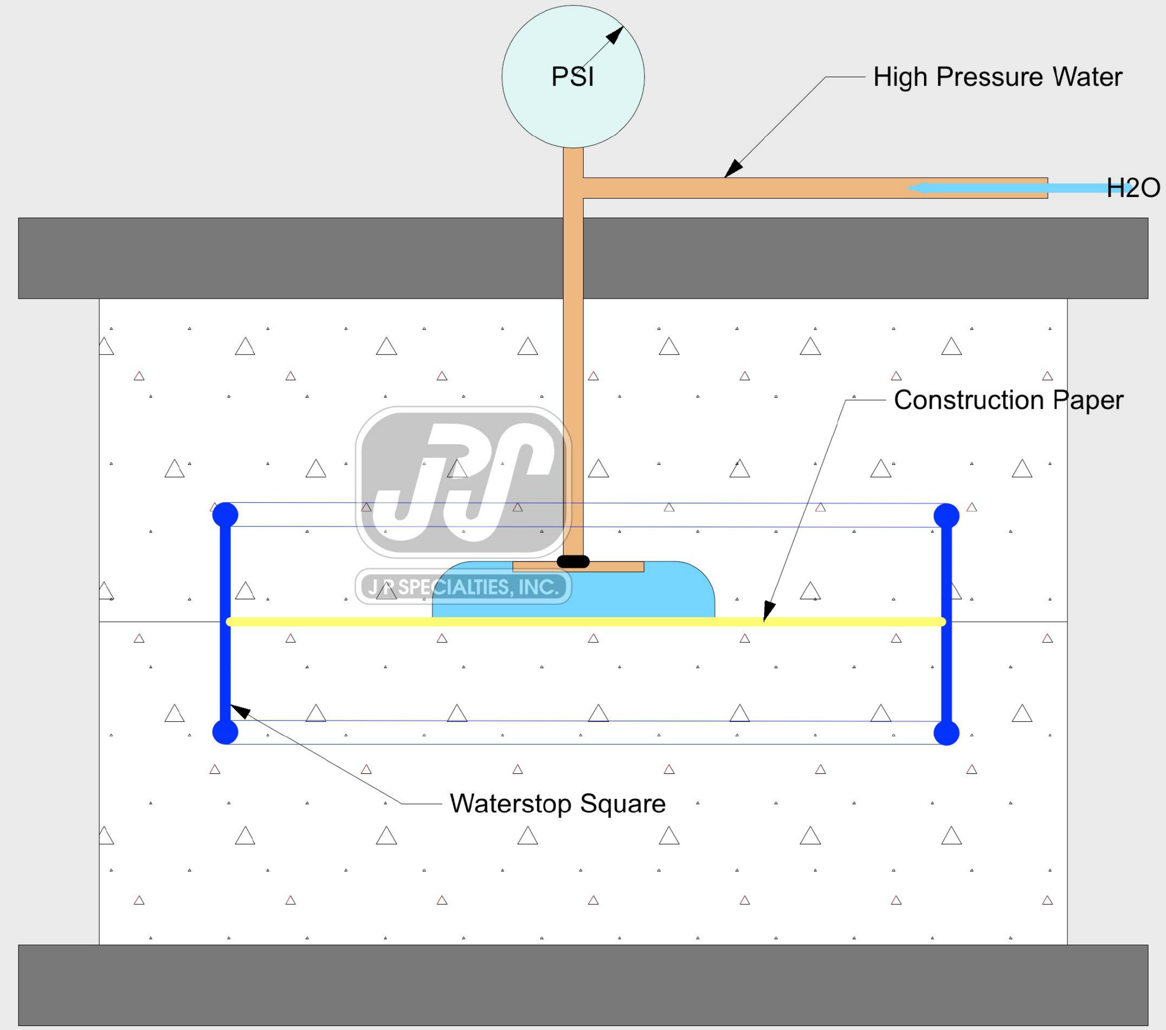
Movie 15.1 Spark Tester

Levi Stewart demonstrates the proper use of the ElectroTest Spark Tester by J P Specialties, Inc.

Holiday Spark Test
Use of Portable Holiday Detectors (also known as Spark Testers) is limited to finding defects in plastic or rubber waterstop. Testing should be conducted clear of personnel not involved in the testing procedure. Personnel operating Portable Holiday Detectors should be aware of the safety limitations imposed by their environment. The operator should have an assistant to ensure that unauthorized personnel is kept clear of the testing area.

Danger: Portable Holiday Detectors create an arc or spark. Use of a Portable Holiday Detector in or around combustible or flammable environments can result in an explosion. When operating in any potentially hazardous area, consult with the plant or site safety officer before proceeding with a holiday detection test in any potentially hazardous or suspect area.

Principles of Operation
Holiday detectors inspect the waterstop weld areas for pinholes. They work by generating a voltage high enough to pass through a pinhole or defect to a steel plate. A holiday detector applies a voltage to the outside of the waterstop. When a pinhole or defect is detected, the electrical arc changes both visibly and audibly.



1. The Earth Shield waterstop was factory welded at corners to form a square with the top facing inward to the center of the test block.
2. A void was formed in the center of the concrete test block so that water could flow through the joint, to the test specimen, under pressure.
3. A horizontal, artificial joint was made using roofing paper. The first lift of the concrete was placed and the test specimen inserted in to the concrete. When the concrete was set, the roofing paper was placed everywhere that the second lift of concrete would be in contact with the first lift.
4. The joint was tested at three different widths: closed, 1/8”-open, and 1/2”-open.
5. Three different pressures were used during testing: 10, 25, and 50 psi; these represent approximately 23, 58, and 110 feet of water, respectively.
6. Placement of Concrete — The concrete was placed in six-inch lifts, resulting in the test specimen and the joint being located in the center and middle of the test block. A typical 4,500 psi design mix was used. The batch weights for the mix used for this project is provided below:

- Course aggregate — 210 lbs
- Fine aggregate — 130 lbs
- Cement — 86 lbs
- Water — 34-42 lbs

Chapter 16

Installation Failures

They say a picture is worth a thousand words. The following gallery illustrates some of the many potential installation failures for waterstop.

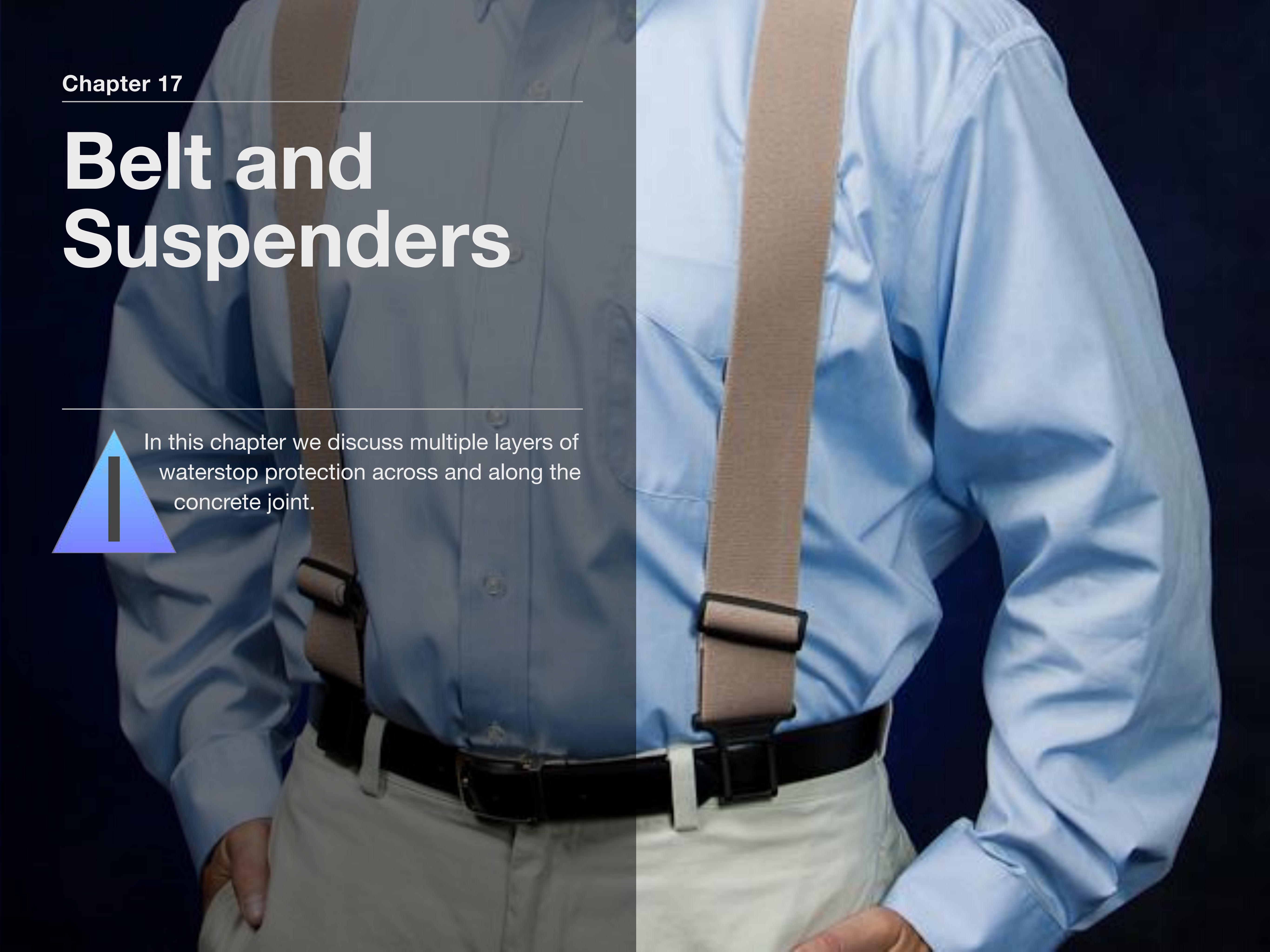
Gallery 16.1 Waterstop Installation Failures

Perhaps one of the singular worst waterstop install pictures ever! The material is not even welded together.

Chapter 17

Belt and Suspenders

In this chapter we discuss multiple layers of waterstop protection across and along the concrete joint.

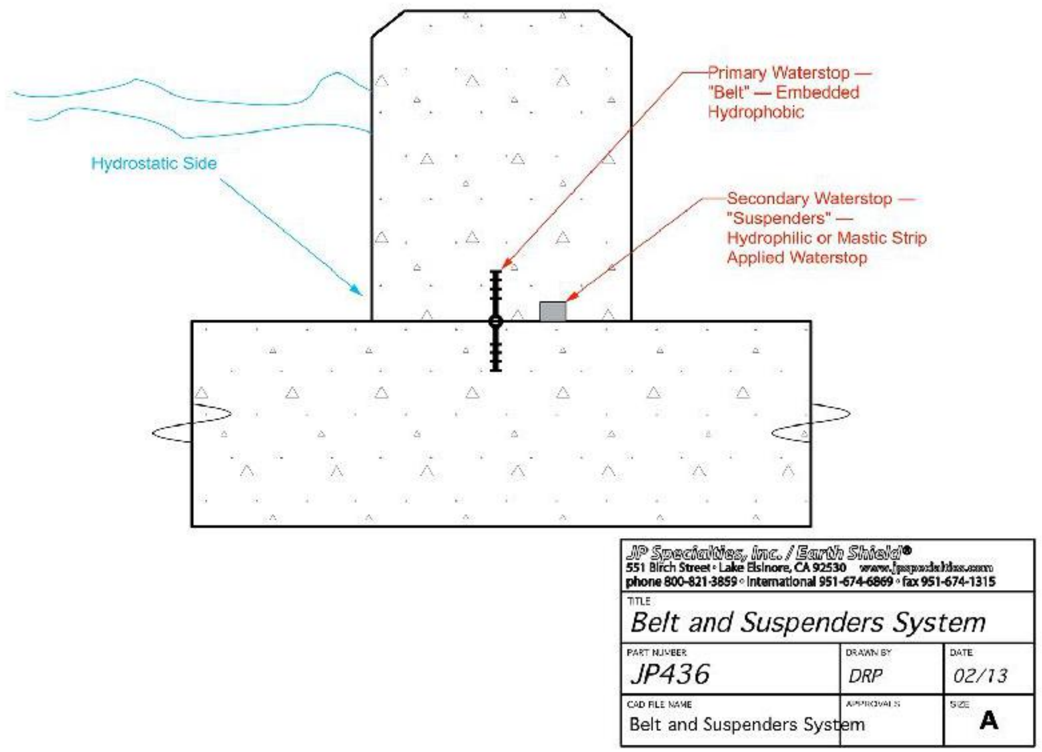


With waterstop, two is often better than one. If your concrete joint has the appropriate clearance (See Gallery 2.5), why not use one waterstop as your primary barrier and another as a secondary barrier as a kind of insurance policy? If the first system fails in any way due to manufacture or installation, the other system is there to ensure fluid-tight integrity at the concrete joint.

Because waterstop systems are relatively inexpensive, having a secondary product installed can be a wise and prudent investment. Let me be clear, if a hydrophobic waterstop is properly installed, there is no need for a secondary waterstop system. Regardless of polymer or manufacturer, these waterstop products only leak from poor installation procedures and a lack of quality assurance. In my near 30 years in this industry, I am yet to see a waterstop burst or fail due to high hydrostatic water pressure. However, I often see an improperly installed product that will result in failure and leakage.

A typical "belt and suspenders" approach would be to have an embedded hydrophobic on the high-pressure side of the joint and a hydrophilic or mastic strip-applied waterstop several inches away at the low-pressure side. An alternative secondary waterstop would be an injection tube system placed on the low-pressure side.

Gallery 17.1 Belt and Suspenders



A hydrophobic, embedded waterstop coupled with a hydrophilic, strip-applied waterstop makes a fantastic "belt and suspenders" system.

Another great option would be to utilize JPEB375 Integrated Capseal as the "belt" and JP211 Base Seal as the suspenders.

The benefits of redundancy in installed waterstop systems is great, and the cost is low, especially when amortized over the extended life of the concrete structure they are installed in.

Chapter 18

Closing Thoughts

Here are a few final thoughts on waterstop's role in environmental engineered concrete construction.

Having spent a significant amount of time in the waterstop industry, I feel that I have seen both the good and the bad that it offers including engineers who care about the entire MSI Process, as it relates to waterstop and liquid-tight concrete joints. These engineer designers work with me in a consultive role. Together, we conceptualize, analyze, and ultimately specify a truly fluid-tight waterstop system that will serve for the project's life cycle.

Contractors have perhaps the most crucial role in the MSI Process — the Installation, and again, I have seen both the good and the bad in this regard as well. Waterstop systems should be treated as structural elements and are genuinely a *keystone* in the long-term success or failure of a project. Contractors who attempt to cut corners with an "or equal" or poorly installing the specified material guarantee leaks and potential litigation. There are many available "free" services for the Contractor in the field from my company. Yet, many Contractors refuse to take them and instead treat waterstop as a commodity rather than as a technical item that requires knowledge and skill to execute properly.

In today's economy, Owners seek additional cost savings through a process euphemistically called "value engineering." I have witnessed owners completely omit waterstop, overwriting their design engineer, and sometimes even in violation of state or federal regulation. A classic example of this is the Owner who feels a sealant is "good enough." The picture in the center of the page does an excellent job illustrating why this is not so.

I have also encountered some really knowledgable and caring individuals in this business, but none more so than my father, Mr. William Poole. Bill Poole was a sales representative for a variety of concrete accessories manufacturers from 1972 until 2008, including several large PVC waterstop companies. He is the one who encouraged me to enter this field, educated me on all the things you can't learn in school, and helped me become a better man. I dedicate this book to him, for without him, I could never have written it.

I hope you enjoyed this short book on waterstop. To the best of my knowledge, it is the only one ever written, so chances are good you will want to save a copy on your (virtual) shelf for future reference.

I like to work closely with my customers and I make myself easily available. If you have a question or concern, please contact me at davidp@earthshield.com.

David R. Poole, *March 2013*

Glossary

Negative-side Waterproofing

Applied on existing construction in remedial applications where exterior (or positive-side) access is unfeasible. This method of waterproofing is applied to the *interior* of a structure.

Related Glossary Terms

Positive-side Waterproofing

Installed during new construction on the exterior of the new structure or after removing the surrounding grade and sub-grade around an existing one. Applied to the *outside* of a structure.

Related Glossary Terms

Thermoplastic

A type of polymer that has the advantage (over Thermosets) of being able to be reshaped and reformed by the application of heat. Heating the polymer softens it, eventually to a liquid state if great enough heat is applied, and when it cools it returns to its rigid state with its mechanical properties intact. Modern waterstops are all manufactured with thermoplastics, with the most popular being a highly plasticized PVC and a TPV (Thermoplastic Vulcanizate [aka TPER]).

Related Glossary Terms

Thermoplastic Elastomeric Rubber (TPER), Thermoplastic Polyolefin (TPO), Thermoplastic Vulcanizate (TPV), Thermoset

Thermoplastic Elastomeric Rubber (TPER)

A generic family name of polymers TPER (Thermoplastic Elastomeric Rubber) is comprised of a finely dispersed thermoset rubber (the soft domain) mixed in-situ with a thermoplastic (the hard domain). Within the TPER family there is TPO (Thermoplastic Polyolefin) that have a soft domain that is not cross-linked and TPV (Thermoplastic Vulcanizate) that have a fully cross-linked rubber phase. Waterstops are sold and marketed as TPER, TPE-R, and TPE Rubber and because this is a generic term it is very important for the designer to confirm if the waterstop is actually a TPO or a TPV, as the cross-linked TPV has vastly superior physical properties.

Related Glossary Terms

Thermoplastic, Thermoplastic Polyolefin (TPO), Thermoplastic Vulcanizate (TPV), Thermoset

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Thermoplastic Polyolefin (TPO)

A specific category of TPER (Thermoplastic Elastomeric Rubber) where the rubber phase (aka the soft domain) is comprised of a non-cross-linked thermoset rubber enabling the polymer to exhibit inferior mechanical properties (ultimate elongation, tensile strength, etc.) and chemical resistance compared to its cross-linked cousin TPV (Thermoplastic Vulcanizate). Like all TPERs, TPV is a two-phase product with a soft domain comprised of finely dispersed rubber mixed in-situ with the hard domain (a Thermoplastic) that allows for heat welding.

Related Glossary Terms

Thermoplastic, Thermoplastic Elastomeric Rubber (TPER), Thermoplastic Vulcanizate (TPV), Thermoset

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Thermoplastic Vulcanizate (TPV)

A specific category of TPER (Thermoplastic Elastomeric Rubber) where the rubber phase (aka the soft domain) is comprised of a fully cross-linked thermoset rubber enabling the polymer to exhibit superior mechanical properties (ultimate elongation, tensile strength, etc.) and chemical resistance over its non-cross-linked cousin TPO (Thermoplastic Polyolefin). Like all TPERs, TPV is a two-phase product with a soft domain comprised of finely dispersed rubber mixed in-situ with the hard domain (a Thermoplastic) that allows for heat welding.

Related Glossary Terms

Thermoplastic, Thermoplastic Elastomeric Rubber (TPER), Thermoplastic Polyolefin (TPO), Thermoset

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Thermoset

A polymer material that irreversibly cures, usually by high heat (>200°C), through a chemical reaction (e.g. two-part epoxy), or (infrequently) irradiation (e.g. electron beam). Thermoset materials, once hardened can not be reheated and reshaped or formed. Thermoset waterstops include: neoprene, EPDM, (ethylene propylene diene monomer), SBR (styrene butadiene rubber), and natural. Thermoset rubber waterstops share one serious flaw, in that they can not be heat-welded into continuous lengths or change of directions, necessitating the use of adhesives and mechanical coupling devices. Thermoplastic waterstops solve this shortcoming.

Related Glossary Terms

Thermoplastic
