CHAPTER 1: VITRIFIED CLAY PIPE

Figure 1-1: Modern Vitrified Clay Pipe (VCP) with factory-applied, compression joints, which "shall not leak," per ASTM C425.

Properties

Vitrified Clay Pipe (VCP) is uniquely suited for gravity sanitary sewers and is the longest lasting sewer pipe available. No other pipe material can match the properties or deliver the long-term value of VCP.

Vitrified Clay Pipe attributes:

- Rigid Strength
- Flexible Watertight Joints
- Sustainable
- Inert

Rigid Strength

VCP is categorized as a rigid conduit, which means it has inherent structural strength in the pipe itself. The common method to determine structural strength is a three-edge bearing test, which is measured in pounds of load per linear foot of pipe length. Three-edge bearing capacities increase with larger pipe diameters. Minimum strengths

Figure 1-2: Three-edge bearing testing for inherent structural strength.

per pipe diameter are included in the standard ASTM C700 *Standard Specification for Vitrified Clay Pipe, Extra Strength, Standard Strength, and Perforated.*

Flexible Watertight Joints

VCP compression joints shall not leak in accordance with ASTM C425 *Standard Specification for Compression Joints for Vitrified Clay Pipe and Fittings.* The joint test for VCP includes subjecting an assembled deflected joint to a 10-ft head of water pressure with a shear load applied. The pipe joint is deflected to simulate a curvilinear alignment and the applied shear force simulates settlement and lack of proper support. The minimum shear load applied to the unsupported pipe end is 150-pounds per inch of nominal diameter. With all of these loads applied for a total test period of 1 hour, the joint **"shall not leak."** VCP compression joints are designed to allow angular deflection while retaining joint integrity. See Table 1-1 for the limits of joint deflection and page 2-4 for designing curvilinear sewers with deflected joints.

Nominal Diameter (inches)	Deflection of Pipe, inches/linear ft.
3 to 12	1⁄2
15 to 24	3⁄8
27 to 36	1⁄4
39 and 42	3⁄16
48	1⁄8

Table 1-1: *Joint Deflection limits*

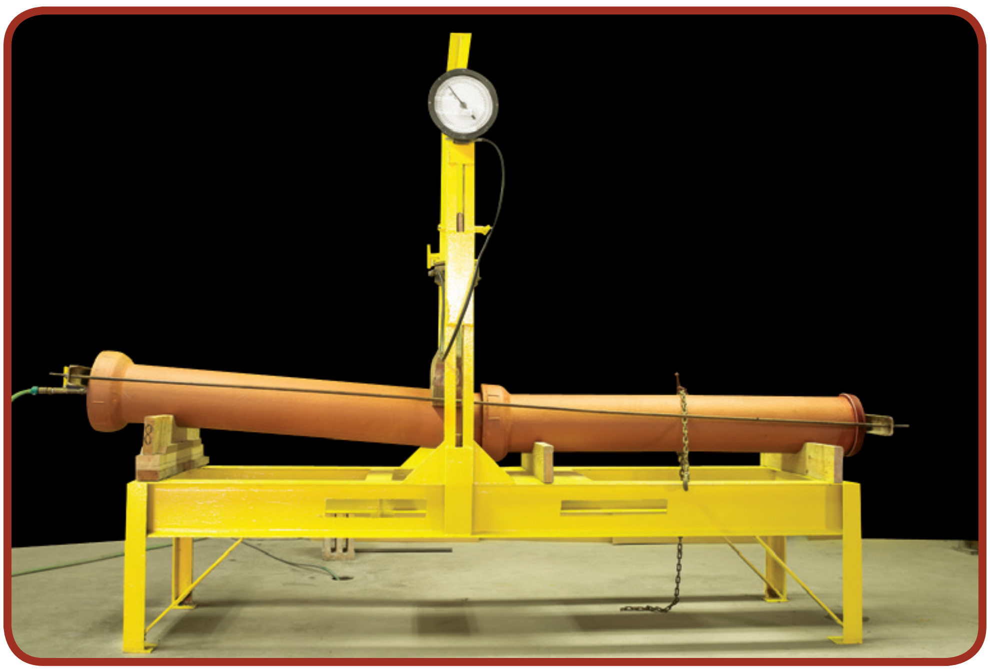

Figure 1-3: *Compression joint test simulates joint performance under conditions of shear load and angular deflection.*

Sustainable

Vitrified Clay Pipe is the most sustainable sewer pipe manufactured today. The documented lifecycle of VCP, coupled with naturally occurring, abundant raw materials makes it the most sustainable pipe product ever made.

The raw materials for the manufacture of VCP are clays and shales. These earthy mineral aggregates are the end products of nature's weathering forces.

VCP manufactured by the member companies of National Clay Pipe Institute (NCPI) has been independently certified as environmentally friendly based on an ISO 14001-compliant life cycle assessment. This review included critical evaluation of the raw materials, sourcing, manufacture and expected product lifecycle as they impact human health and the environment over both the short and long term. To see the scorecard from this assessment, visit the sustainability page of the NCPI website (ncpi.org).

Inert

Through centuries, soluble and reactive minerals have been leached from rock and soil, leaving an inert material. This chemically inert material is transformed into a dense, hard, homogeneous clay body through firing in kilns at temperatures of about 2000°F (1100°C). "Vitrification" occurs as the clay mineral particles become mechanically bonded into an inert, chemically stable compound, integrally bonded by its very nature.

VCP will not rust, corrode, shrink, elongate, bend, deflect, erode, oxidize or deteriorate over time.

Figure 1-4: *Firing at about 2000° F (1100°C) is critical to achieving vitrification which creates a solid pipe body.*

Pipe Specification Considerations

Each municipality has its own set of special challenges, but there are some universal concerns that should be addressed when specifying any pipe material for sanitary sewers.

- Life expectancy: No other pipe material can match the 200-years of proven service life in the United States.
- Chemical attack: VCP is inert and therefore resistant to internal and external attack from solvents, acids, alkalis, gases, etc.
- Flow characteristics: Low friction coefficient.
- Structural integrity: Inherent load bearing capacity.
- Joint tightness: Factory applied flexible compression joints that "shall not leak."
- Abrasion resistance: Exceptional resistance to abrasion and scour.
- Availability: Available in a full range of sizes, fittings and adapters.
- Environmental impact: No other pipe material can come close to the natural environmentally responsible credentials of VCP.
- Economics: Best total value considering cost of material, installation, maintenance and useful life.
- Durability.

Manufacturing Process

Vitrified Clay Pipe is one of man's most enduring materials. Manufacturers blend specially selected clays and shales to develop the inherent strength and load bearing capacities of the pipe. The principal steps in the manufacture of clay pipe are:

- Mining
- Grinding
- Extruding
- Drying
- Firing
- Testing the Pipe and Joint

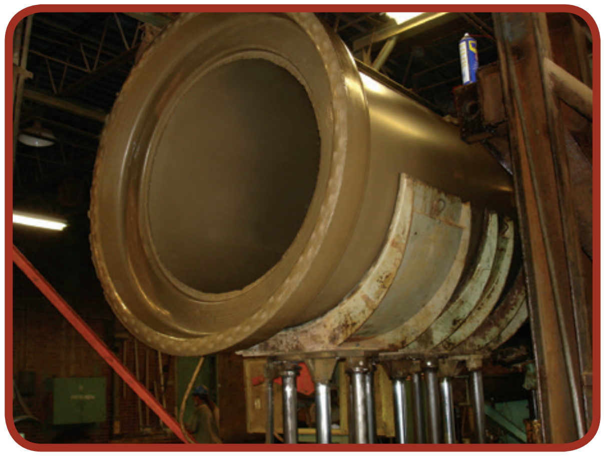

Figure 1-5: *Modern manufacturing methods enable production of larger diameter pipe.*

To see a video of the VCP Manufacturing process from the *How It's Made* Science Channel episode, visit our YouTube channel.

Mining

Only specialized clays, found in hydrous alumina silicates, are suitable for the manufacture of Vitrified Clay Pipe. These clays must have an appropriate level of plasticity (essential for forming the pipe), suitable vitrification properties and stability at high temperatures (to achieve the desired strength during firing). Laboratory tests determine that all raw materials used meet these qualifications and ensure that the resultant pipe meets the rigorous standards of ASTM.

Grinding

The clay mixture is ground in heavy, perforated metal pans by large crushing wheels. The mixture is then sent through fine, heated, vibrating screens to assure proper particle size.

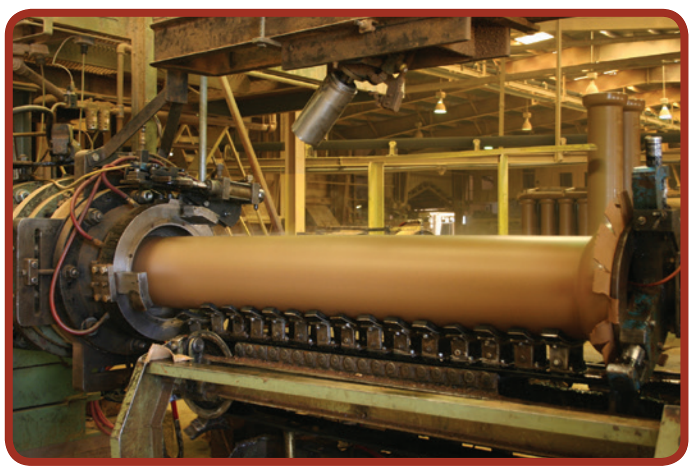

Figure 1-6: *More powerful extrusion equipment produces stronger pipe bodies and longer pipe lengths.*

Extruding

Ground raw materials are mixed with water in a pug mill. This material is forced through a vacuum, de-airing chamber to produce a smooth, dense mixture. The moistened clay is extruded under high pressure to form the pipe. Because the pressure is extreme, voids and laminations are not a concern in modern VCP.

Drying

The pipe is transferred to large, heated drying rooms to remove moisture. Drying time can vary based on the size of the pipe and the level of ambient humidity

Figure 1-7: *Drying rooms capture excess heat from the kilns to help make VCP the most environmentally responsible sanitary sewer pipe product.*

Firing

The temperature in the kiln is gradually increased to approximately 2000°F (1100°C). The first phase of firing must take place slowly so that the shape of the pipe is set before the ramp-up to the higher temperatures required for vitrification. At the highest temperatures the interior portions of the pipe body are almost liquefied to create the solid ceramic structure. Cooling also has to happen in a controlled, slow process to prevent damage. Firing times vary by raw materials and pipe size.

Testing the Pipe & Joint

Every pipe exiting the kiln is visually and physically inspected. Representative samples from each firing are tested for bearing strength (in accordance with ASTM C700 *Standard Specification for Vitrified Clay Pipe, Extra Strength, Standard Strength, and Perforated*). The final test per ASTM C425 *Standard Specification for Compression Joints for Vitrified Clay Pipe and Fittings* includes shear load, deflection and hydrostatic pressure to simulate the most extreme conditions in the field.

Figure 1-8: *Aggressive testing of the joint ensures long-term, leak-free performance.*

Perforated Pipe

Figure 1-9: *Perforated clay pipe is an environmental alternative for drainage applications.*

Perforated clay pipe are used in a variety of drainage applications including leachate detection and transmission. Normal use requires that the pipe be installed on a controlled grade with the perforations placed down. The surrounding materials should be properly sized to prevent migration of fines or blockage of the perforations. A filter fabric which restricts the passage of fines may be required in certain installations. Refer to ASTM C700 *Standard Specification of Vitrified Clay Pipe Extra Strength, Standard Strength, and Perforated,* and ASTM C12 *Standard Practice for Installing Vitrified Clay Pipe Lines.*

Vitrified Clay Pipe ASTM Specification & Testing Standards

ASTM C12	*Standard Practice for Installing Vitrified Clay Pipe Lines*
ASTM C301	*Standard Test Methods for Vitrified Clay Pipe*
ASTM C425	*Standard Specification for Compression Joints for Vitrified Clay Pipe and Fittings*
ASTM C700	*Standard Specification for Vitrified Clay Pipe, Extra Strength, Standard Strength, and Perforated*
ASTM C828	*Standard Test Method for Low-Pressure Air Test of Vitrified Clay Pipe Lines*
ASTM C896	*Standard Terminology Relating to Clay Products*
ASTM C1091	*Standard Test Method for Hydrostatic Infiltration Testing Of Vitrified Clay Pipe Lines*
ASTM C1208/1208M	*Standard Specification for Vitrified Clay Pipe and Joints for Use in Microtunneling, Sliplining, Pipe Bursting, and Tunnels*