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THE EVOLUTION OF JOINTING VITRIFIED CLAY PIPE

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Abstract

Advances made in the jointing of vitrified clay pipe during the last half century, illustrate the concern of the clay pipe industry to provide top quality jointing methods. Prior to this, the lack of standards for joint integrity meant testing for infiltration and Exfiltration was seldom implemented. Sewers were often designed simply to convey surface water, excessive groundwater and untreated sewage to area lakes, rivers, streams, estuaries and bays. Leakage was even designed into the system for cleaning purposes associated with high flow rates.

Early 19th century clay pipe jointing often utilized a field applied cement mortar, or other specialty jointing materials. The water tightness of these rigid joints depended on many factors including the skill of the work force and the stability of the bedding materials.

The need to replace rigid joints to provide a degree of flexibility in the pipe system caused a variety of flexible materials such as tars and mastics to come into use. However, they were not always successful in eliminating infiltration/exfiltration problems.

After World War II, increased population density along with economic and health considerations led to a rise in separate storm and wastewater systems. It was at this time that the water tightness of sewer lines became a requirement.
The clay pipe industry offers choices of many excellent jointing methods. Factory applied compression joints adhere to strict performance standards. The introduction of low profile plain end pipe led to the development of additional jointing alternatives. These along with reducer couplings, adaptors, repair collars, and o-rings are a few of the methods available from the clay pipe industry to meet today's needs of minimal infiltration/exfiltration, ease of installation, flexibility, durability and to prevent rood intrusion.

History of Jointing Vitrified Clay Pipe

Prior to 1940 the disposal of sewage in most cities was performed by the most expedient methods available. Metcalf and Eddy in American Sewerage Practice, reported; *"As late as 1924, 88% of the population in cities of 100,000 or over in the United States disposed of their sewage by dilution without prior treatment."* The design of sewers was concerned with the conveyance of sewage, surface drainage ad in some instances as an acceptable method of eliminating excessive ground water. Infiltration was designed into some systems to increase flow and dilute the contents. Many cities had combined sewers and it was common practice for sewer outfalls to discharge directly into lakes, rivers, streams, estuaries and bays.

It is not surprising; therefore, that the subject of jointing materials for sewer pipe was not high on a list of priorities. Testing for infiltration was not a major factor and when it was exercised, allowances as high as 1500 gallons per inch diameter, per mile, per day, were common.

Prior to World War II the most common and probably the first type or class of jointing clay pipe was with oakum and cement mortar. The joints produced were rigid and not resistant to earth movement. The joints were made in the trench by the workmen and the workmanship could be excellent or it could be poor. Water testing was infrequent, air testing and televising lines unknown.

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After World War II rapid population growth and the attendant increase in sewage flow opened new horizons in the design of sewerage systems. The construction of separate sewer was a matter of economic necessity, and sewage treatment plants were a must. It was not long before it was apparent that the increased flows and excessive infiltration would tax the capacities of treatment plants and pumping stations and greatly increase operating costs.

The clay pipe industry was approached by the engineering profession to undertake a study to come up with an improved method of jointing clay pipe. The request did not fall upon deaf ears and the National Clay Pipe Institute made this its number one priority.

The second type or class of joints for vitrified clay pipe was a group known as "Hot-Pour Compounds" put on the market in a number of varieties by numerous compound manufacturers. Recognizing that some of these compounds were failing to fulfill the objective for which they were intended, the Research Laboratory of the National Clay Pipe Manufacturers, Inc., undertook a complete survey of all hot-pour compounds and evaluated them on their ability to meet the following permanent performance requirements:

1. Tightness
2. Root Resistance
3. Flexibility
4. Corrosion Resistance

All of the compounds examined failed in one or more of the essentials forcing the Research Laboratory to direct its efforts towards developing a compound which would meet all the necessary requirements to qualify as a satisfactory and acceptable hot-pour compound. Such a compound was ultimately developed and its specification made available to all manufacturers of compound material. The name brands most commonly used were bitumastic compounds, CPI-2, GK, and JC-60, a plastic base sewer joint compound.

Hot-pour joints were made by the installer in the trench but were considerably more difficult than the cement mortar joint. It was essential that the kettle for heating the compound be thoroughly cleaned before using. This was particularly true if the kettle had been previously used for sulfur-bearing compounds. The compound was heated to a temperature of from 350 degrees to 450 degrees F, depending upon which compound was used, and the temperature maintained. Before pouring, the joint surfaces had to be clean and dry and a gasket of dry twisted jute caulked in the annular space.

After the joint was properly yarned a suitable runner was placed and the joint poured in a single pour so that the compound ran around the pipe, completely filling the annular space. The compound must (1) melt and flow freely at the pouring temperature, (2) adhere firmly to the surface of the sewer pipe and (3) have sufficient flexibility to permit a slight movement of the pipe without injury to the joint. It was very necessary that the compound be properly heated in order to assure getting a satisfactory joint.

Another joint for bell and spigot pipe introduced to the market about that time was the Tubular Joint which consisted of a specially designed hollow, collapsed, rubber ring capable of fitting within the annular space of a bell and spigot pipe, and of being inflated with a suitable grout mixture (Portland cement, TJ-41 and water) to a pressure of 50 to 60 psi, so as to produce a tight, flexible joint. The gasket (tube) had only one opening, a short tubing, similar in shape to the valve-stem of an inner tube, but of such size as to readily admit the grout mixture. Although the tubular joint had considerable merit it was a slow and cumbersome method of operation involving a relative high labor cost.

Although vast improvement was made over the cement mortar joint, results were still far short of the ultimate goal insofar as requirements for flexibility were concerned.

On the West Coast a rubber ring was introduced; but its success depended on the manufacturer supplying select pipe having both spigot and bell dimensions within small tolerance; it was not found to be economically feasible.

There was considerable activity throughout the entire industry and soon two new types of joint material were made available. The first had a plastic ring bonded to both the bell and spigot, while the second had a rectangular shaped rubber gasket mounted on a bonded plastic spigot ring.

Still not satisfied, the clay pipe industry engaged in further research for a jointing system that would be:

1. factory applied to perform to close tolerances.
2. flexible enough to be unaffected by possible earth movement.
3. resistant to sewer acids.
4. easily assembled.
5. tight enough to eliminate infiltration/exfiltration problems and root penetration.

A plastisol resin ring molded in the bell and on the spigot end was developed. This factory fabricated compression joint came very close to meeting all the performance requirements. Prefabricated compression joints quickly became the standard of the industry. In 1958 the adoption of *ASTM C425, "The Tentative Specification for Vitrified Clay Pipe Joints Using Materials Having Resilient Properties",* introduced a means to test compliance of joints to both end – users' and manufacturers' requirements.

Early Jointing Systems

There has been confusion about the quality of vitrified clay pipe jointing systems brought on by studies of inflow and infiltration required by the Environmental Protection Agency. In order for many cities to be eligible for sewer grant money from the EPA, there must be compliance with EPA requirements. Early studies of sewers found problems of infiltration to be widespread. The difficulties and expense encountered with the treatment of this extraneous flow into sewer systems lent a bad name to vitrified clay pipe. The erroneous and undeserved correlation of infiltration problems and vitrified clay pipe was to a great extent due to two things. First, as stated earlier, early sewer systems represented the state-of-the-art in their day and were, in many cases not designed to prevent infiltration. Second, since the majority of sewers in the country were vitrified clay pipe, it stood to reason that more problems would be found with clay than any other material.

Modern Jointing of Vitrified Clay Pipe

The development of prefabricated compression joint underwent many stages of evolution. Various materials and designs were evaluated in research sponsored by members of the National Clay Pipe Manufacturers' Institute. The factory applied compression joint has continued to have widespread industry acceptance.

Today's modern vitrified clay sewer pipe adheres to stringent requirements outlines by the American Society for Testing and Materials. Many manufacturers also have a set of quality standards they follow, as well as those standards set by municipalities across the United States.

ASTM standards were developed to aid in the elimination of infiltration problems. ASTM C425 addresses several currently used basic joint designs. All are compression joints. One type has sealing elements bonded to the bearing surfaces. Others have independent sealing elements. Elastomeric components used in joints must pass tests of chemical resistance, showing no weight loss when exposed to solutions of sulfuric acid and hydrochloric acid. Rubber components must pass the chemical tests and also meet requirements of tensile strength, ozone resistance, oven aging, water absorption, compression set and hardness. Any metal parts introduced into the joint must be resistant to corrosion.

After the individual materials used in jointing systems are tested for adherence to all specifications, completed joints are tested for performance. In 1958, infiltration of 500 gallons per inch of nominal diameter per mile of line per day, was an acceptable rate. The rate most commonly used today is 60 percent less or 200 gallons per inch diameter per mile per day. Representative specimens of pipe must pass plant tests performed under hydrostatic, misalignment, shear load and combination conditions. Pipe and joints must withstand an internal pressure of 4.3 psi without leaking. A shear load of 150 pounds per inch of nominal diameter with the same internal pressure must also be passed. Misalignment, or deflection, is based upon pipe diameter and length of the specimen. The test is also performed while maintaining hydrostatic pressure. ASTM testing of vitrified clay pipe joints was designed to insure earth loads, pipe line settling and certain degrees of improper bedding would not allow exfiltration of the sewer contents, as well as infiltration of excessive amounts of ground water.

Vitrified clay pipe lines are also examined after installation. Air tests, infiltration tests and/or television checks are standard practice.

Types of Prefabricated Joints

There are a variety of joints available from vitrified clay pipe manufacturers that adhere to the strict requirements of ASTM. Traditional bell and spigot compression joints are formed by an interference fit. A bead molded onto the bell casting insures a tight compression assembly. The assembly of the joint is simply a matter of applying a manufacturer supplied lubricant to the elastomer and pushing the pipe home.

Another system available on bell and spigot pipe is a polyester and o-ring joint. The polyester resin in cast onto the bell portion of the pipe with a lead in taper. The spigot end is cast with a groove or gland. At the job site, the o-ring, a flexible gasket, is positioned into the spigot groove. Joint lubricant is applied and the pipe can be shoved home.

Both the polyurethane and the polyester/o-ring joint are designed and manufactured under the rigid dimensional control. Resins of the highest quality are incorporated to yield lasting joints. Both systems have the advantages of being factory applied using thermosetting resins. Cure is induced by combining two components. In some instance, heat is added to economically speed cure of slow catalysts.

Other jointing systems have also been developed. A new low profile joint is based on principles in a design used over 2,000 years ago in ancient Ephesus. Plain end pipe, as it is known, has been made with diverse coupling systems. Fiberglas-reinforced polyester (FRP) bells have been wound directly onto pipe as large as 36 inch inside diameter. Spigots were poured with urethane. These low profile plain end pipe allow longer lengths to be produced.

In some areas, FRP bells have been replaced with a more economical PVC (polyvinyl chloride) collar. Since the load in the ditch is carried by the vitrified clay pipe and not the PVC, ring deflection is not a problem. The PVC collars are cut from extruded tube stock and heat formed to close diametric dimensions. Interference beads are molded during this process. Both ends of the plain end pipe are cast with urethane couplings. The PVC collar is installed with an air bladder and cylinder device on the factory end. The field end is sized to allow ease of field installation through the use of joint tube and a pipe puller or hand shove.

Another type of plain end pipe uses a urethane spigot and PVC bell. In this joint the urethane on the spigot end contains the interference bead and the PVC collar is smooth. The PVC collar is attached to the bell end of the pipe through the combined use of an adhesive and the heat shrinking of the collar.

A system that is in use for both normal installation and repair work of VCP is a flexible rubber coupling with heavy duty shear rings. For normal installations, the pipe is delivered with the factory end of the coupling in place. Stainless steel take up clamps on both ends allow a tight, but flexible, compression seal. This coupling can also be utilized as a repair sleeve with a split stainless steel shear ring around the outside diameter replacing the interior shear ring. This coupling simplifies branching of existing lines.

Connections into existing lines of dissimilar materials have been facilitated through the production of a wide range of fittings, adaptors and transition joints.

The joints in use in today’s modern sewer systems provide many benefits. Limited infiltration and exfiltration reduce sewage treatment plant loads, and prevent contamination of ground water supplies. The durable, high compression joints inhibit root penetration, thus reducing maintenance costs. The ease of assembly due to factory prefabrication reduces labor costs in the field, and lessens the possibility of poor field installation. The flexibility of today’s vitrified clay pipe joints adjusts to minor trench settlement and pipe movement.

Dedication and modern methodology within the industry have resulted in a tremendous improvement in the jointing of clay pipe. Commitment by the industry continues as research into new jointing elastomers is conducted. Like the profession it serves, vitrified clay sewer pipe joints have advanced from the pre-treatment days to today’s scientific age of sewage treatment.

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