PVC Pipe & Fittings: Underground Solutions for Water and Sewer Systems in North America

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ABOUT S&B TECHNICAL PRODUCTS / HULTEC

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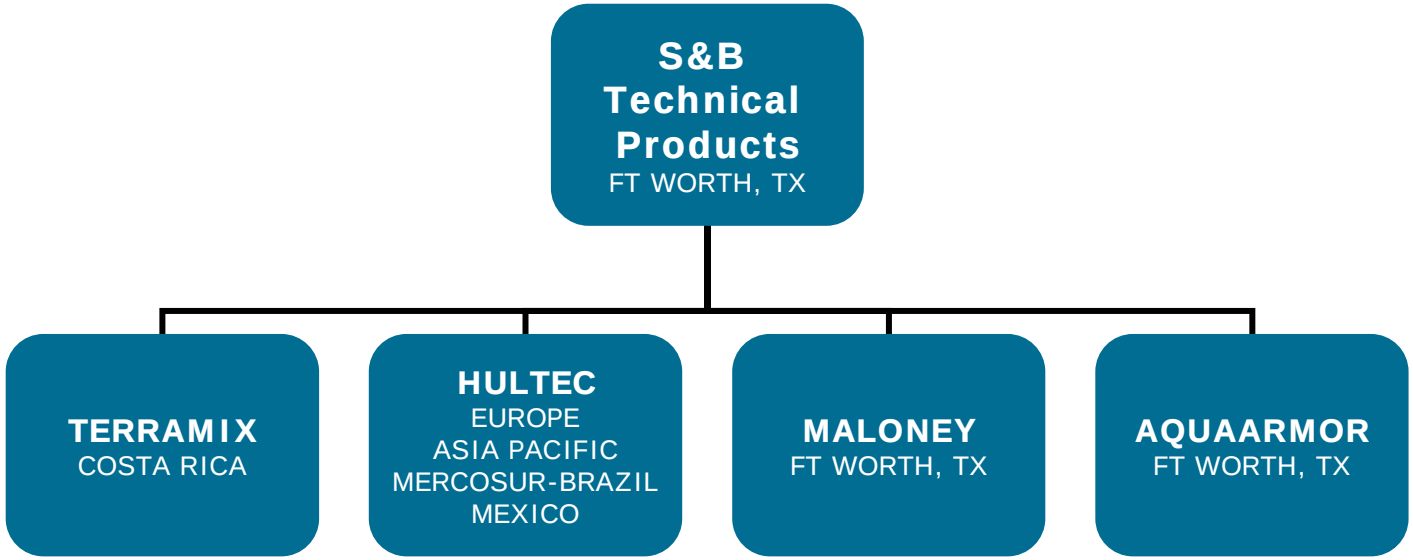
- S&B Technical Products is a family-owned business, founded in 1981
- Core Business is Pipe Sealing Systems – Elastomeric / Rubber Products for Pipelines & Appurtenances
- Largest Pipe Seals Market Share in the World (85-90% of North American Market, 50% of European Market)
- Other Businesses Include Rubber and Specialty Products for Oil and Gas Industry, Corrosion Protection Systems, and Energy-Efficient Cooling Systems
- Products are Sold in Over 70 Countries

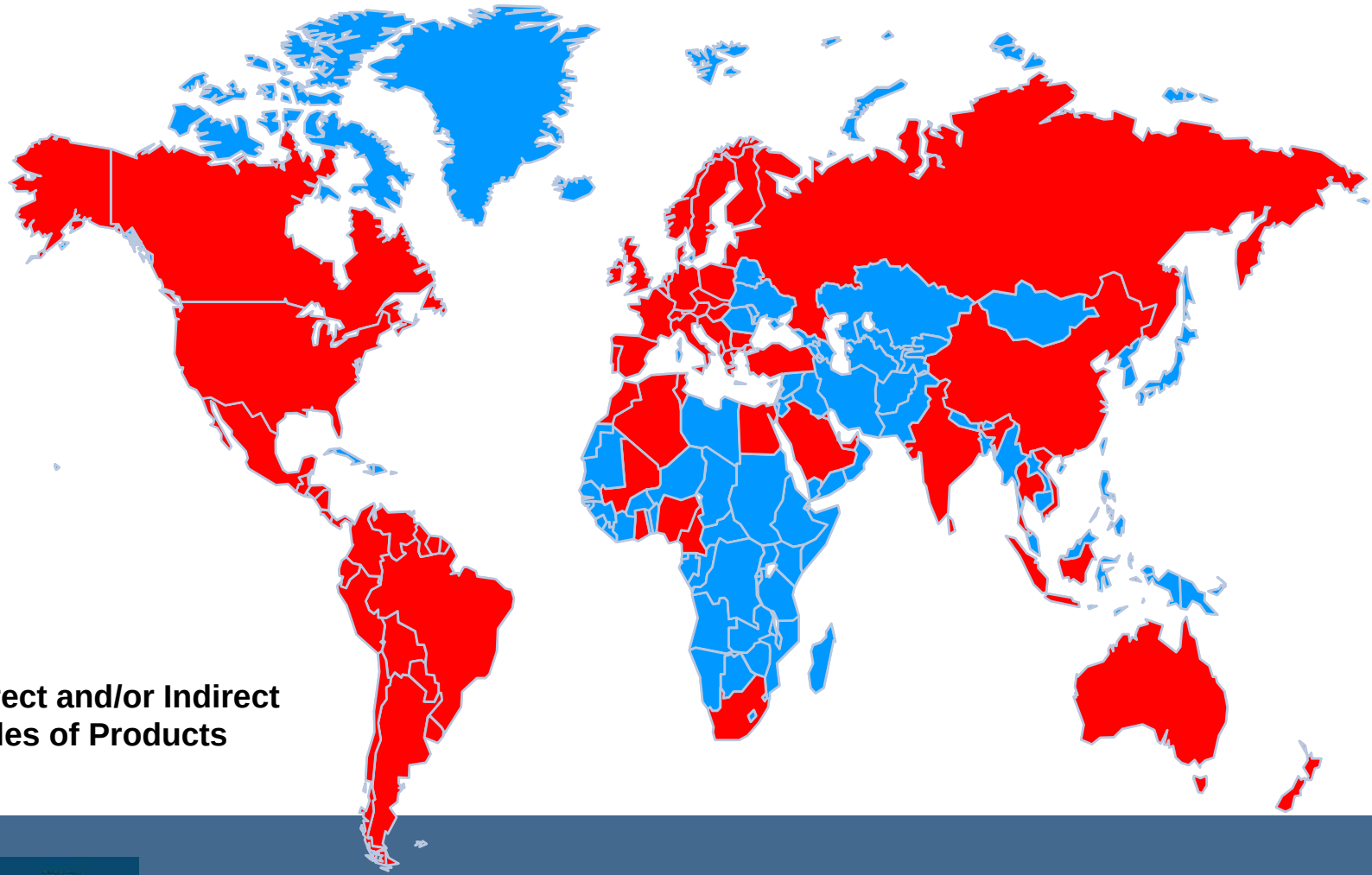
ABOUT S&B TECHNICAL PRODUCTS / HULTEC



All S&B Pipe Seals Operations and Products Outside North America Carry the HULTEC Trade Name

OFFICES, WAREHOUSES & MANUFACTURING – WORLDWIDE

PRODUCT SALES – WORLDWIDE



● **Direct and/or Indirect Sales of Products**

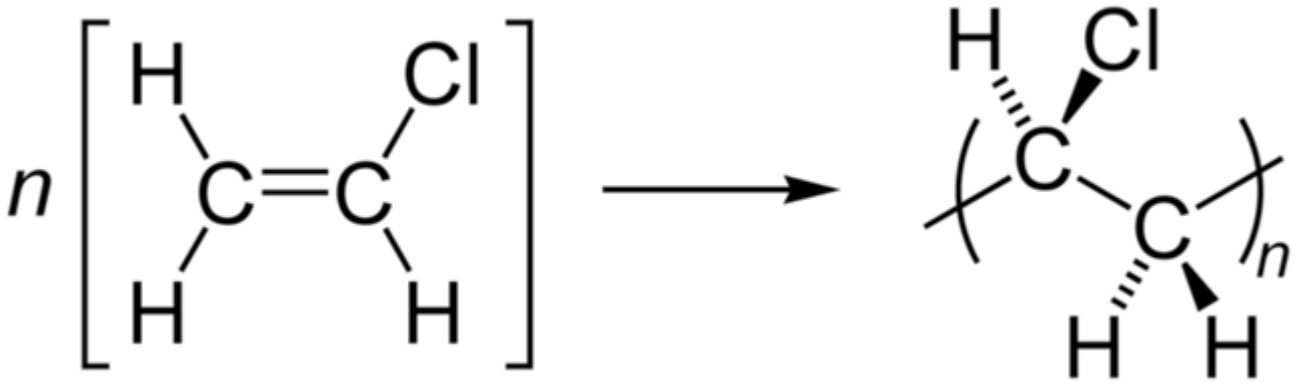
ABOUT S&B TECHNICAL PRODUCTS / HULTEC

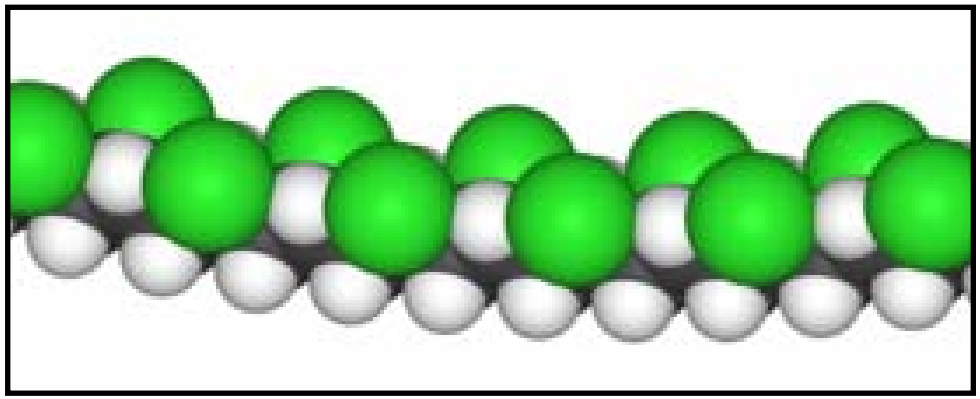
- Global Technological Leaders in Pipe Sealing Solutions
- More Than 65 Patents and Patents Pending, More Than All Our Competitors Combined
- Engineers, Chemists and Scientists Provide the Best Technological Solutions to Meet Customers' Needs

AGENDA: Topics of Discussion

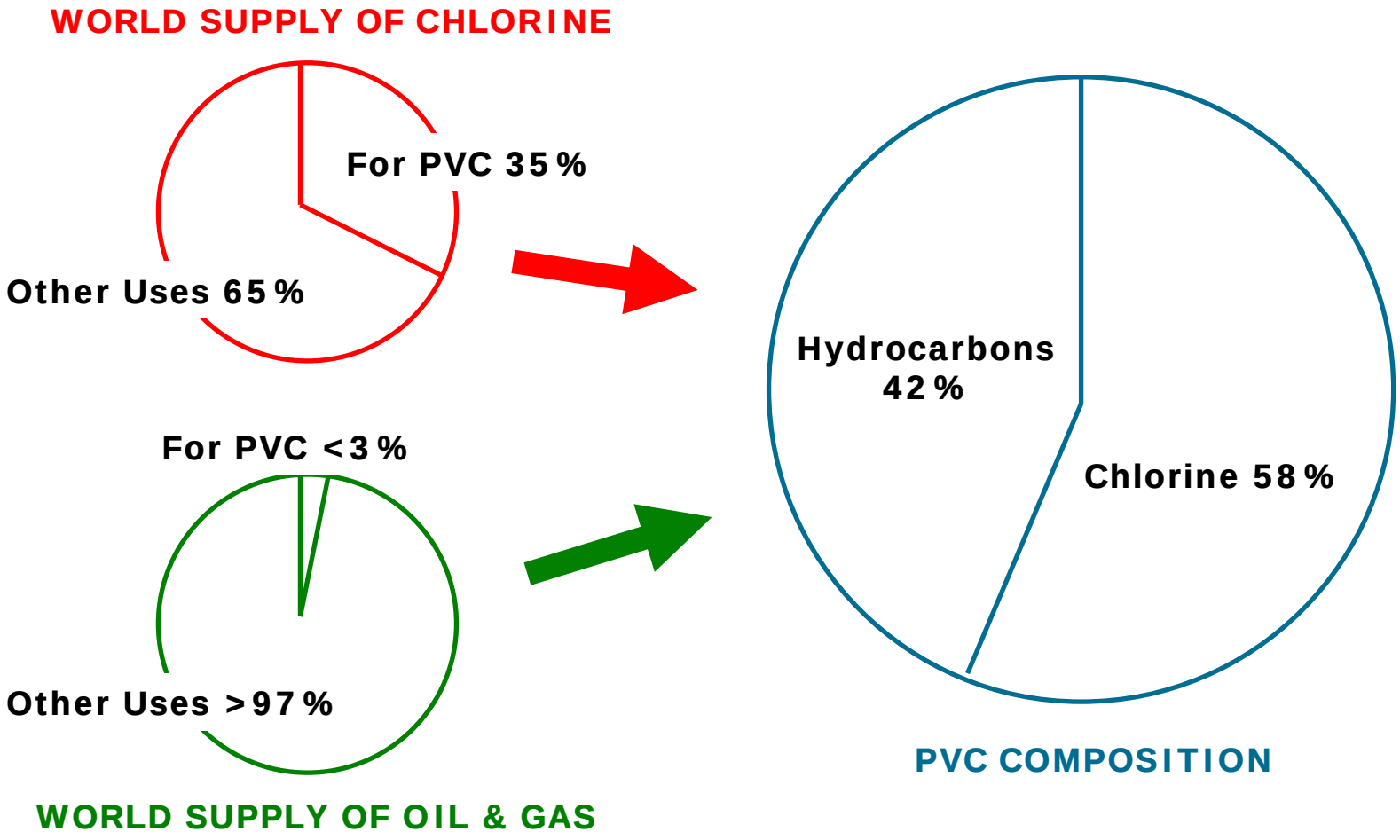
EVOLUTION OF PVC IN INFRASTRUCUTURE

Vinyl Chloride





Raw Material Contents of PVC

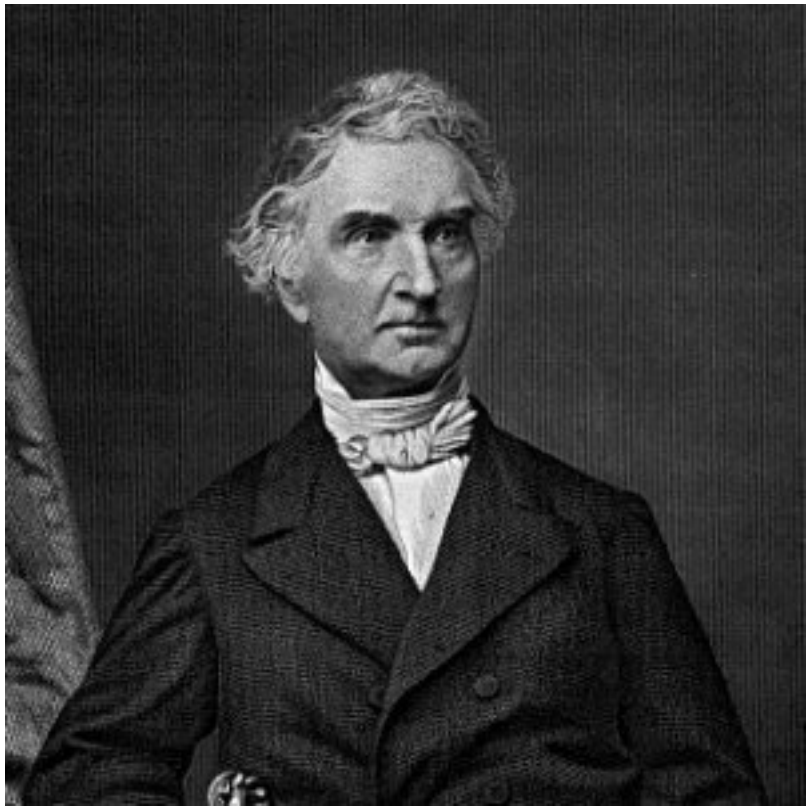


A Brief History of PVC

- **Carl Wilhelm Scheele** , a Swedish pharmacist discovered *CHLORINE* in 1774 by dropping hydrochloric acid onto manganese dioxide

- In 1810, **Sir Humphrey Davy**, identified CHLORINE as an element

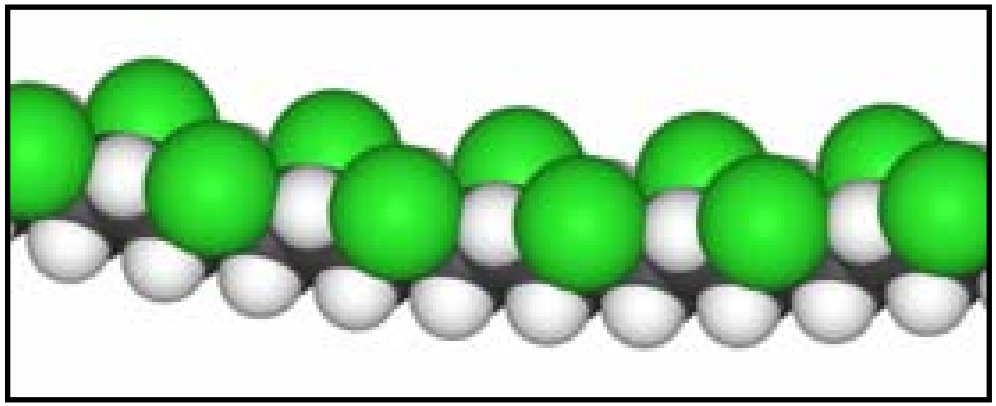
A Brief History of PVC



- **Justus von Liebig** first produced Vinyl Chloride *Gas* from ethylene dichloride in **1835** at the University of Giessen, Germany

- His student, **Victor Regnault**, confirmed the work and wrote a technical paper

A Brief History of PVC



- **E. Baumann** , in **1872**, accidentally produced the first Poly (vinyl Chloride) as a white powder when he exposed vinyl chloride to sunlight
- This was the first *POLYMERISATION* of vinyl chloride
- He reported that PVC melted with decomposition above 130 deg. C

A Brief History of PVC

- **Fritz Klatte** of Chemische Fabrik Griesheim-Electron (CFGE) developed commercial route to vinyl chloride from acetylene and hydrogen chloride in **1912.**
- He found that polymerization of vinyl chloride could be initiated w/ organic peroxides in **1915**
- Due to difficulties, CFGE gave up patents in **1926**

A Brief History of PVC

- *Union Carbide* in USA made vinyl chloride using a new process utilizing ethylene dichloride and sodium hydroxide in **1926**
- Also in 1926, **Dr. Waldo Semon**, of *BFGoodrich*, discovered Plasticized PVC while trying to find a solution for rubber-to-metal bonding.
- In **1928**, Union Carbide and DuPont made vinyl chloride copolymer with vinyl acetate
- In **1928**, cPVC (chlorinated PVC)
- *From late 1920's to 1940's, tremendous gains were made by Germans and Americans in the field of stabilizing PVC for commercial manufacture*

PVC for Infrastructure: First PVC Pipes

- The first known PVC Pipes were manufactured in **1934** in the Bitterfeld-Wolfen chemical industry area in Germany
- The pipes were used as potable water pipes, transparent food contact pipes (brewery applications), and as industrial conduits for chemical laboratories and plant applications
- In particular, during WWII, PVC pipes were widely used in Germany
- In the USA, the first PVC pipe was made in **1951**that had high rigidity

PVC for Infrastructure: Pipes & Fittings in USA

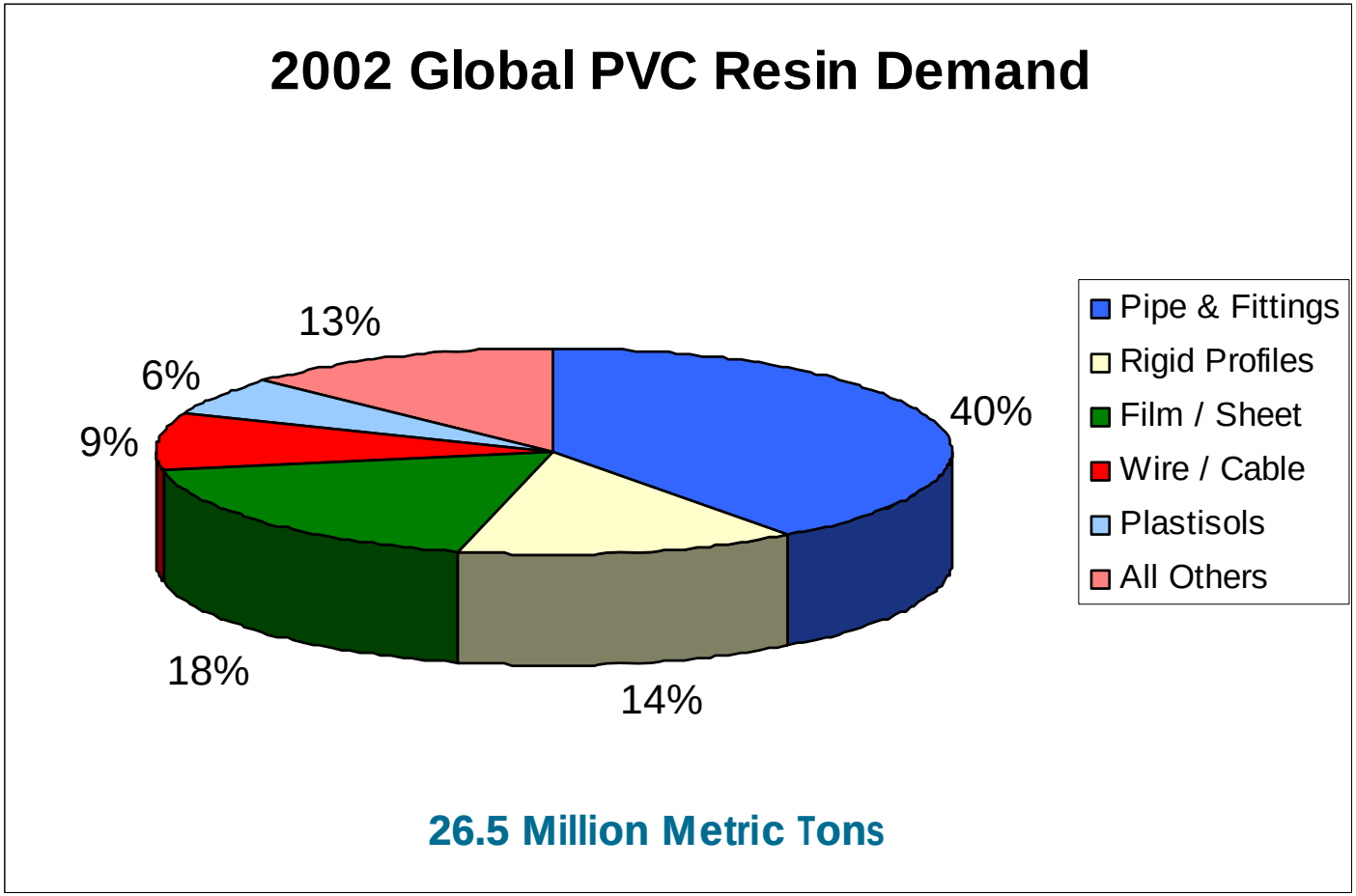
- From the mid-1960's through the 1970's, PVC pipe manufacture grew in North America.
- Major companies included **Robintech**, **Johns-Manville**, and **Certainteed**

- **Robintech** was started in the early 1970's by **Brad Corbett, Sr.,** later Founder and CEO of Hultec/S&B Technical Products
- Later, vertical integration between Shin-Etsu and Robintech ultimately resulted in **SHINTECH**

PVC for Infrastructure: Siding, Windows, Fencing, and Decking

- In **1960**, BFGoodrich developed weatherable grades of PVC, commercialized by Bird & Son in house siding
- Andersen used this PVC to cover wood to make windows
- In 1968, vinyl bottles became commercial
- Today, PVC serves more than 70% of the construction market for plastics, dominating pipe and fittings, sidings, windows, fencing, and decking
- PVC has captured 60% of the wire and cable plastics market
- PVC also serves 25% of the coatings market

PVC Usage by Application



Why PVC for Infrastructure???

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AGENDA: Topics of Discussion

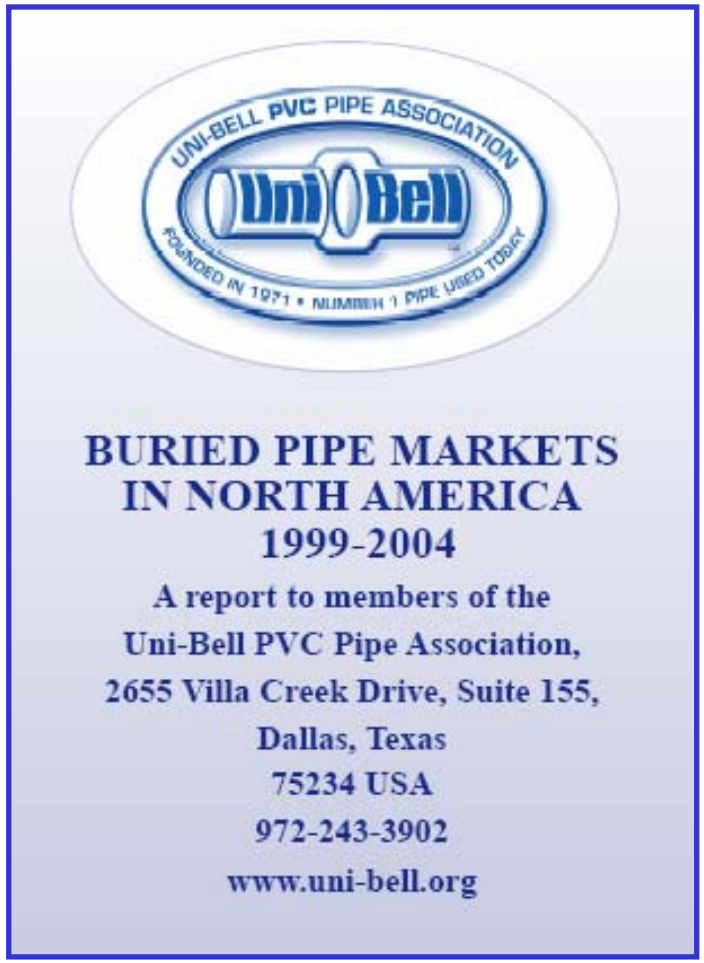
1. **Introduction to Municipal Piping Industry**
2. Pressure Pipes for Potable Water
3. Gravity Pipes for Sewer
4. Sealing Systems for PVC Pipes & Fittings
5. Trenchless Technology Solutions

America's Drinking Water Infrastructure

- *54,000 Drinking Water Systems Serving …*
- *264 Million+ People in the U.S., Via …*
- *2 Million Miles of Water Distribution and Transmission Pipe*

America's Sanitary Sewer Infrastructure

- *60,000+ Sanitary Sewer Systems Serving …*
- *264 Million+ People in the U.S., Via …*
- *2.5 Million Miles of Sewer Mains and Service Lines*


UNI-BELL PVC PIPE ASSOCIATION
Uni-Bell
FOUNDED IN 1971 • NUMBER 1 PIPE USED TODAY
BURIED PIPE MARKETS
IN NORTH AMERICA
1999-2004
A report to members of the
Uni-Bell PVC Pipe Association,
2655 Villa Creek Drive, Suite 155,
Dallas, Texas
75234 USA
972-243-3902
www.uni-bell.org

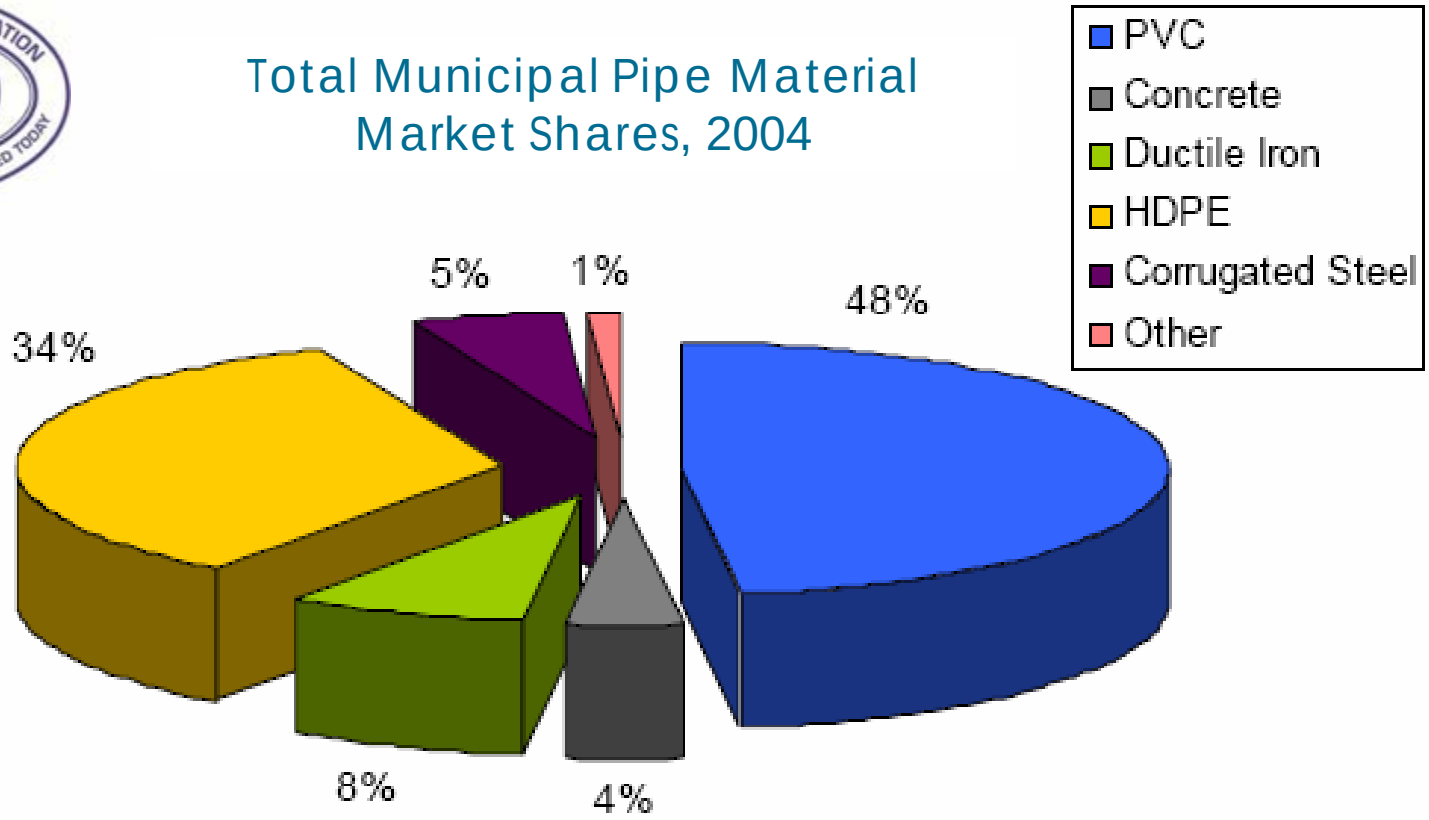
Market Study - Details

- Municipal Applications in North America Include:
  - Drinking Water Distribution and Transmission
  - Sanitary Sewer Mains
  - Storm Sewer
  - Drainage

- Pipe Materials Include Plastics (PVC and HDPE), Ductile Iron, Concrete, Corrugated Steel, Others (Fiberglass, Clay, Welded Steel, Composites)

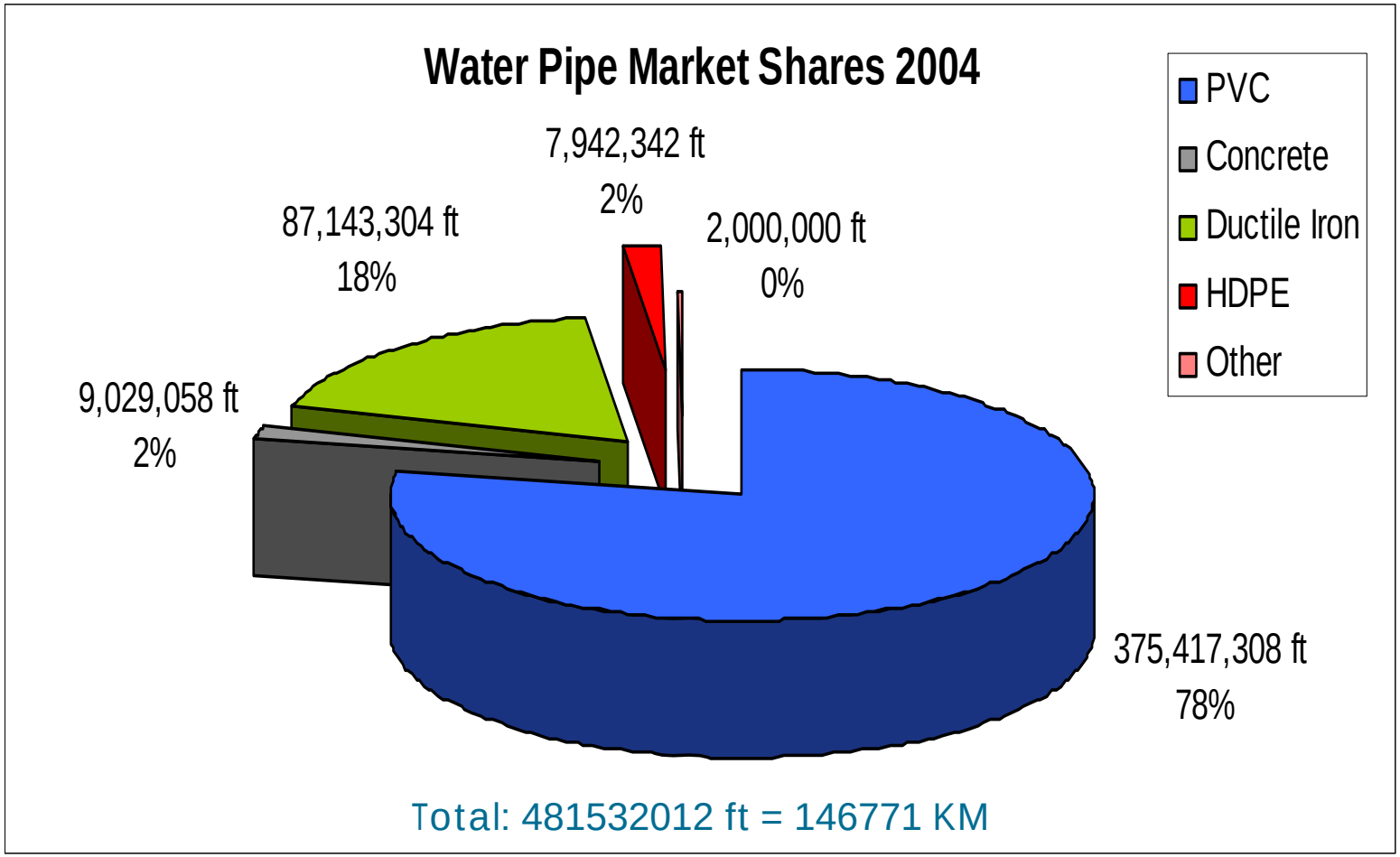
Municipal Market – North America

Total Municipal Pipe Material Market Shares, 2004



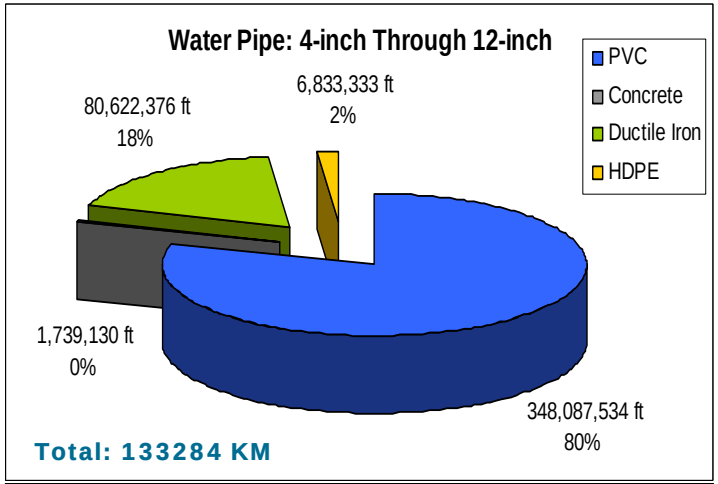
Total Municipal Pipe Laid in 2004 in North America: 1.5 Billion Feet (460,000 km)

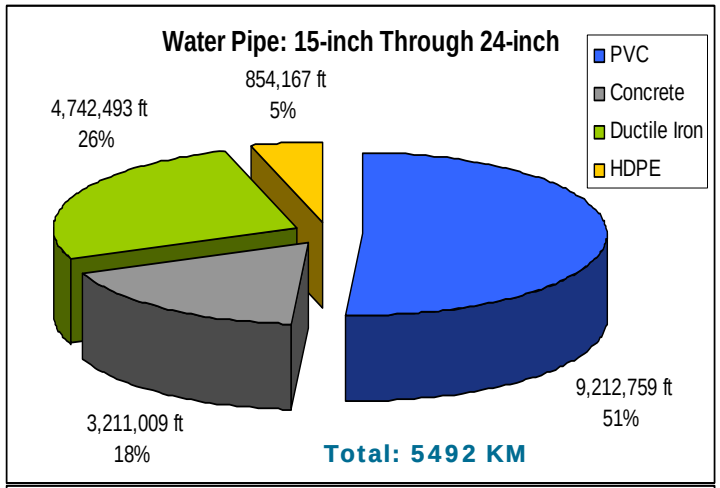
Potable Water Market – North America

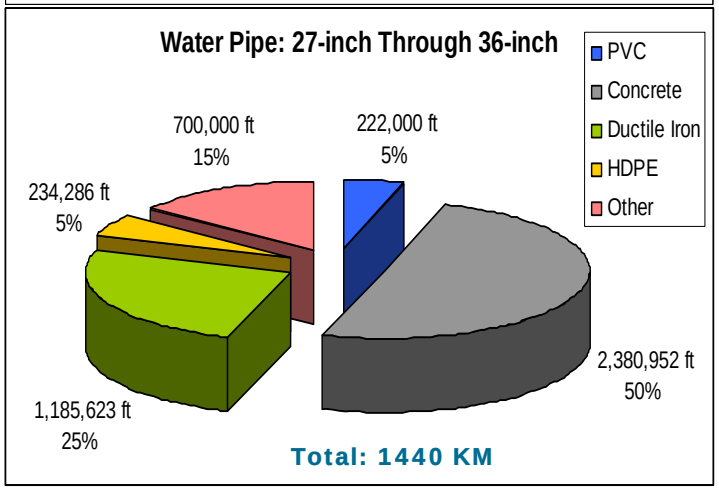


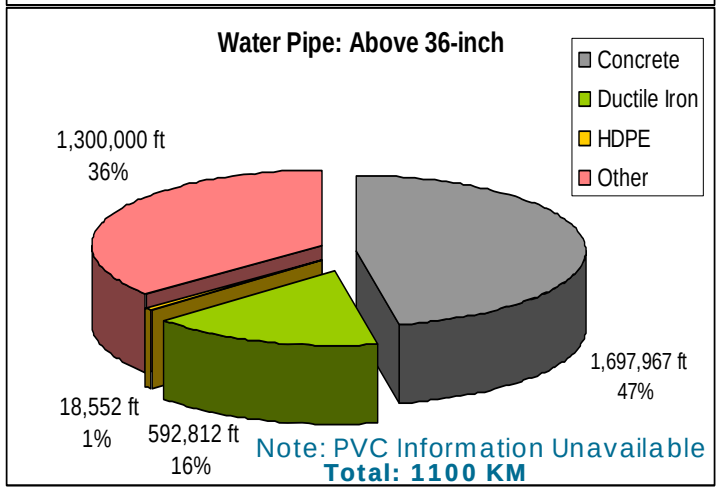
Total: 481532012 ft = 146771 KM

Potable Water Market – North America

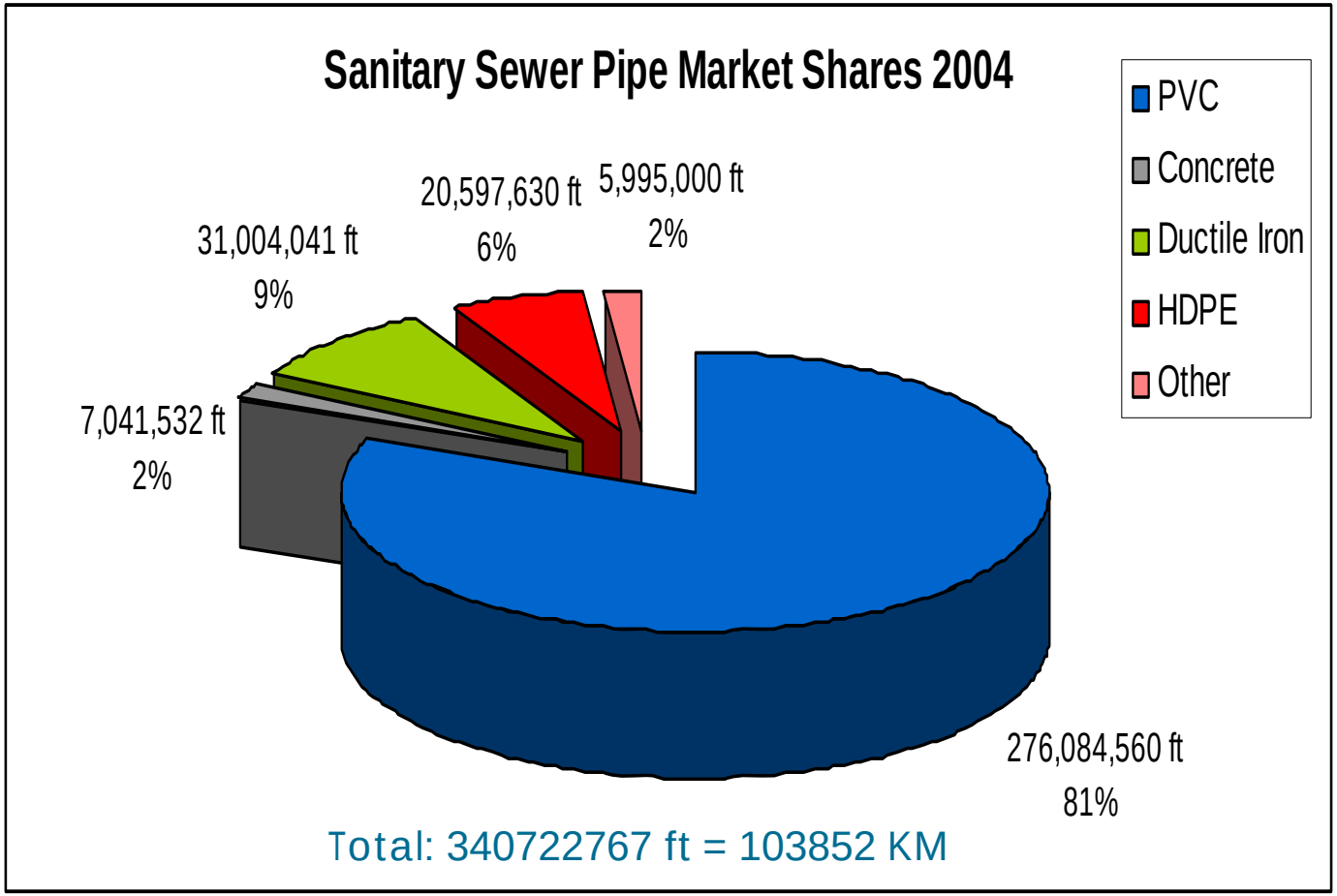








Sanitary Sewer Market – North America



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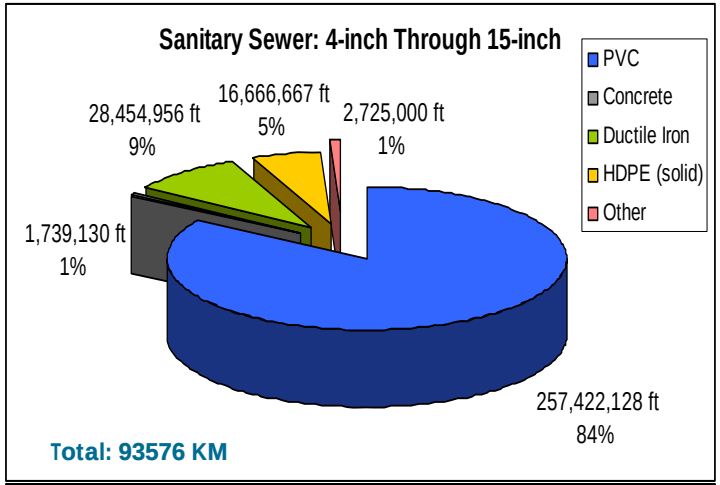
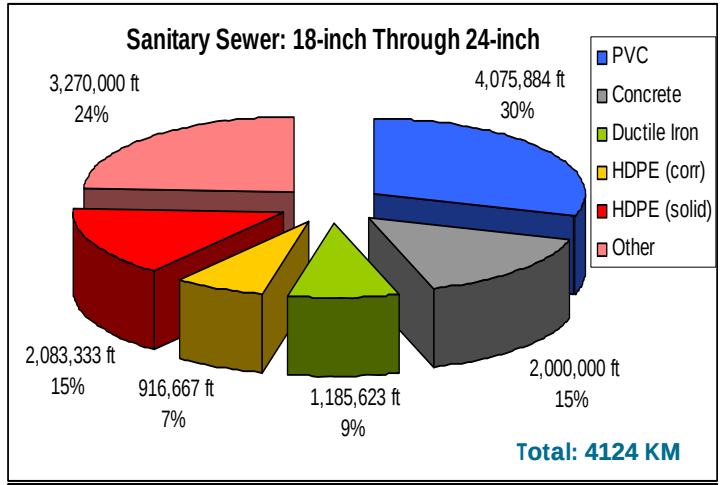
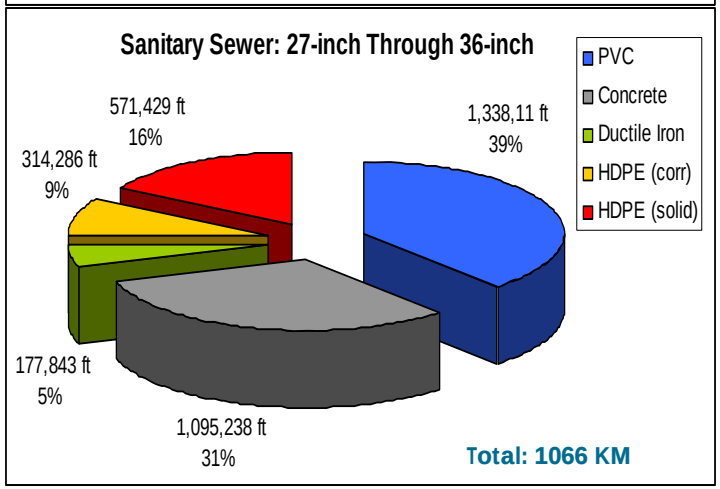
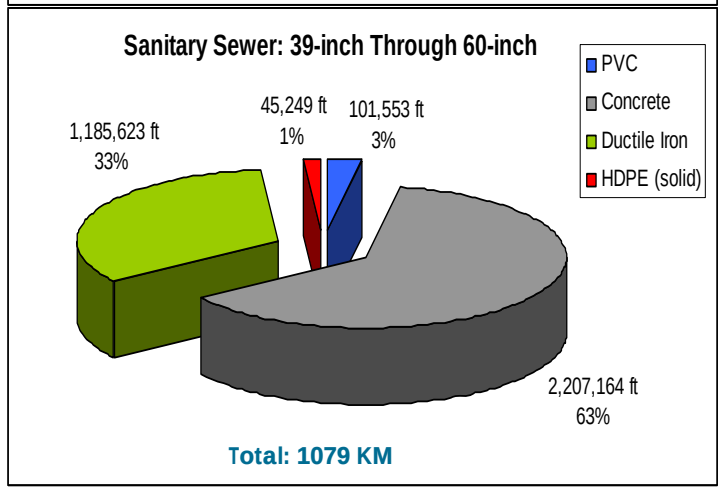
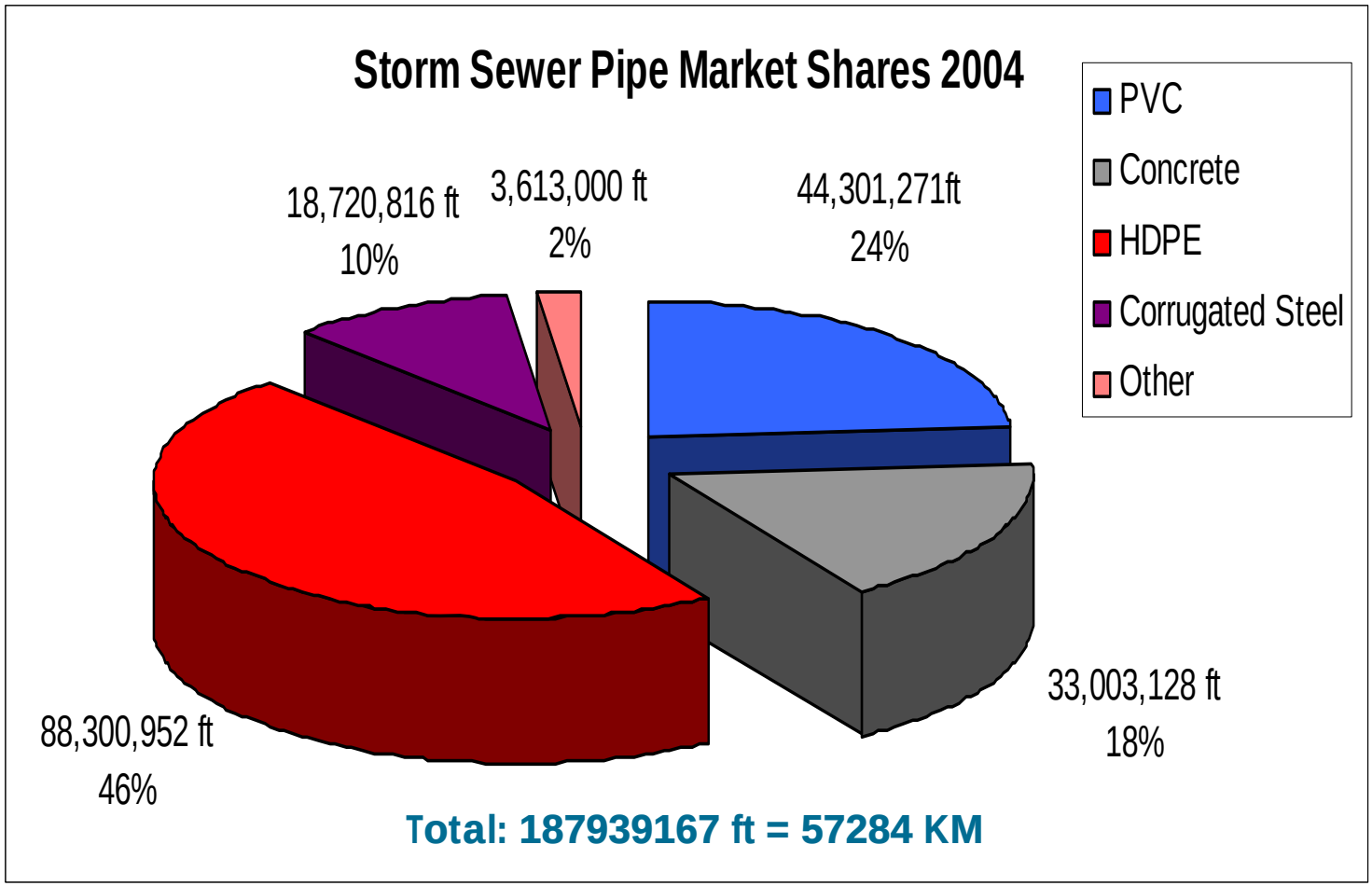




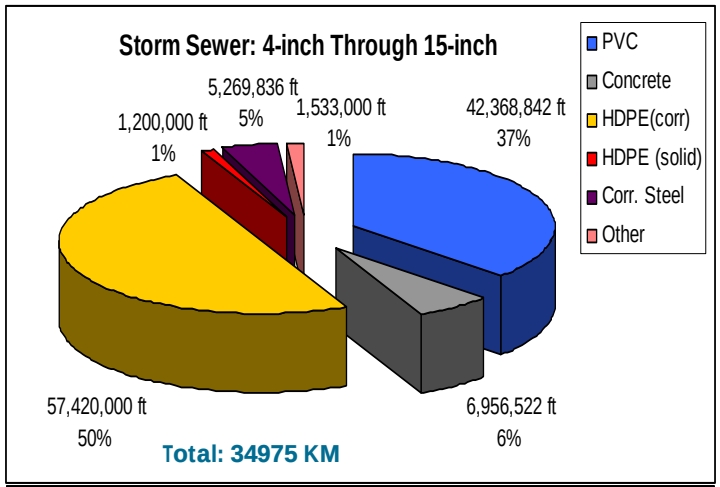


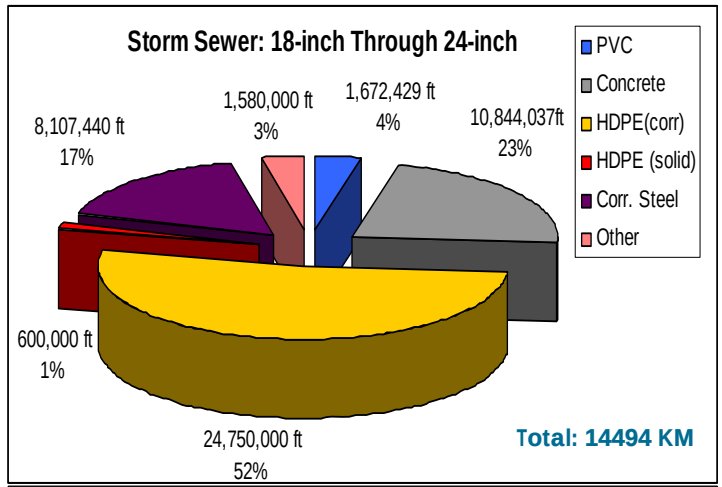


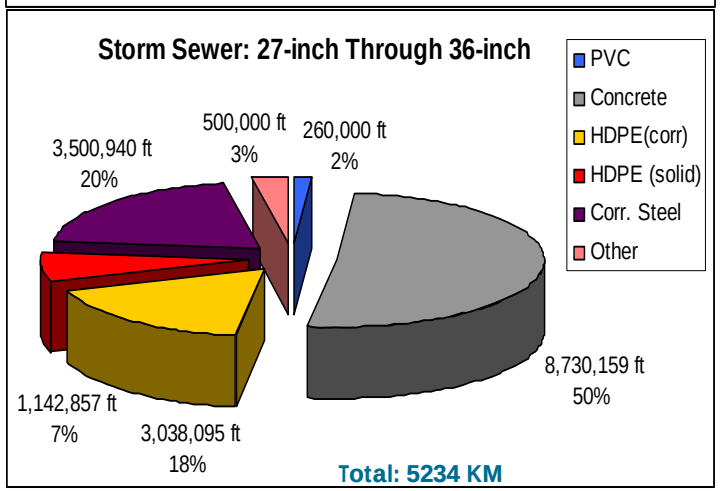
Storm Sewer Market – North America

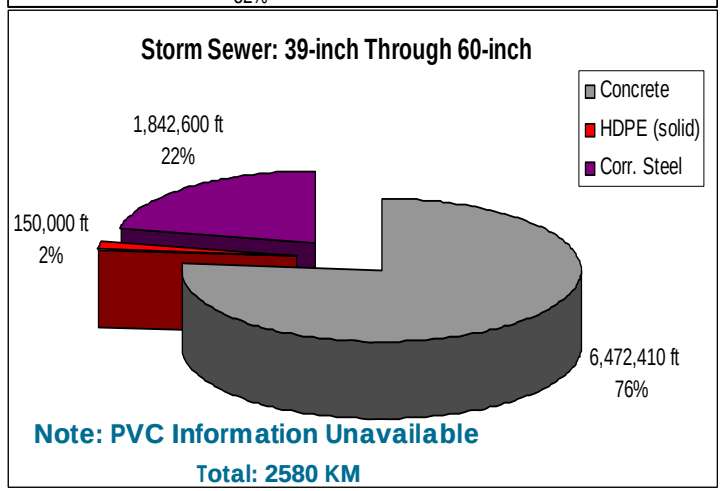


Storm Sewer Market – North America

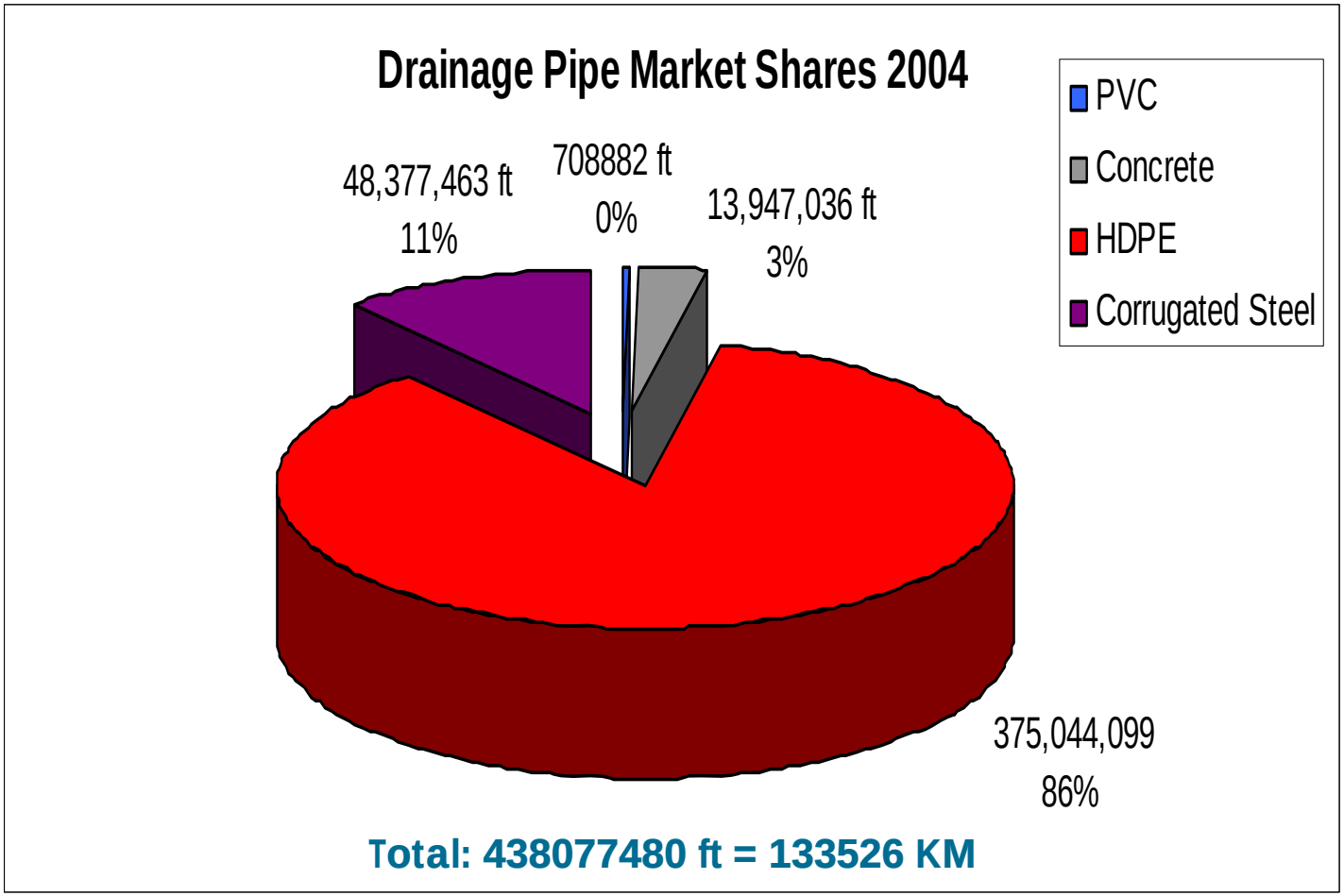




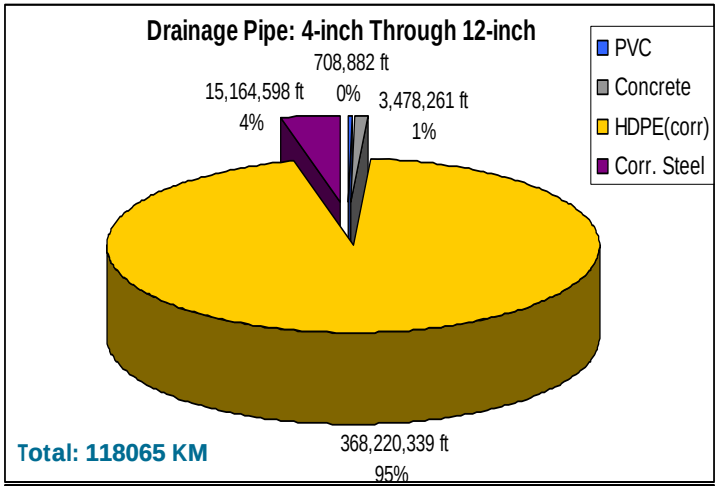


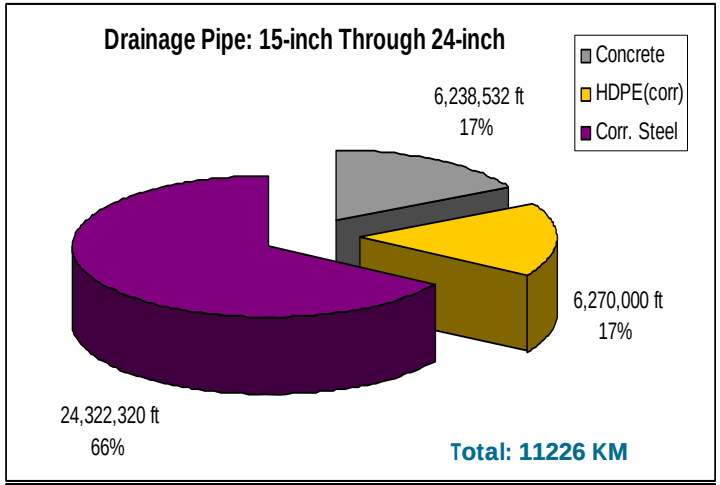


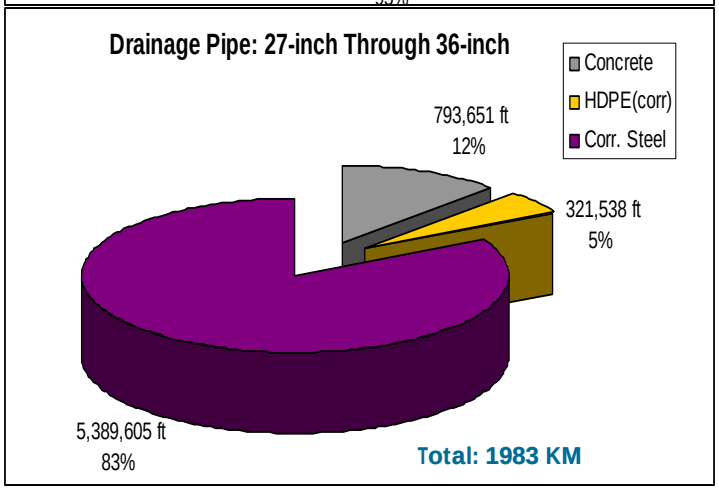
Drainage Market – North America

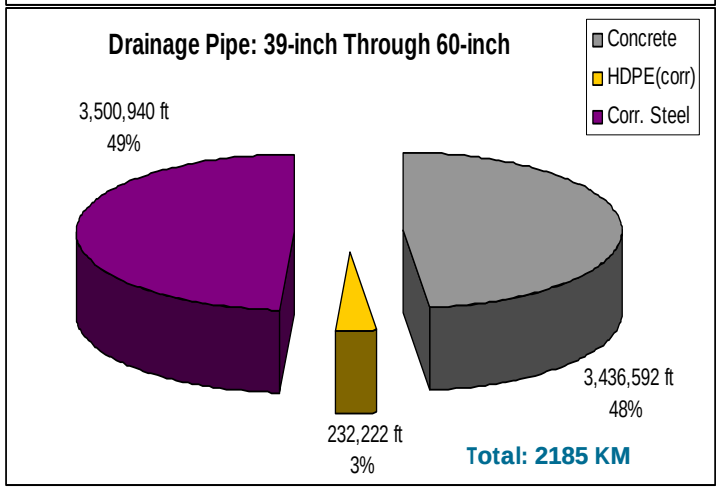


Drainage Market – North America









AGENDA: Topics of Discussion

1. Introduction to Municipal Piping Industry
2. **Pressure Pipes for Potable Water**
3. Gravity pipes for Sewer
4. Sealing Systems for PVC Pipes & Fittings
5. Trenchless Technology Solutions

PVC – Pressure Pipes

- Rural Water Systems, early 1960's
- First Pressure Pipe ASTM Standard written in 1964
- Prior Commercial Standards already existed
- Used in drinking water distribution and transmission and also sewer force-mains

PVC – Types of Pipes

- **PVC-U / uPVC:** Unplasticized PVC (used for both potable water and sanitary sewers)
- This is the most common type in North America

PVC – Types of Pipes

- **PVC-O:** Molecularly Oriented PVC pipe
- Only one manufacturer in North America – technology licensed from Europe (Offline Process)

PVC – Types of Pipes

- **PVC-M:** Modified PVC Pipe
- Only one manufacturer in North America, but pipe is used in above-ground applications
- Australian Study found US uPVC to display same characteristics as PVC-M in Australia and elsewhere

PVC Pipe – Physical/Mechanical Properties

- **ASTM D1784:** *Standard Specification for Rigid Poly(Vinyl Chloride) (PVC) and Chlorinated Poly(Vinyl Chloride) (CPVC) Compounds*

- **Five Digit Cell Classification Number**
- **Example: 12454 or 12364**
- Base Resin
- Izod Impact Strength
- Tensile Strength
- Elastic Modulus in Tension
- Deflection Temperature Under Loading

PVC Pipe – Physical/Mechanical Properties

Class	1	2	4	5	4
Identification:					
Poly(vinyl chloride) homopolymer					
Property and Minimum Value:					
Impact strength (Izod) [34.7 J/m (0.65 ft. - lbf/in)]					
Tensile strength [48.3 MPa (7000 psi)]					
Modulus of elasticity in tension [2758 MPa (400,000 psi)]					
Deflection temperature under load [70°C (158°F)]					

PVC – Pressure Pipes

- Used in Water Distribution and Transmission and also for Sewer Force Mains
- Only Cell Class 12454 is used for pressure pipe manufacture
- Tensile Strength of 7000 psi (48.3 MPa)
- Modulus of Elasticity of 400,000 psi (2758 MPa)
- PVC and PVCO are both used for pressure pipe manufacture

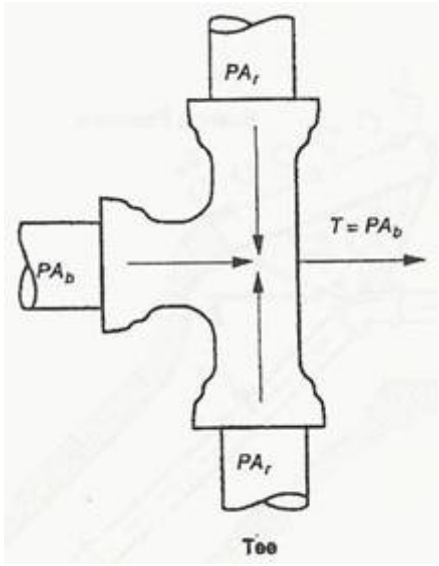
PVC Pressure Pipe Standards

- **ASTM D 2241:** *Standard Specification for Poly (Vinyl Chloride) (PVC) Pressure-Rated Pipe (SDR PR Series)*
- **AWWA C900:** *Polyvinyl Chloride (PVC) Pressure Pipe and Fabricated Fittings, 4 In. through 12 In. (100 mm through 300 mm), for Water Distribution*
- **AWWA C905:** *Polyvinyl Chloride (PVC) Pressure Pipe and Fabricated Fittings, Nominal Diameter 14 In. through 48 In. (350 mm through 1,200 mm), for Water Transmission and Distribution*
- **ASTM F 1483:** *Standard Specification for Oriented Poly (Vinyl Chloride), PVCO, Pressure Pipe*
- **AWWA C909:** *Molecularly Oriented Polyvinyl Chloride (PVCO) Pressure Pipe, 4 In. through 24 In. (100mm through 610 mm), for Water Distribution*

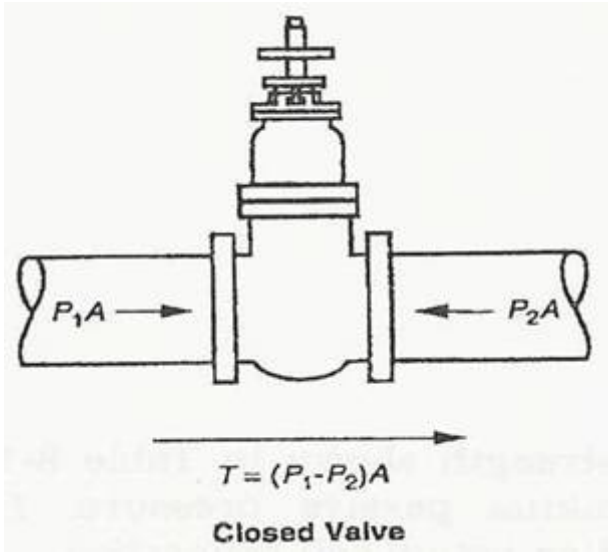
NEW PRODUCTS – Joint Restraints

- Changes in Direction
- Size Changes
- Dead Ends
- Closing of Valves and Hydrants

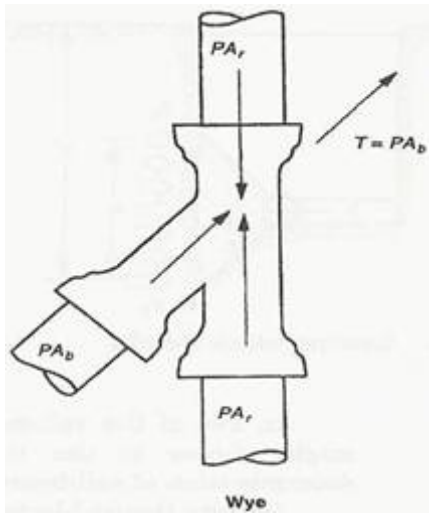
THRUST FORCES – Where do They Occur?



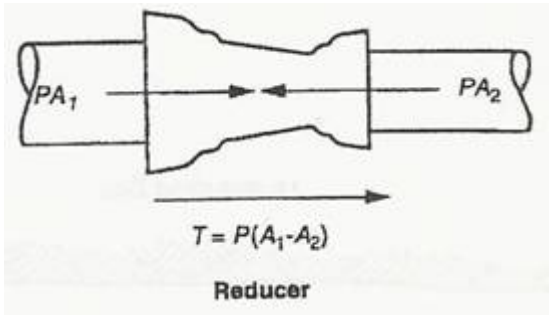
Tee



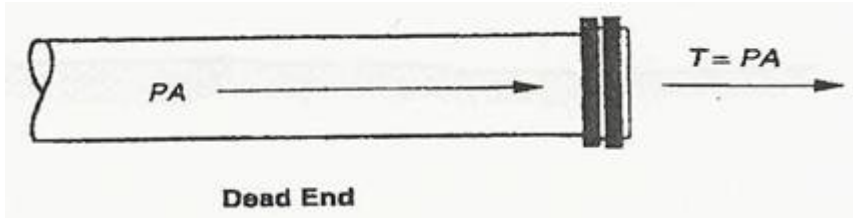
Closed Valve



Wye



Reducer

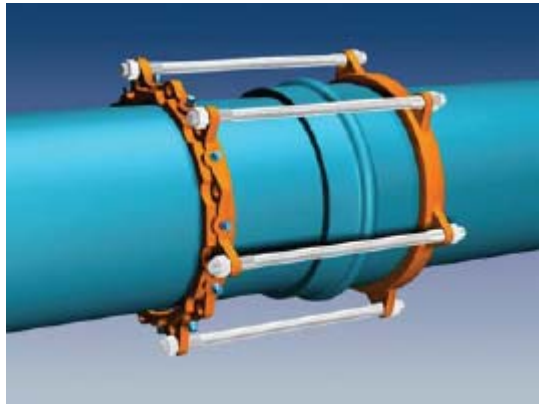


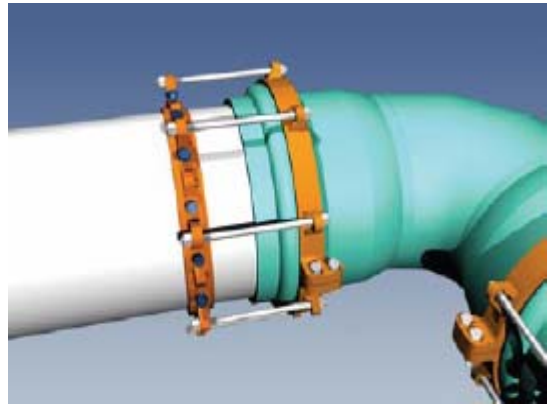
Dead End

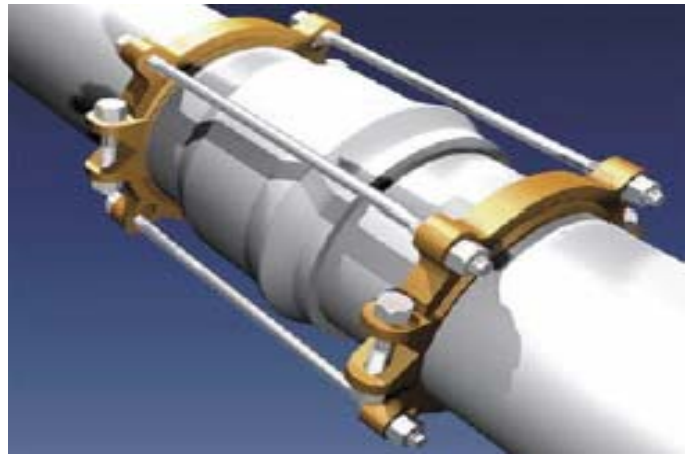
THRUST BLOCKS – Disadvantages

- Replication of Design in the Field
- Soil Bearing Capacity of In-situ Soils
- Availability of Space
- Time Required for Concrete to Dry & Cure
- Future Excavations

THRUST RESTRAINT – Mechnical Restraints







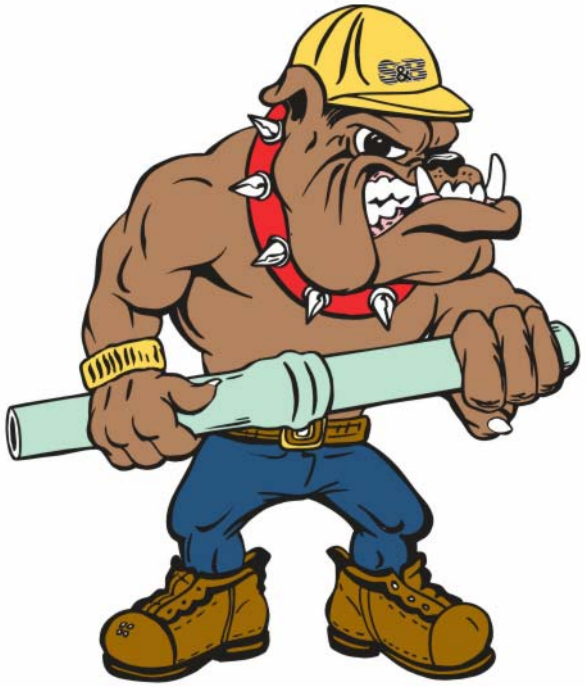
Mechanical Restraints – Disadvantages

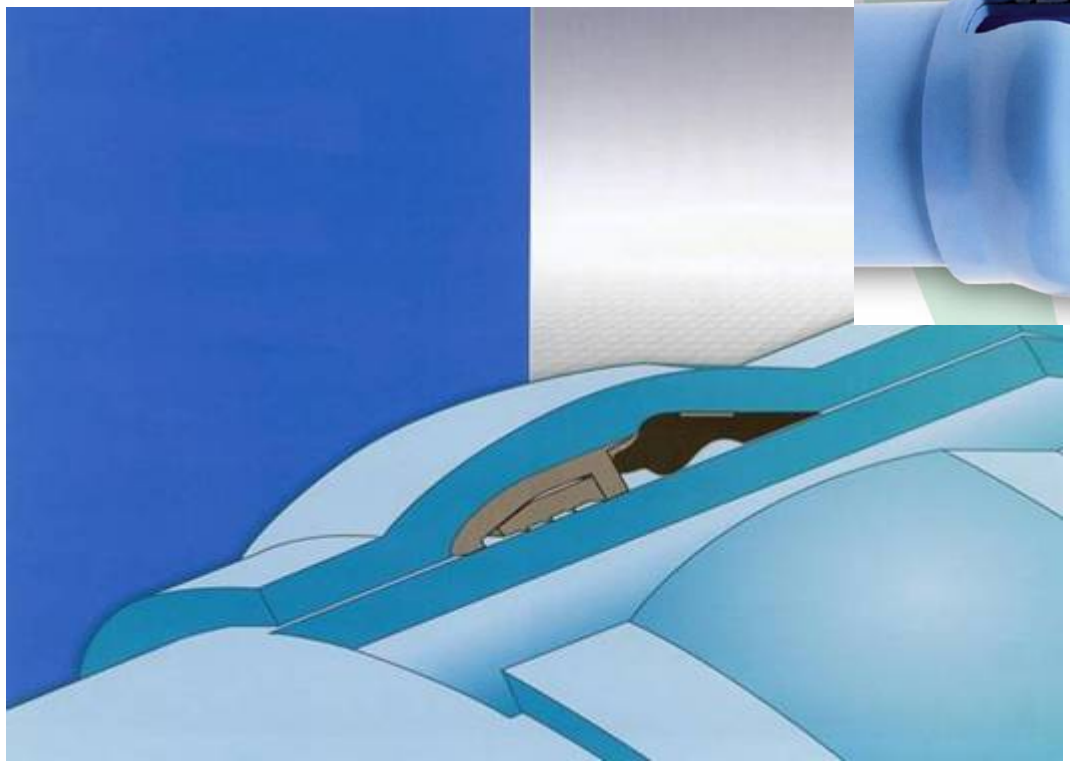
- External + Metallic = CORROSION
- Time Consuming Installation
- Prone to Human Error
- Majority do not Meet ASTM F1674
- Point Loading Causes Pipe Wall Damage
- Larger Size Casing Pipe Required Due to Restraints

Joint Restraints – The Next Generation

The BULLDOG™ INTEGRAL JOINT RESTRAINT SYSTEM FOR PVC

THE ONLY CHOICE FOR EASY ASSEMBLY





The BULLDOG™ INTEGRAL JOINT RESTRAINT SYSTEM FOR PVC

THE ONLY CHOICE FOR EASY ASSEMBLY

NEW PRODUCTS – Joint Restraints

- Internal – Non-Corrosive
- Easy Installation
- Meets ASTM F1674
- PVC Pipe-friendly

Focus on Large Diameter Pressure Pipes

- **Potable Water Transmission**

- **Sanitary Sewer Force main**

Focus on Large Diameter Pressure Pipes

- AWWA C605: *Underground Installation of Polyvinyl Chloride (PVC) Pressure Pipe and Fittings for Water*

Focus on Large Diameter Pressure Pipes

PLACE: Magrath, Alberta, CANADA
CANADA'S FIRST LARGE DIAMETER PVC PRESSURE PIPE PROJECT
DATE: 1984
SCOPE: 6.5 miles of 18-in and 20-in, Series 160 pipe
It was reported in Spring 2000 that not a single failure of any kind had occurred since installation

PLACE: Corpus Christi, Texas
DATE: 1987
SCOPE: 4,600 feet of 24" force main
"The line is alive and doing well. I have no regrets about my selection of pipe material."
Vernon Wuensche
Project Engineer

Focus on Large Diameter Pressure Pipes

PLACE: Pueblo, Colorado
DATE: 1987
SCOPE: 5000 ft of 24” DR 25, 4000 ft of 20-in DR 25, UNI-B-11
“We haven’t touched it since it was installed --- we’ve had no reason to.”

Lee Huffstutter
Engineering Manager

PLACE: Batavia, New York
DATE: 1988
SCOPE: 4,900 feet of 30” force main
“It has been running 24 hours a day, seven days a week since we installed it with no problems. In fact, we have not had to touch the line since it was installed.”

Matt Worth,
Deputy Superintendent

Focus on Large Diameter Pressure Pipes

PLACE: Muleshoe, Texas
DATE: 2001
SCOPE: 5 miles of 30-inch DR 25 water line for power station
Provides cooling water to a power station that provides power to over 52,000 sq.mi. in TX, OK, NM, and KS.

PLACE: Loudon County, Virginia
FIRST 48" DR 32.5 INSTALLED IN NORTH AMERICA
DATE: 2003
SCOPE: 10,000 ft of DR 32.5, 48-in, 42-in, 36-in. Sewer Force Main
The 26 MGD design flow will provide sewer service to two communities of approximately 2500 new homes. Burial depths vary from 10 to 15 feet.

AGENDA: Topics of Discussion

1. Introduction to Municipal Piping Industry
2. Pressure Pipes for Potable Water
3. **Gravity Pipes for Sewer**
4. Sealing Systems for PVC Pipes & Fittings
5. Trenchless Technology Solutions

PVC Gravity Pipes

- Government's Drive for Cleaner Environment
- Clean Water Act and other Legislature
- Need for better performing joints
- Used in various non-pressure applications including sanitary sewer
- ASTM D3034 first approved in 1972

PVC – Gravity Pipes

- Solid Wall Pipe

- Profile Wall Pipe

PVC Gravity Pipe Standards

ASTM D3034: *Standard Specification for Type PSM Poly (Vinyl Chloride) (PVC) Sewer Pipe and Fittings* **(4"–15")**

ASTM F679: *Standard Specification for Poly (Vinyl Chloride) (PVC) Large-Diameter Plastic Gravity Sewer Pipe and Fittings* **(18"–36")**

ASTM F789: *Standard Specification for PS-46 and Type PS-115 Poly (Vinyl Chloride) (PVC) Plastic Gravity Flow Sewer Pipe and Fittings* **(4"–18")**

AASHTO M278: *Standard Specification for Class PS46 Polyvinyl Chloride (PVC) Pipe* **(4"-15")**

PVC Gravity Pipe Standards (Profile Wall Pipe)

ASTM F 794: *Standard Specification for Poly(Vinyl Chloride) (PVC) Profile Gravity Sewer Pipe and Fittings Based on Controlled Inside Diameter*

ASTM F 949: *Standard Specification for Poly(Vinyl Chloride) (PVC) Corrugated Sewer Pipe With a Smooth Interior and Fittings*

ASTM F1803: *Standard Specification for Poly(Vinyl Chloride) (PVC) Closed Profile Gravity Pipe and Fittings Based on Controlled Inside Diameter*

AASHTO M 304: *Standard Specification for Poly (Vinyl Chloride) (PVC) Profile Wall Drain Pipe & Fittings Based On Controlled Inside Diameter* **(4"-48", wide variation in pipe stiffness)**

PVC Molded & Fabricated Fittings

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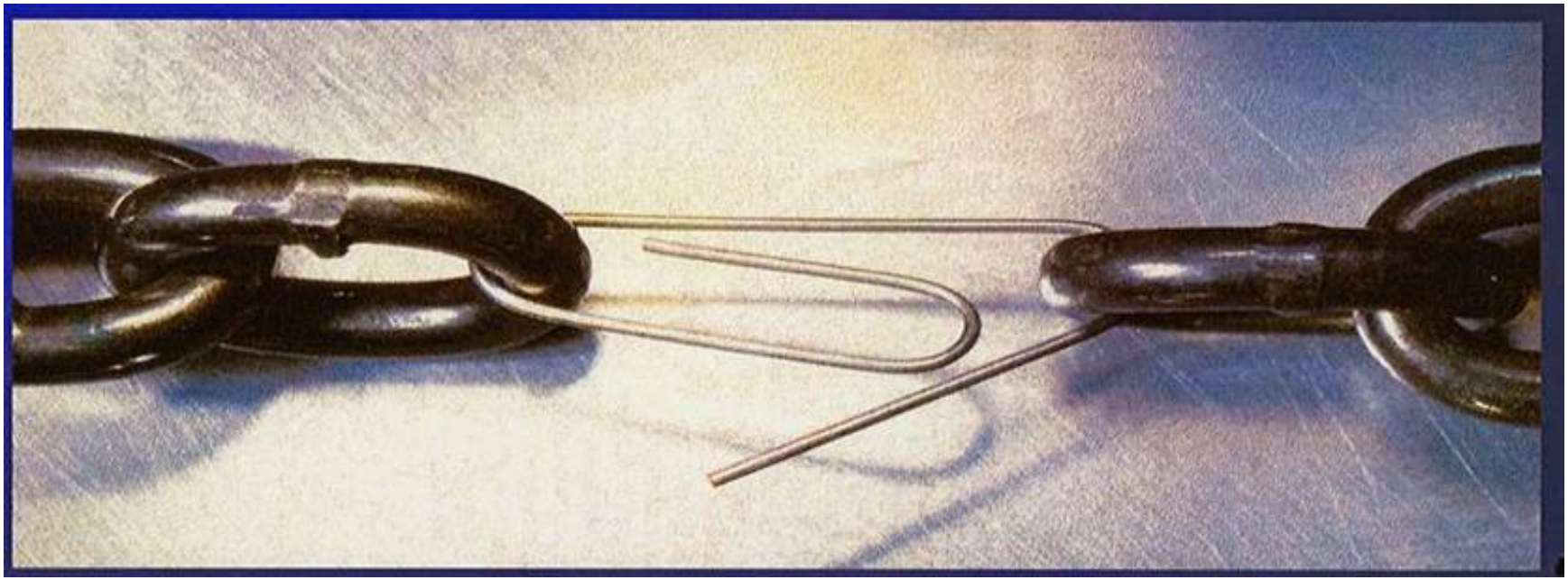
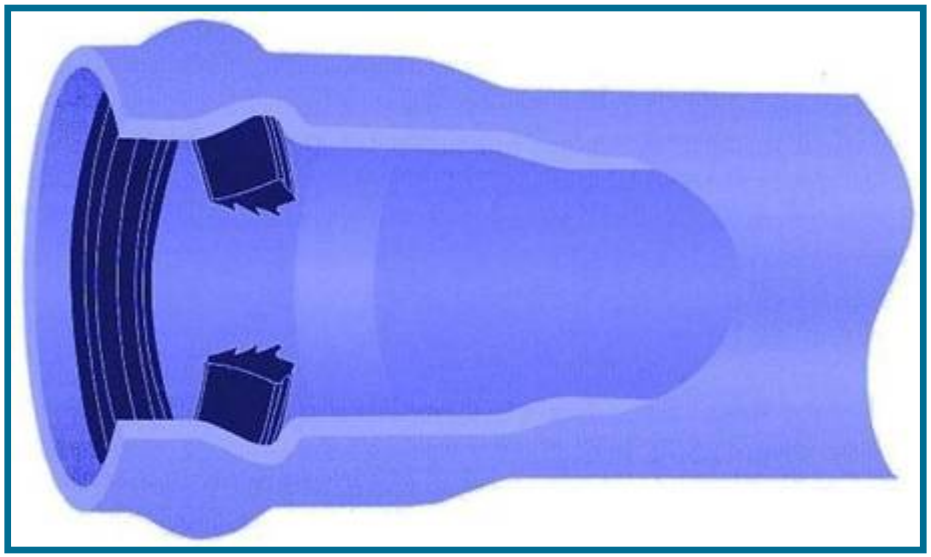
PVC Pipe Seals

Jointing of Municipal Pipelines



- Joints are the weak links in a pipeline

"Traditional" Sealing System for PVC Pipe

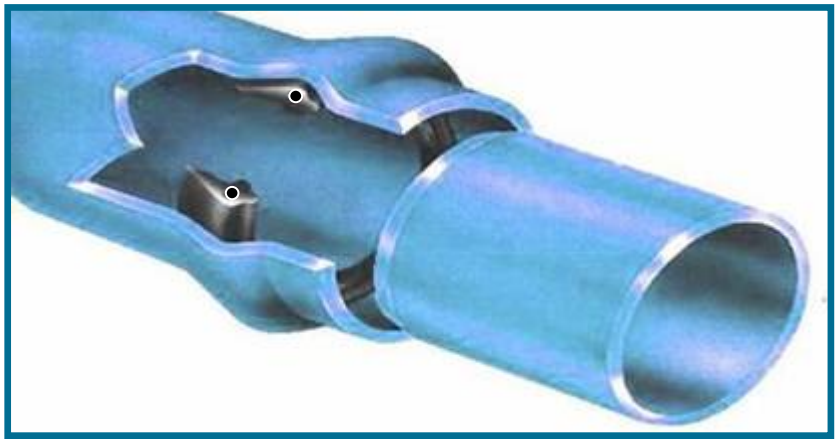


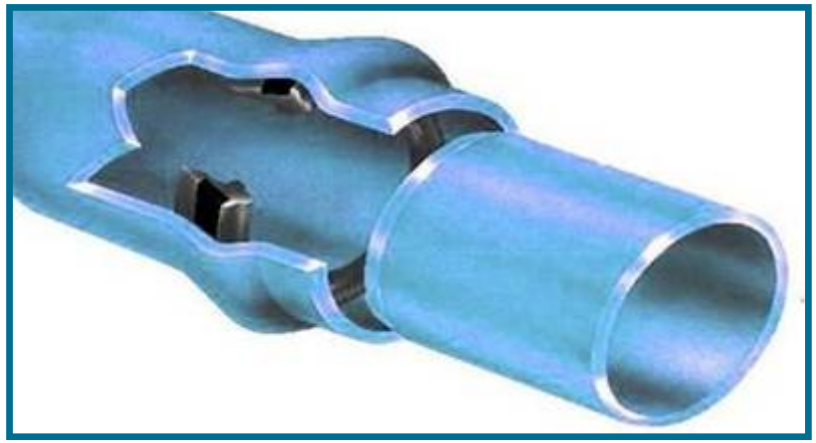
- *gaskets manually inserted on-site or at factory into gasket grooves ("race ways") in pre-belled pipe*

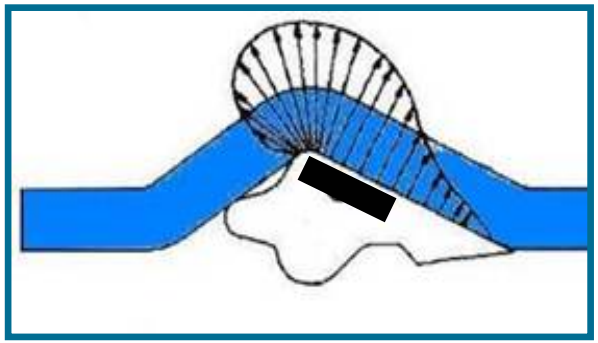
Problems w/ Traditional Seals

- *dislodgement of gaskets from bell groove during insertion of spigot ("fish-mouthing")*
- *excessive lubrication causing fish-mouthing*
- *compromise of gasket's sealing surfaces by entry of foreign particles*
- *involuntary use of wrong gasket type*

Rieber Joints for PVC Pipe: The Solution

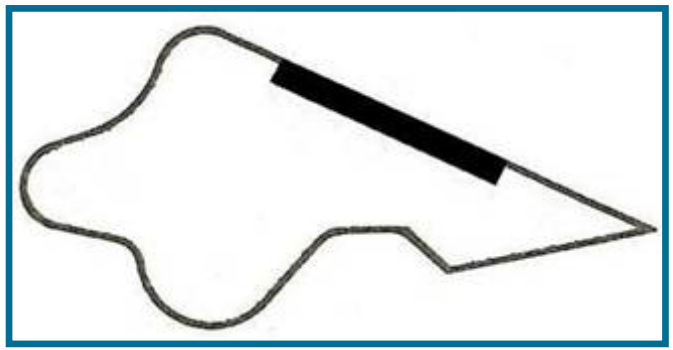


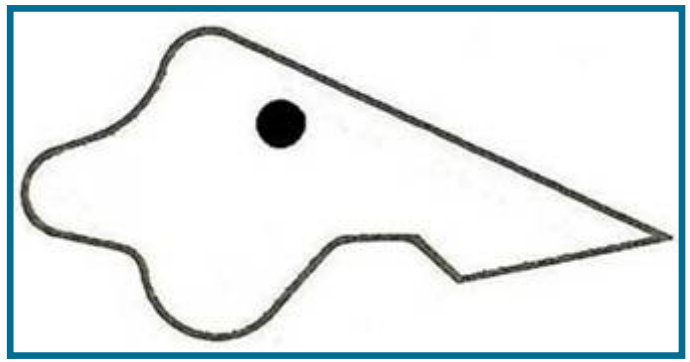


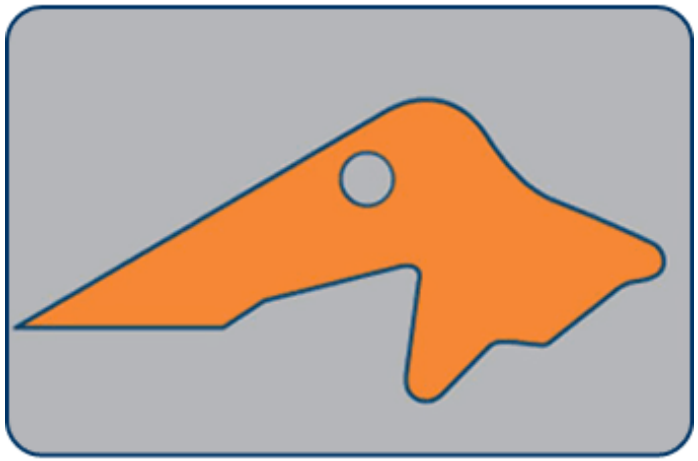


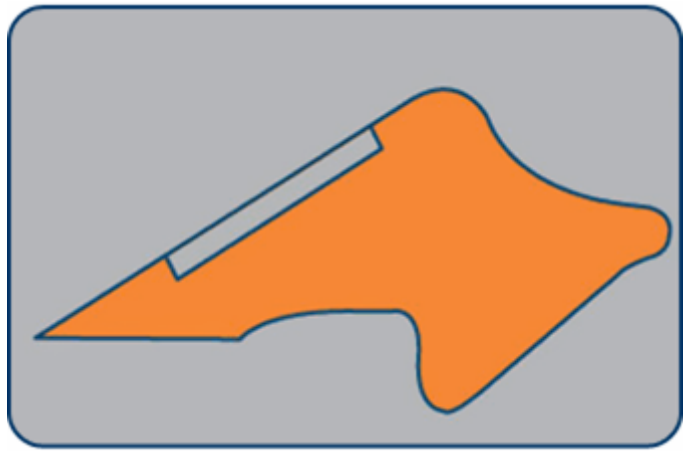
- steel-reinforced *elastomeric gasket*

Rieber Joints for PVC Pipe: The Solution





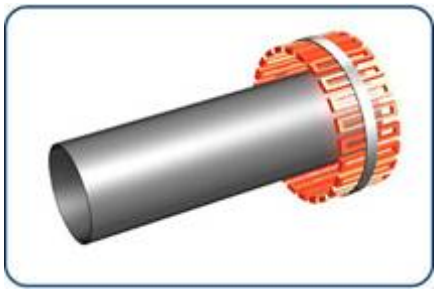




Rieber Joint: Steel Reinforcement

- *acts as the mould-element during manufacture, to create bell-groove ("race way") within the bell where it sits*
- *provides structural support and permanent pre-compression of the rubber ring against the pipe (prevents contamination of sealing surface)*
- *"locks-in" the gasket, preventing dislodgement from bell during joint assembly --- no "fish-mouthing"*

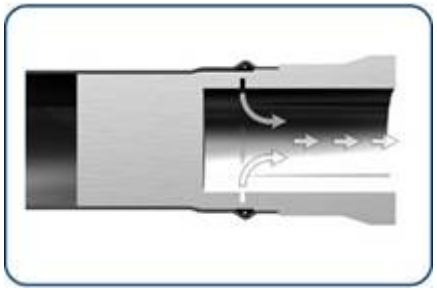
Rieber Joints: Manufacture



1. The pipe is heated

2. The gasket is loaded onto a mandrel

3. The pipe is formed over the mandrel

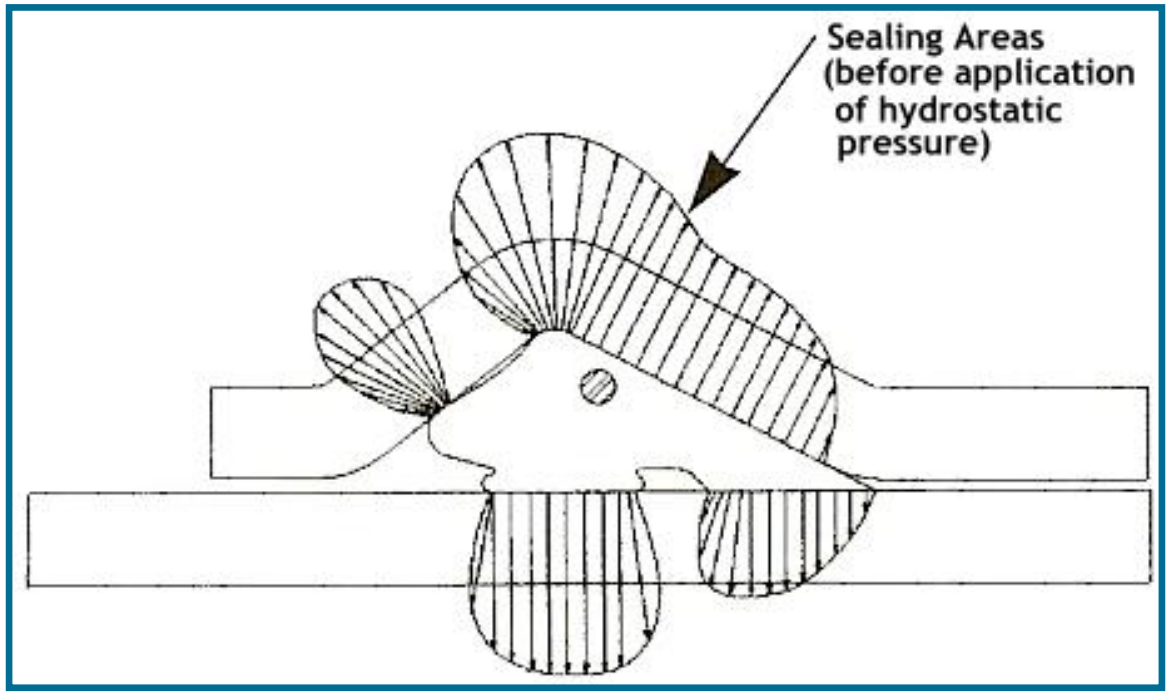


4. Vacuum or pressure is applied

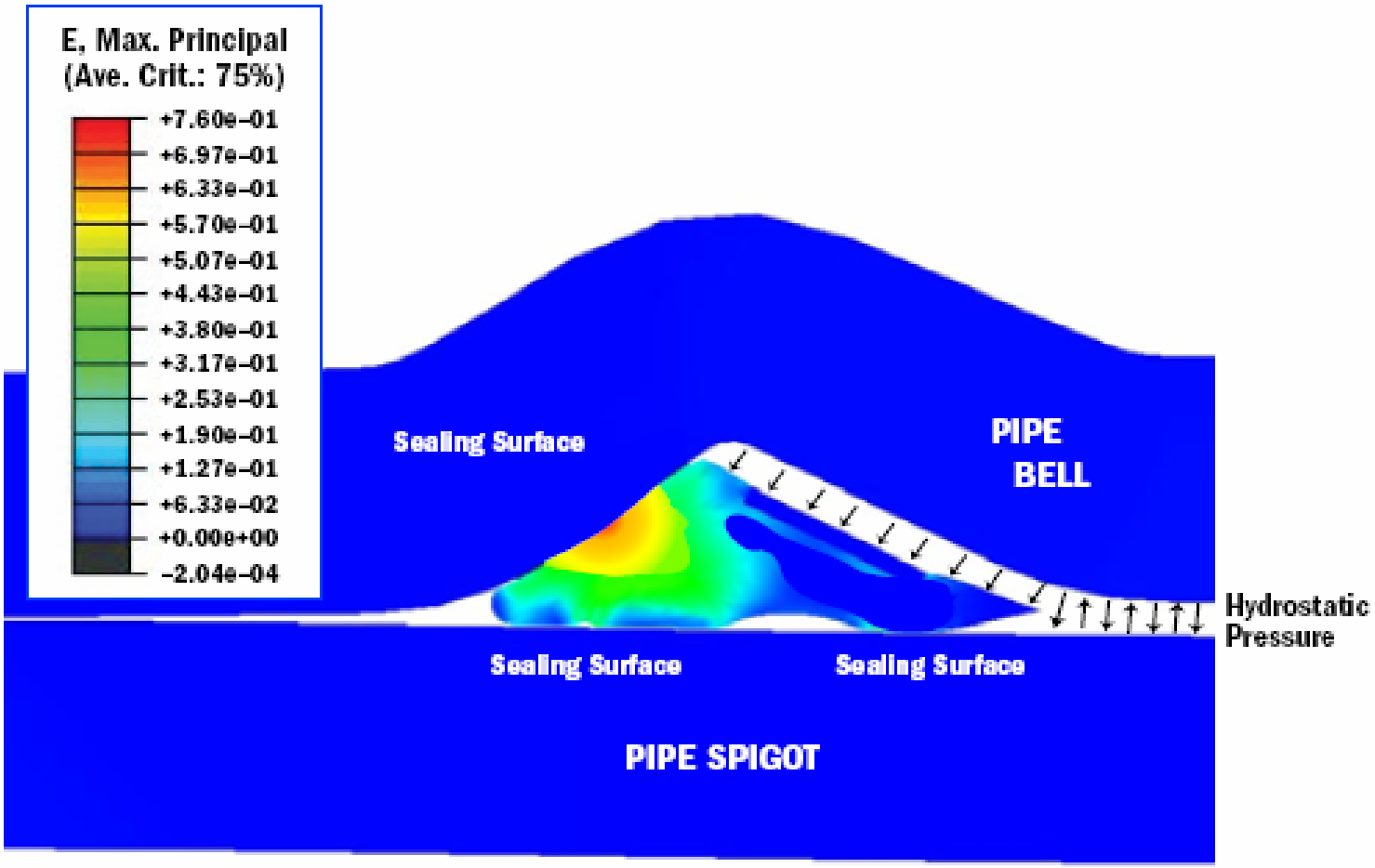
5. The pipe is cooled by water or air

6. The pipe is pulled off the mandrel

Rieber Joint: Gravity Flow Seal



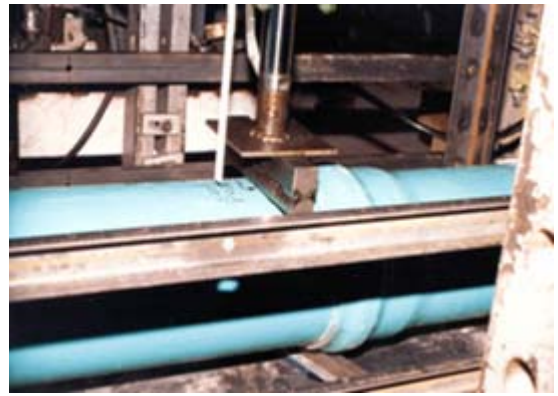
Rieber Gasket FEA

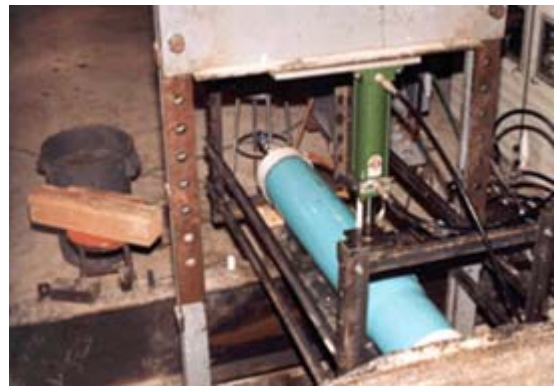


Pipe Sealing Standards

The following ASTM Standards apply to the design and performance of rubber gaskets for PVC Pipe:

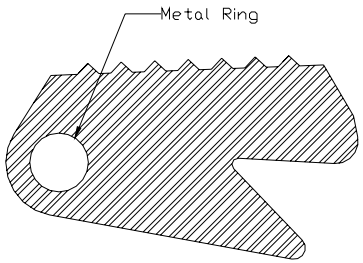
- **ASTM F 477** / Materials – Elastomeric Seals for Plastic Pipe
- **ASTM D 3139** / Performance of Gasketed PVC Pressure Pipe
- **ASTM D 3212** / Performance of Gasketed PVC Sewer Pipe



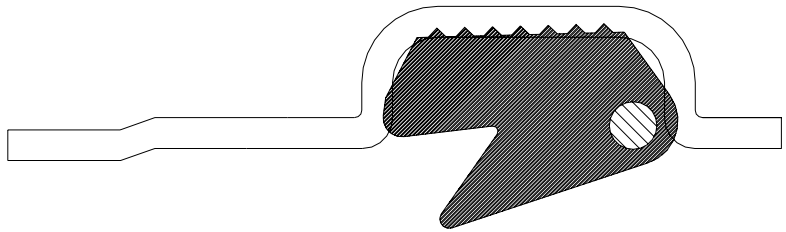


Gaskets for PVC Fittings

- A Rieber-type gasket is also used in PVC Pressure and Sewer Fittings (referred to as the Mambo Gasket)
- Similar gasket is also used in PVC-O Pipe



Gasket Profile



Assembled Joint

Gaskets for PVC Fittings

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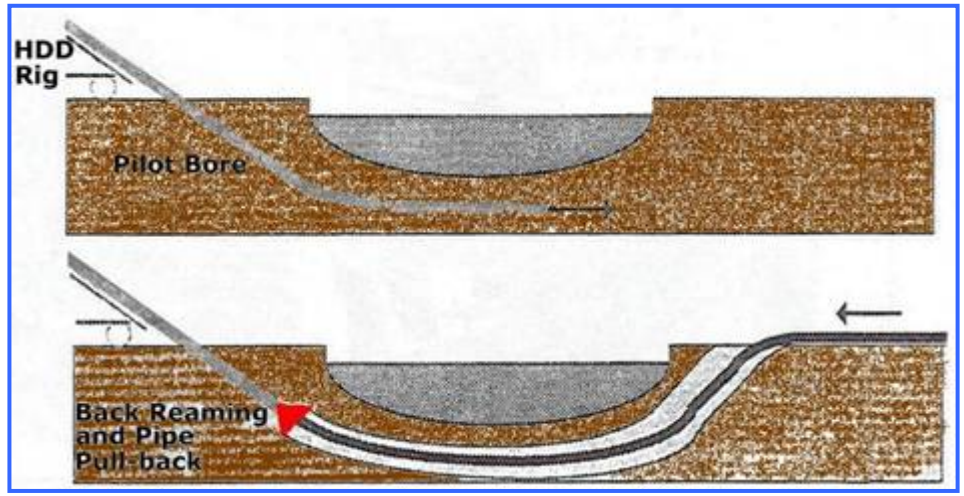
Trenchless Technology Products

- Method by which pipe is installed **without** the cutting of trenches
- Tunneling or boring of holes underground, from one pit to another, through which pipe is either **pushed** or **pulled** for installation
- Used for both new construction and rehabilitation

Trenchless Technology (HDD)



Trenchless Technology

Fusible C900™/C905™

Underground Solutions, Inc.

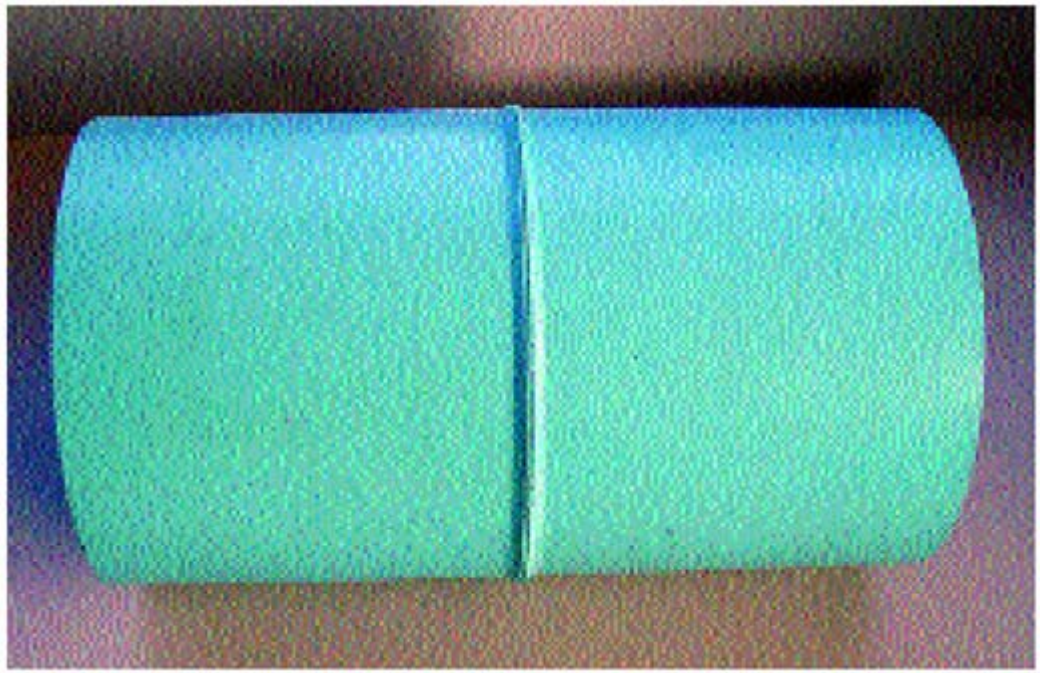
TerraBrute™

IPEX, Inc.

CertaLok C900/RJ™

CertainTeed Corporation

Trenchless Technology

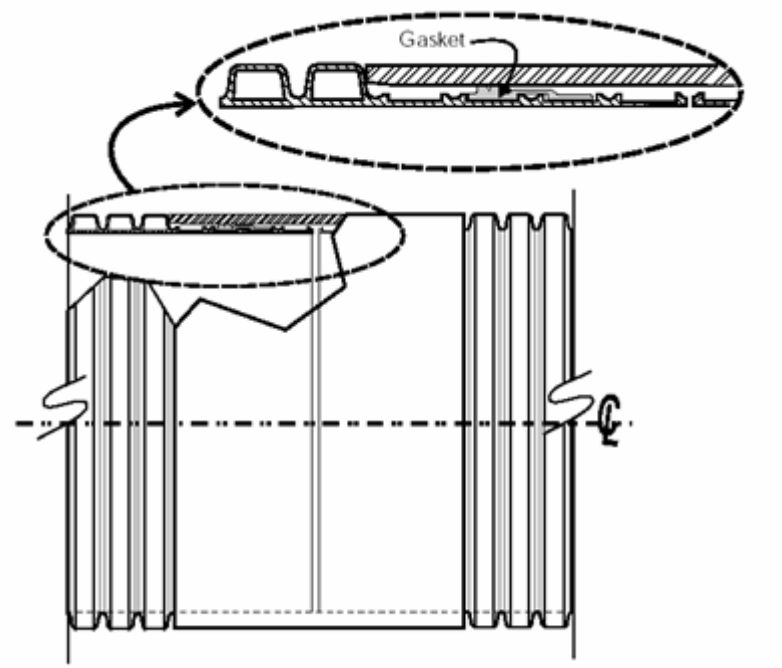


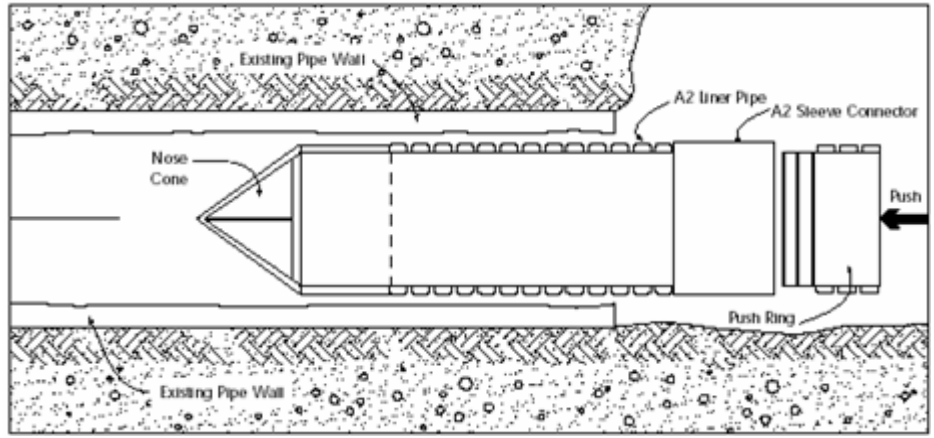
Trenchless Technology

Trenchless Technology

Trenchless Technology (Sliplining)

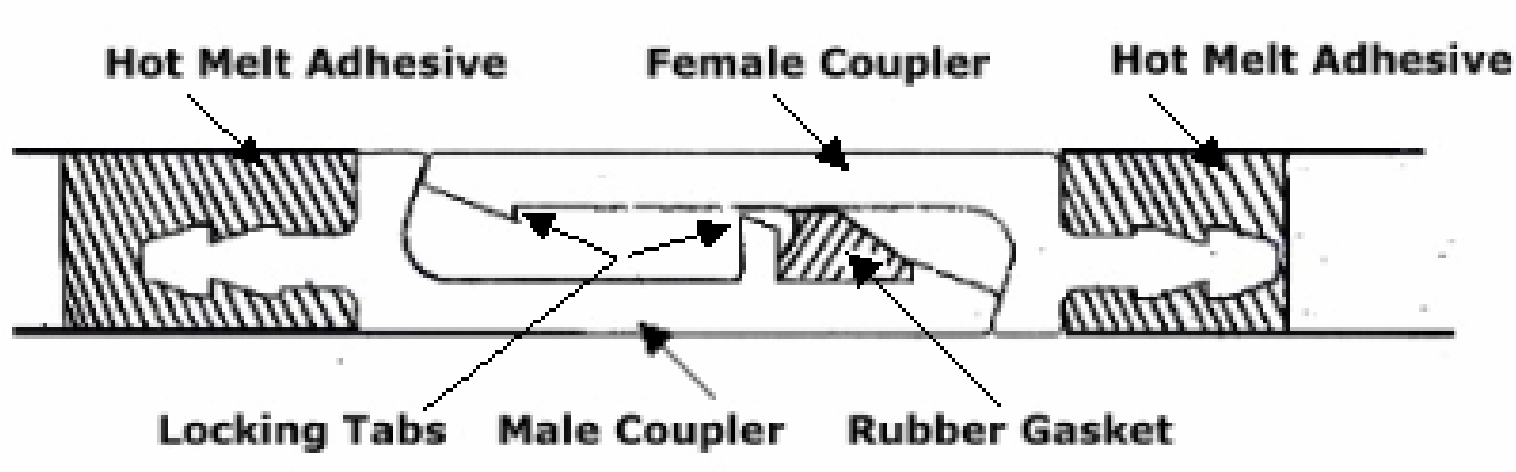
Trenchless Technology





Trenchless Technology

Trenchless Technology



Trenchless Technology

QUESTIONS ?