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TO: PRO Members

FROM: Dan Stanowick Dan

SUBJECT: Uni-Bell PVC Pipe News

DATE: August 5, 1992

COPIES: Bob Burnett
Pat Benkner
Bob Walker
Nora Jacobs
Dave Meeker

Enclosed for your information is a copy of the current issue of the above. It contains an excellent mix of technical articles, case histories, industry news items and features. Included among these is a story on page 10 about the alliance between our two organizations, as discussed at our most recent meeting.

As always, please let me know if you have any questions.

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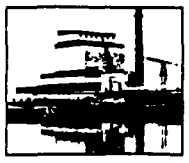

POWER for the FUTURE

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PVC at BULL CREEK

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CANADIAN SHALLOW BURIAL TESTS

See Page 8

Published by the Uni-Bell PVC Pipe Association, Dallas, Texas

UNI-BELL PVC PIPE NEWS

Volume 15, Number 1 Summer 1992

Abrasion Study grades PVC over concrete

By Dave Eckstein

The rise in popularity of profile wall PVC nonpressure pipes has been nothing short of phenomenal. With the full size range from 4-48 inch diameter, applications previously closed are now in hot demand of PVC. Whole end-use markets, such as storm drainage piping, present new opportunities for the product to provide its excellence of service.

New opportunities also mean new challenges. New questions must be answered.

"PVC Profile Pipes exhibited no measurable sensitivity or patterns of invert wear with increasing acidity of the water flowing within."
- Dr. Gabriel

With storm drainage applications have come questions of abrasion resistance. Although dormant the majority of time, these systems are called upon to handle high velocity, debris inclusive flow for a portion of their service life.

Traditional solid wall PVC products provide sufficient minimum wall thickness to allay concern. Profile wall products, with thinner minimum waterway wall thicknesses, however, would require testing to verify their ability to perform.

To that end, in early 1991 a group of Uni-Bell member profile wall pipe manufacturers funded study on invert wear at California State University in Sacramento. Conducted by Dr. Lester H. Gabriel, Professor Emeritus of Civil Engineering, the study incorporated velocities and aggregate materials meant to simulate very aggressive conditions. Further, acidity (pH) ranges were varied to introduce the ever-increasing experience of acid rains in North America.

Abrasion or wear data has traditionally been difficult to interpret or extrapolate to field service in that actual

CONTINUED ON PAGE 2

'Shake it up'

The "Tilt Table" allows for side-by-side comparison of abrasion resistance.

Designing PVC pressure capacity

By Peter Lloyd
The BFGoodrich Company

Editor's Note: The following is a portion of a submittal Mr. Lloyd made to the American Water Works Association for use in update to Manual #23, on Design and Installation of PVC Pressure Pipe. We found Mr. Lloyd's viewpoint, as a polymer expert, to give a refreshing new slant to this strength of material property.

The earliest PVC pipe systems were installed in Germany in the late 1930's and are still in use, so that there is now firm evidence of fifty year's service life. The real growth of PVC pipe did not start until the 1950's, so many conservative engineers still regard it as a new material.

To satisfy their need for reliable data, the PVC industry has carried out an extraordinarily thorough research program lasting over thirty years to provide a sound engineering basis for the design of PVC pipe. Unplasticized PVC is now probably the most completely understood pipe material available.

The pressure capacity of PVC pipe depends on the stress which the PVC material is able to withstand, without failure, for the expected life of the pipe.

Like most structural materials in everyday use - metals, ceramics, glass and plastics - the strength of PVC depends mainly on the way it is formulated and made. Pipe grades of PVC are required by AWWA C900 and C905 to be made from material which meets the requirements of Class 12454-A or -B of ASTM D1784. This ensures that PVC compound

CONTINUED ON PAGE 11

Two decades of dedication

Uni-Bell proudly celebrates 20th Anniversary

For many of us, birthdays are viewed with mixed emotions. Our culture places so much emphasis on youth that we approach the anniversary of our birth bemoaning the passage of time and yearning for the good old days when the years stretched out in front of, rather than behind, us. Therefore, it is not surprising that many of us prefer to let birthdays pass with little fanfare or fuss.

Not so for the Uni-Bell PVC Pipe Association. Uni-Bell's recent 20th anniversary was an occasion worthy of celebration. Uni-Bell's service and dedication to pipeline specifiers, designers, installers, managers and manufacturers for two decades, represented a milestone in the Association's accomplishment-filled history.

Uni-Bell's 1992 Annual meeting in Naples, Florida provided the occasion to spotlight Uni-Bell's anniversary. Member company attendees gained a sense of pride and ownership in their organization. "It was a celebration of longevity, accomplishment, growth and future potential," commented one Board Member.

Uni-Bell's Executive Director, Bob Walker, in his meeting address, took the attendees on a timely stroll down memory lane, recapping major milestones.

In The Beginning

The organizational meeting of the Integral Gasketed Joint Plastic Pipe Association took place on October 14, 1971 in Philadelphia, Pennsylvania. The original Board Members present at that meeting were John Madden, Jr. with Clow Corporation, Keith Swinehart with CertainTeed, Miles Devine with Johns-Manville, and Uni-Bell's legal

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CSU Abrasion Study grades PVC over concrete

Figure 1

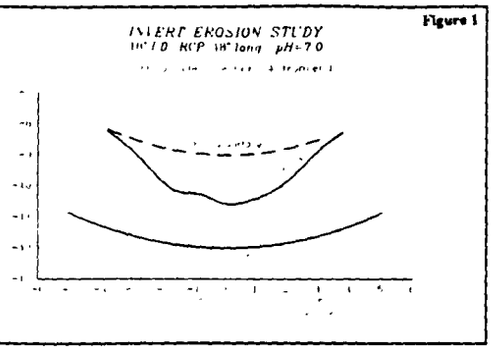
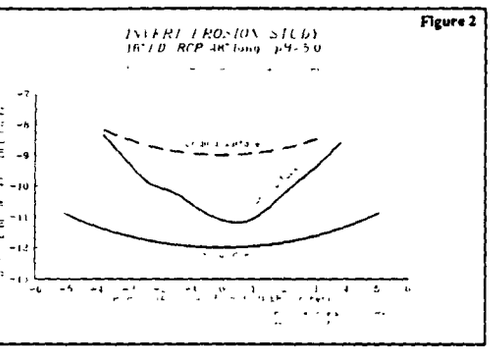


Figure 2



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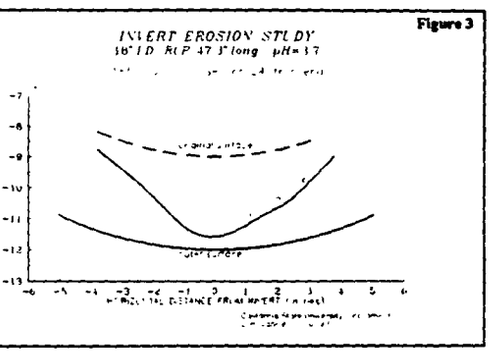


Figure 4

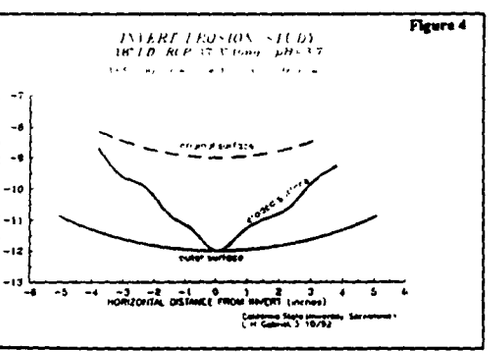
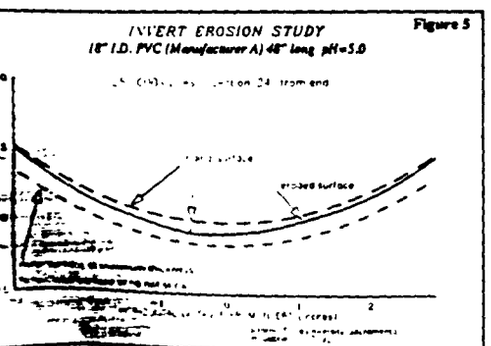


Figure 5



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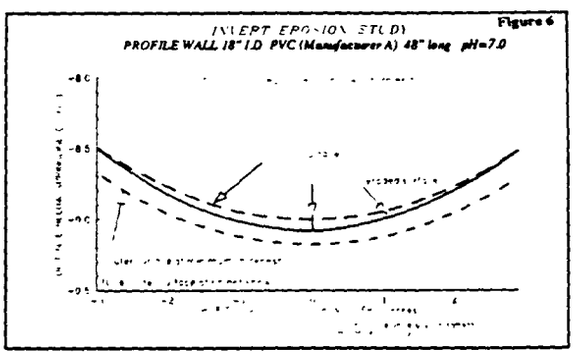
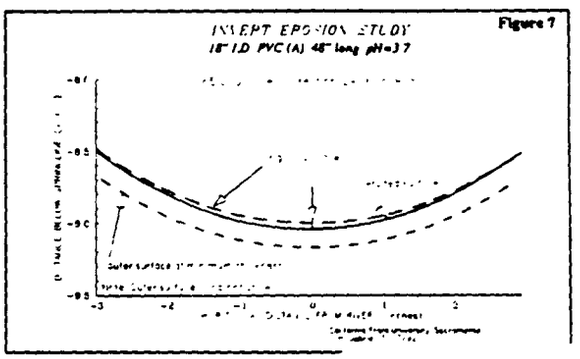


Figure 7



field abrasion experience is difficult to predict. To overcome this, the study also analyzes the effect on reinforced concrete pipes (RCP's) subjected to identical testing as the profile wall PVC pipes. The selection of RCP as a basis of comparison was due to the fact that the engineers have sufficient experience with the anticipated performance of these products.

MATERIALS

Pipe

Reinforced Concrete Pipe, ASTM C76, Class 3

Polyvinyl Chloride Pipe, ASTM F794, Pipe Stiffness = 46 psi

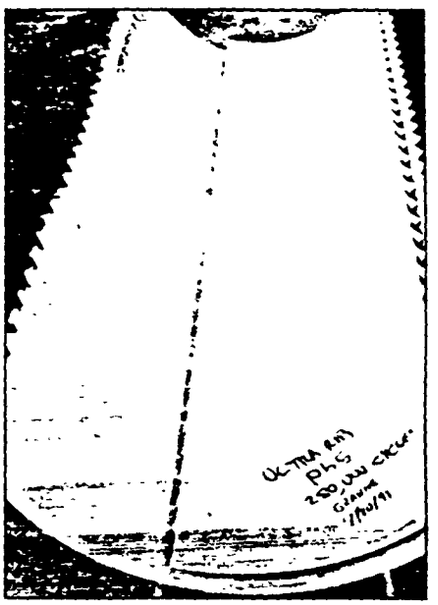
Aggregate

Granatic aggregate of crushed rock of uniform size, 2/3 by weight at 1/2 inch and 1/3 by weight of rounded gravel 2 inch and larger. Aggregate would be removed and replaced every 25,000 cycles due to abrasion of the aggregate during testing.

TEST EQUIPMENT

Referred to by Dr. Gabriel as the Reciprocating Tilt Table, it consists of the following:

- Tilt table which rotates from 45° above horizontal to 45° below horizontal. One cycle is to be considered one full rotation from starting point back to starting point.
- One full cycle is completed every 10 seconds.
- Table accommodates testing of 4' 0" pipe specimens.
- Automatic counter records number of cycles.
- Water traveling with aggregate exits and enters end caps each half-cycle to a pH regulating tank to maintain constant acidity level



This Profile Wall PVC Pipe shows little wear after the California State University tests.

TEST PROTOCOL

Nine pipe samples were tested to 250,000 cycles as follows:

- Concrete at pH = 7.0 (neutral)
- Concrete at pH = 5.0
- Concrete at pH = 3.7
- PVC profile wall at pH = 7.0, Manufacturer A
- PVC profile wall at pH = 5.0, Manufacturer A
- PVC profile wall at pH = 3.7, Manufacturer A
- PVC profile wall at pH = 7.0, Manufacturer B
- PVC profile wall at pH = 5.0, Manufacturer B
- PVC profile wall at pH = 3.7, Manufacturer B

Two separate sources of PVC were selected to test for any differences due to manufacturer.

TEST RESULTS

Graphs 1 - 10 represent the results of the testing by representation of the cross-sections of pipe at the midlength. Graphs note original versus worn invert to demonstrate the effect of testing.

Note that graphs 3 and 7 were taken to only 165,000 cycles. These two pipe specimens, tested in parallel, were stopped prematurely due to wall breach in the concrete sample. Graph #4

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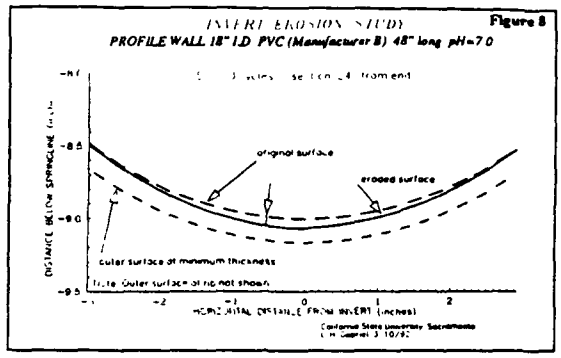
represents cross-section at the breach location. Graph #10 represents the second PVC pipe at pH = 3.7 for the full 250,000 cycle test limit to judge wear sensitivity to pH.

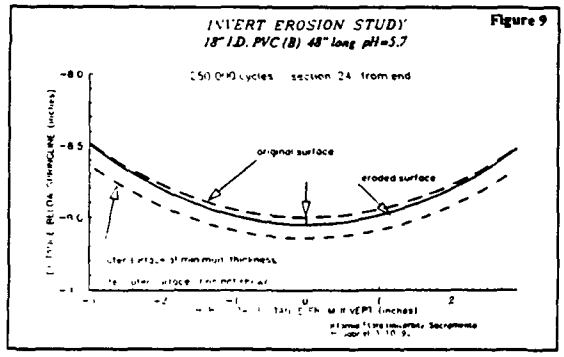
It is clear from the graphs that the research protocol accurately described an aggressive abrasion situation. The reference concrete pipe experienced excessive wear to the point of reinforcement exposure, typically viewed as pipe failure, even at neutral pH. The concrete, as expected, also showed extreme sensitivity to lower pH's (higher acidity).

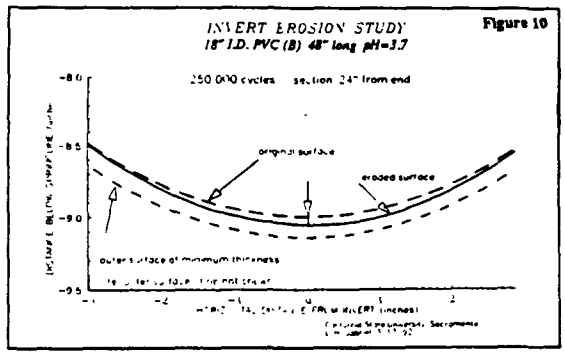
PVC, however, exhibited no sensitivity to manufacturer or acidity. In no case was a PVC waterway wall ever breached.

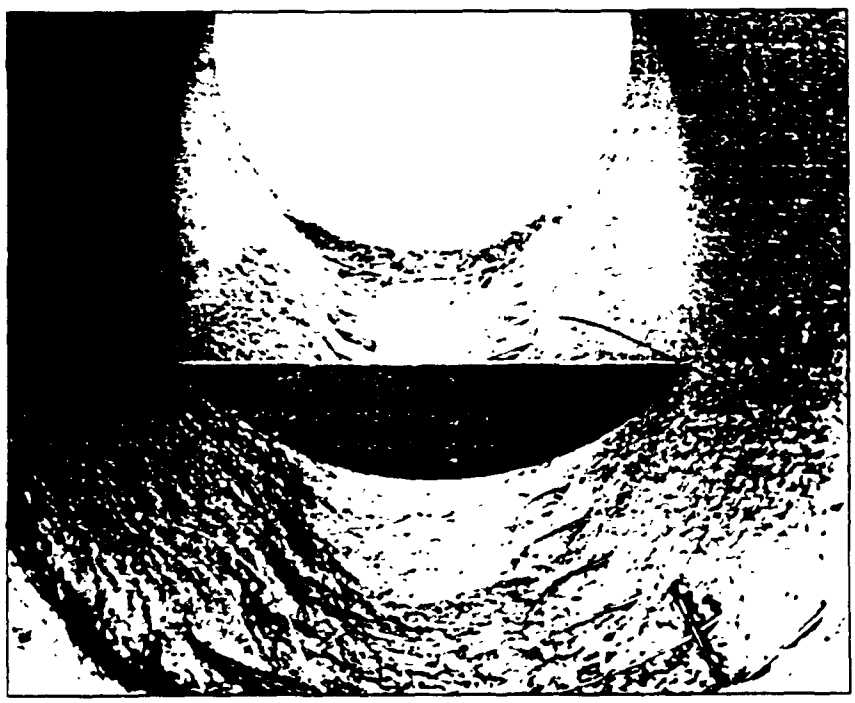
From the report itself, Dr. Gabriel states, "...PVC Profile Pipes exhibited no measurable sensitivity or patterns of invert wear with increasing acidity of the water flowing within. The reinforced concrete pipes, studied in parallel, were influenced by the acidity of the flowing water. Increasingly severe invert wear followed increasing acidity."

The PVC pipe industry has historically provided the user community with research designed to directly answer field service questions. Our congratulations to Dr. Gabriel and the work's sponsors on another shining example. ■









Concrete pipes tested exhibited dramatic wear.

CONTINUED FROM PAGE 1

Celebrating two decades

counsel, Arthur Kahn.

Membership doubled in 1972 and four working committees were formed to begin servicing the markets for water and sewer pipes. The Integral Gasketed Joint Plastic Pipe Association was renamed the Uni-Bell Plastic Pipe Association in April of 1972.

Later in 1972, Uni-Bell published its first two recommended standards. One was a recommended standard for gasketed joints and the other for PVC municipal water pipe. The latter served as a predecessor to the now extremely popular American Water Works Association (AWWA) standard C900.

PVC Handbook

The idea to develop a comprehensive handbook for water and sewer pipe was born in 1975. The Uni-Bell Handbook of PVC Pipe: Design & Construction has been the reference source for information about PVC pipe ever since it was first published in 1977. Uni-Bell has kept the handbook technically up-to-date through the periodic development of new editions. The first update (second edition) was completed in 1982 and a second major update (third edition) was completed just last year.

New York to Texas

A full-time executive director was hired in 1976 to help manage Uni-Bell's growing commitment to rapidly expanding the responsible use of PVC pipe. Uni-Bell headquarters were moved from New York City to Dallas, Texas and Uni-Bell's publications and educational services expanded.

The PVC pipe industry grew and so did Uni-Bell. In 1978, Uni-Bell hired their first engineer, someone to oversee Uni-Bell sponsored research and provide technical information services. The very first issue of the *Uni-Bell PVC Pipe News* was also published in 1978.

The 1980's

Throughout the 1980's Uni-Bell served the engineering, regulatory, public health and standardization communities with integrity and considerable measures of both time and resources. Whenever questions or problems arose relative to PVC pipe, Uni-Bell members, through their Association, responded. Uni-Bell's engineering staff grew and Uni-Bell sponsored research provided designers and installers with useful, practical information.

Hundreds of Uni-Bell pipe technology seminars were conducted to educate public works officials, consulting engineers, contractors and systems operators about the performance capabilities of PVC pipe. As a result, more and more communities revised and updated their specifications to take advantage of PVC pipe's many performance and durability attributes.

Measured Success

Today, PVC pipe products enjoy an overwhelming majority share of both the wastewater collection and water distribution piping markets in North America. On a linear basis, more than 90 percent of all wastewater sewers being installed are made of PVC and over 70 percent of all potable water distribution pipes (≤ 12") are PVC products.

PVC pipes' excellent performance history in these demanding pipe markets will provide strong impetus for PVC acceptance and use in larger diameter buried pipeline applications which include storm sewers, highway culverts and major water transmission lines.

In the 1990's Uni-Bell will continue working for all PVC pipe users and potential PVC pipe users, helping to assure proper product application and understanding through responsive research and education. As Uni-Bell celebrates its first 20 years of technological and educational service, they look ahead to the next 20 years. The future holds every indication that PVC pipe usage will continue to grow steadily. Such growth will be the result of the responsible, quality conscious member companies that comprise Uni-Bell and the performance versatility of PVC pipe and fittings.

For a listing of the Uni-Bell member companies, please refer to page 12 of this issue of PVC Pipe News or call Uni-Bell at (214) 243-3902

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'POWER FOR THE FUTURE'

Shand Power Station requires over 20 miles of large diameter PVC pipe

Saskatchewan is expanding its economic and industrial base. This expansion necessitated the construction of the Shand Power Station, by Sask Power, near Estevan, Saskatchewan. The government of Saskatchewan, through the Souris Basin Development Authority, is presently constructing the Rafferty Dam on the mainstream of the Souris River, 3.7 miles northwest of Estevan.

The Rafferty Dam is being built at the location identified by government engineers 50 years ago. The reservoir created by the dam will serve a number of useful purposes. First, it allows greatly enhanced recreation opportunities for southeastern Saskatchewan through the development of park facilities, cottages and additional water-based recreation. Second, the reservoir will provide cooling water for the Shand thermal electric generating station. Third, the Rafferty reservoir will provide for certain fish and waterfowl species and enhanced wildlife development potential. Fourth, the Rafferty reservoir will provide water for irrigation in the valley downstream of the dam. Fifth, there is considerable flood protection for the downstream communities of Estevan, Roche Percee and Oxbow, as well as providing flood protection for North Dakota, in particular, the city of Minot.

The Shand Power Project received environmental approval in February, 1988 for construction on 275 hectares. Site work began in May of 1988 on the first unit, a 300 megawatt plant which will provide 2 billion Kilowatt hours of energy per year. Shand will burn 1.5 million tons of coal annually and consume 3,200 cubic decameters of water in the cooling process. Unit one will cost $578.3 million and will begin serving Saskatchewan in July of 1992.

Kilborn (Saskatchewan) Ltd. was retained by Sask Power in November 1990, to provide design engineering services for the Shand Power Station, water supply system. "The Proposed Water Supply System," says Greg Miazga, Kilborn's Project Manager, "will transport make-up water to the Shand Power Station from three sources, for a total flow of 360 liters per second" (4,752 imperial gallons/minute).

- Rafferty Reservoir
- Boundary Dam Supplementary Water Supply
- City of Estevan Sewage Treatment Facility

A second water supply system with a total flow of 500 liters per second (6,600 imperial gallons/minute) will transport water from the Rafferty Reservoir to the Boundary Dam Reservoir.

According to Miazga, the evaluation study completed by Kilborn compared capital, energy and maintenance costs for alternate pipeline materials to determine the optimum combination of pump(s) (size and quantity) and pipeline(s) (diameter and material). The evaluation assessed the following three items:

- Four possible pumping arrangements including the possibility of twinning the pipeline.
- Four different types of pumps.
- Three pipeline materials including carbon steel, polyethylene (PE) and polyvinyl chloride (PVC) in diameters ranging from 500 millimeters (20") to 1,050 millimeters (42").

Miazga added, "The results of the study confirmed that all pipeline materials were technically acceptable. The sensitivity analysis indicated that the material type and size which would exhibit the lowest present worth in 1991 dollars was 600 millimeter (24") diameter PVC pipe. Based on providing the most cost effective means of transporting water some 23 kilometers (14.3 miles) from the Rafferty Reservoir to the Shand Power Station, it was Kilborn's recommendation to construct a single 600 millimeter (24") CIOD PVC pipeline. Consideration of PVC within Kilborn's technical/economic review was given but not limited to the following:

- Ease of construction - no welding or fusing required, therefore any bonafide sewer and water contractor could install.
- Corrosion resistance - no need for corrosion protection (both internal and external) and subsequent field testing after installation.
- Track record - Kilborn had contacted the City of Weyburn on their water supply main (6.11 miles - 20" PVC gasketed joint pressure pipe) and found that they have had no problems in the 10 years that they have been operating their system.
- Flexible joint - Allows for ease of transition for vertical and horizontal deflection.
- Factor of safety - 2.5 as applied to the hydraulic design basis.
- Approvals - CSA Certified to Standard B137.3 and AWWA Standard C905.
- Water hammer - Surge Pressure Rise (psi) per lineal foot per second velocity change of 11.4 and 14.7 for DR 41 and DR 25 respectively
- Vacuum - The joint is design to hold an above-ground vacuum of 22 inches of mercury.
- Ease of repair
- Good hydraulic characteristics - Hazen Williams C=150
- Market place - In Kilborn's discussions with various pipeline contractors, they all indicated that the easiest piping system to install would be PVC, which would reflect in the lowest installed costs and the most dependable installation.

Sealed tenders for the pipeline construction were received by Sask Power in May of 1991.

Miazga continues, "The tenderers were requested to submit supply and installation tenders for all three piping materials, PVC, PE, and Carbon Steel." Ten bids were received from contractors throughout Manitoba, Saskatchewan and Alberta.

"All bidders submitted tenders on PVC, four submitted tenders on PE, no tenders were submitted on Carbon Steel and one alternate was received on Hyprescon. Of the four low (short listed) bidders, only one supplied a quotation for PE and that quote was 83% higher than the submitted PVC quote. The balance of bidders who quoted the PE option submitted PE quotes that were 76%, 77% and 58% higher than their submitted PVC quotes."

"The bids, as received," says Miazga, "confirmed our recommendation/finding that the PVC piping system would be the most cost effective means of transporting water from Rafferty to Shand."

On June 24, 1991 Sask Power awarded the supply and installation contract, for the Shand Power Station Water Supply Pipeline, to Hamm Construction Ltd. of Saskatoon, Saskatchewan.

The pipe material requirements for the project include the following:

- 36,540 Ft- 24" CIOD SDR 25 AWWA C905, PVC Pipe
- 34,380 Ft- 24" CIOD SDR 41 AWWA C905, PVC Pipe
- 880 Ft- 20" CIOD SDR 25 AWWA C905, PVC Pipe
- 3,420 Ft-12" CIOD SDR 25 AWWA C905, PVC Pipe

The details of the installation include:

- Start of construction July 4 1991
- Total number of crews combined, 3
- Total manpower per crew 9
- Average bury depth 2.5 meters (9 ft.)
- Average trench width bottom 1.3 meters (4.3 ft.)
- Average trench width top 9 meters (29.5 ft.)
- Deepest bury 7.5 meters (24.6 ft.) on 24" SDR 41

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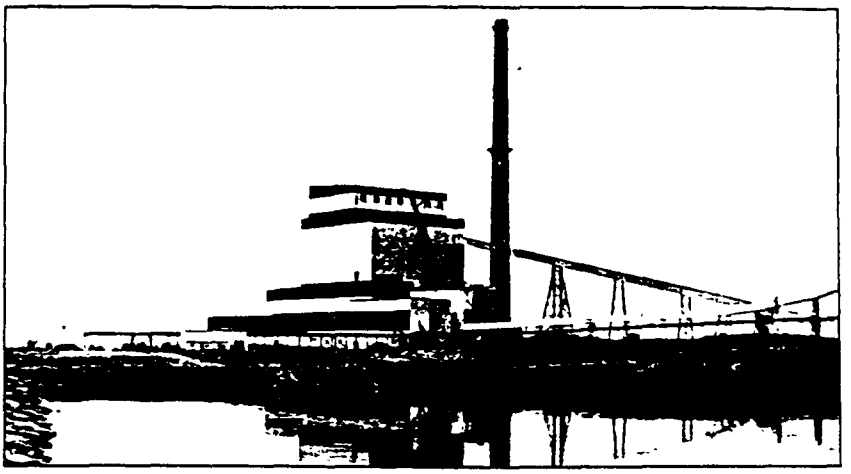
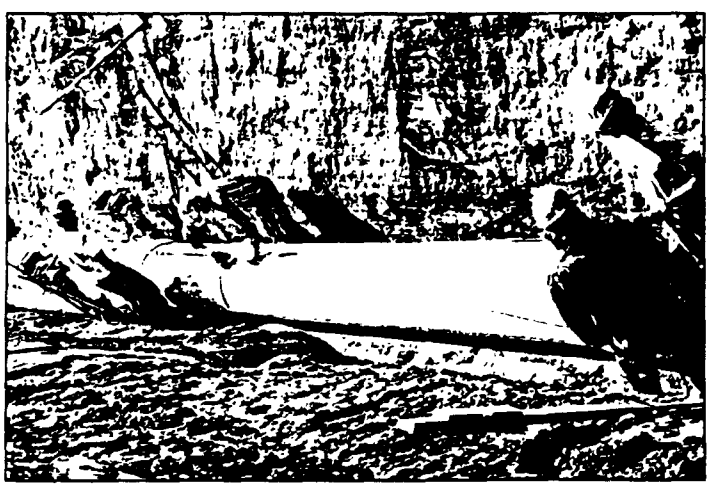


The Shand Power Station in Saskatchewan will provide many services including; recreational, cooling water, enhanced wildlife development, irrigation water and flood protection.



Shown above: Pipe joints are made easily and reliably with a come-along.

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W E L C O M E

UNI-BELL WELCOMES NEW MEMBERS

The Uni-Bell PVC Pipe Association is a non-profit technical and educational organization headquartered in Dallas, Texas, which provides information regarding the specification and use of gasketed PVC pipe products, for use in water, sewer, drainage and irrigation applications. The Association is made up of manufacturers committed to providing quality products and service to the PVC pipe industry. Formed in 1971, Uni-Bell offers technical service, research and development data and support in standards development.

Uni-Bell is proud to be directly affiliated with quality producers of gasketed PVC pipe, PVC fittings, PVC resin and PVC compound micro ingredients.

Uni-Bell member companies benefit from a philosophy that top quality pipe, service and technology all go hand-in-hand. They serve the PVC pipe industry and their customers with quality products, professional personnel and Uni-Bell technical expertise.

This issue we are pleased to welcome the Royal Plastics Group as our newest regular member. In addition, both Borden Chemical and Plastics Company and Occidental Chemical Corporation join Uni-Bell as Associate members as manufacturers of PVC resin.

ROYAL PIPE CO.

a division of Royal Plastics Limited

The Royal Plastics Group of Companies is comprised of Flex-Lox Pipe Limited in Western Canada and Royal Pipe Company in Eastern Canada. Headquartered in Woodbridge, Ontario, Royal manufactures pipe in Abbotsford, British Columbia, Toronto, Ontario and Montreal, Quebec.

Main product lines produced are gasketed PVC pressure and sewer pipe in sizes 4" through 27", PVC irrigation pipe in sizes 4" through 12", telephone and electrical conduit in sizes 1/2" through 6" and ABS/PVC drain waste and vent pipe in sizes 1 1/2" through 12". Recognizing the demand for large diameter profile pipe, manufacture has begun on a double wall R-D 2000 PVC pipe. R-D 2000 is currently available through 12" with future plans for larger diameters.

With one of the largest research and development facilities in North America, Royal Plastics will continue to answer market needs and provide innovation, service and quality.

For further information, please contact Royal at 5885 Highway #7, Woodbridge, Ontario L4L 1T9.

OxyChem

Occidental Chemical Corporation is a wholly-owned subsidiary of Occidental Petroleum Corporation. OxyChem® is North America's leading producer of PVC (vinyl) resins, the second largest producer of high density polyethylene (HDPE) and the pipe industry's leading supplier of rigid PVC resin and compound.

The parent company, Occidental Petroleum, is one of the nation's largest industrial companies having diverse operations in oil and gas exploration and development, natural gas transmission and chemicals. Their sales exceeded $10 billion in 1991 with employment at over 25,000 people in their domestic and international operations.

Occidental Petroleum was founded in 1920 as an oil and gas producer. Over the past twenty years,Occidental Chemical Corporation grew steadily as a supplier of electrochemicals, phenolic resins, detergents, specialty and agricultural products, polyethylene and PVC resins.

A contributing factor to their success has been OxyChem's decision to become fully integrated in all of the products and processes necessary to produce PVC resins. Consequently, of OxyChem's fifty domestic manufacturing facilities, eighteen produce either natural gas, chlorine, ethylene, ethylene dichloride or vinyl chloride monomer (raw materials for PVC) and four produce PVC resin. OxyChem is the only PVC supplier fully integrated in this way. Because PVC resin and its raw materials are an integral part of OxyChem's core operation, customers can be assured OxyChem will continue to grow in this business.

OxyChem is now headquartered in Dallas, Texas. Their fully staffed technical service laboratories for their vinyl products is located in Pottstown, Pennsylvania. For more information please contact Occidental Chemical Corporation; P.O. Box 809050, Dallas, Texas 75380-9050; (214) 404-3800.

BCP

BORDEN CHEMICALS and PLASTICS

Borden Chemicals and Plastics Limited Partnership commenced operations through its operating partnership on November 30, 1987 after acquiring the polyvinyl chloride resin and basic chemicals businesses from Borden, Inc., which built and operated the business starting in the early 1960's. BCP Management, Inc., a wholly owned subsidiary of Borden, owns a minority interest as the sole general partner in the operating partnership.

The assets of BCP consist of a polyvinyl chloride resin plant located in Illiopolis, Illinois, and a petrochemical complex located in Geismar, Louisiana. The Geismar complex consists of nine fully integrated plants, including a polyvinyl chloride resin plant, along with plants that produce vinyl chloride monomer, acetylene, methanol, formaldehyde, ammonia, urea, and urea-formaldehyde concentrate. The Geismar complex also operates two cryogenic air separation units and three co-generation units which allow self-sufficiency of certain operating gases, steam, and all electrical power.

Borden Chemicals and Plastics Limited Partnership trades on the New York Stock Exchange under the symbols, "BCP" and "BCU".

■

Scepter and Canron announce merger

On November 28, 1991, Canron, Inc., a wholly owned subsidiary of Ivaco Inc. and Scepter Manufacturing Company Ltd. jointly announced that they had signed a Memorandum of Understanding to combine their plastic pipe businesses. The new firm will be named Scepter/Canron Pipe Inc., the registered trade name of the SCP and Company Limited Partnership, which will be equally owned by both parties. The closing of the transaction is expected to have taken place by the time this article goes to press.

Scepter and Canron have competed aggressively in the Canadian municipal market for the last 20 years, so the natural question is: why would these two long time adversaries merge, and why now? Tom Torokvei, the owner of Scepter Manufacturing and partner in the new venture, answers these questions candidly. "The way markets are moving, we had to be bigger in order to compete. Our respective businesses and markets have undergone irrevocable, dramatic change in the last little while. Some of the key elements driving this change are the implementation of the Free Trade Agreement, historically low levels of construction activity resulting in weak demand for our products, and American competition. Simply, continuation of the status quo would have put our companies' futures in almost certain peril."

Scepter/Canron Inc. will be a formidable, cost competitive, pipe and fitting supplier with the broadest municipal product range available in North America. The new company will operate 18 plants in 8 out of the 10 Canadian provinces, providing significant economies of scale that combined with the services of some 50 technically qualified, customer-oriented, professional municipal sales people will allow Scepter/Canron to [illegible] pate in the North American [illegible] or supply [illegible] ucts with plastic pipe. The type of [illegible] stories in 1991 that have occurred in Laval, Halifax, Kitchener, Sault Ste-Marie and Trois Rivières, where C900 and C905 PVC pressure pipe was used for the first time in ductile iron strongholds, will continue unabated with the merger.

On the gravity sewer side of the equation, the combination of smoothwall DR 35, Ultra-Rib and Perma-Loc will be front and center in the battle to accelerate the erosion of concrete pipe usage for storm and sanitary sewer applications.

With PVC pipe enjoying commanding market shares in the smaller diameter pressure and non-pressure pipe markets in North America (in 1989, the Canadian industry estimated that 60% of all 4" - 18" pressure pipe and 80% of all 4" - 15" gravity sewer pipe installed was PVC), the last and possibly most challenging markets for PVC pipe will be in the larger diameter markets. In 1991, speaking as the Chairman of Uni-Bell, Mr. Torokvei's message touched on the boundless opportunities for PVC pipe growth. He outlined the advent of new standards for pressure pipe up to 36" (i.e., AWWA C905) and for profile wall pipe through 48" diameter (i.e., ASTM F794), and suggested that for the same reasons PVC has come to dominate the smaller diameter markets over the last twenty years, the inherent superiority of plastics should result in the same impressive market position in larger diameters over the next twenty years.

Notwithstanding the changing landscape that Scepter/Canron Pipe Inc. faces in the months and years to come, there is one thing that will not change according to Mr. Paul Graddon, President of Scepter/Canron Pipe Inc. "Over the last 15 years, both Canron and Scepter's respective marketing thrusts have been ably supported by the professional, technically competent personnel working for the Uni-Bell PVC Pipe Association. We look forward to continuing to draw on their expertise to help us to accomplish our long term marketing goals."

For further information, please contact: Scepter/Canron Pipe Inc., 50 Valleybrook Drive, Don Mills, Ontario, Canada, M3B 2S9 Phone number: (416) 445-3400 Fax number: (416) 445-4451.

CTL029111

New PVC fittings are a match for C900 PVC Pipe

By Hugh Fraser

In 1975 the landmark publication of American Water Works Association Standard C900, "Standard for Polyvinyl Chloride (PVC) Pressure Pipe, 4 in. through 12 in., for Water Distribution," gave recognition to a family of PVC pressure pipes that has received widespread acceptance in both municipal systems and water supply lines for fire loops. C900 has the well-deserved reputation of being the more conservative of all the international standards describing PVC pressure pipe. It sets forth requirements for Class 100, Class 150 and Class 200 PVC pipes in sizes 4 in. through 12 in., having cast iron outside diameters (CIOD). The CIOD's make it simple for designers to use cast iron or ductile iron fittings with C900 PVC pipes.

Using iron fittings with PVC pipes has always appeared to be rather inconsistent, even though their service record (with suitable protection where necessary) has been good. About 10 years ago, the industry initiated a two-pronged effort to develop a line of injection moulded PVC fittings that would provide the missing link to an all-PVC system. First, there were the technical hurdles to be overcome and, second, it was essential to bring together industry leaders and a number of general interest groups to develop a consensus standard that would describe the fittings in terms already familiar to users of AWWA standard C900.

Following 10 years of deliberations the standards committees of the AWWA have produced a standard for injection moulded, gasketed Class 150 PVC fittings for use with pipes meeting AWWA standard C900, Class 150 and Class 100. This new standard is AWWA C907, "Standard for Polyvinyl Chloride (PVC) Pressure Fittings for Water — 4 in. through 8 in. (100-200mm)." Before being standardized by AWWA, and in accordance with AWWA policy, the fittings were required to prove themselves in actual service for at least five years. AWWA is not prepared to standardize untried products.

The production technology that was developed for this product line was put in place beginning about 1979 and the products emerging from these initial production runs were immediately placed in service. The performance of the fittings has been outstanding, in part because the computerized design and production facilities are able to identify and overcome anomalies before they enter the production stream. Injection moulded PVC fittings of the sizes described in C907 require injection machines about the size of a railway box car capable of exerting closure forces of 2,500 tons. The state-of-the-art facilities behind the production and testing of these fittings have resulted in what can be conveniently referred to as "C907" fittings.

PVC pressure pipe and fittings have two "funds" of strength. The short term strength allows the pipe or fitting to resist very high pressures when they are applied for a brief period; C907 fittings, for example, are routinely tested to burst pressures in excess of 1000 psi, although the AWWA standard requires a minimum of just 755 psi. But for design purposes the only fund of strength that is significant for indefinite service is the long term strength. In the case of PVC pressure pipe described in C900 the long term strength of the material itself is determined in advance of pipe manufacture. The test is formalized in C900 and requires that the material used in the production of PVC pressure pipe has a minimum circumferential hoop *stress* (referred to as the hydrostatic design basis, HDB) of 4000 psi. Knowing that the material from which the pipe is extruded has a minimum hoop stress capability it is simple to translate this into the minimum dimensions required for pipes having certain pressure classes. The calculation results in the three wall thicknesses included in AWWA C900, DR 14, DR 18 and DR 25. The DR refers to "dimension ratio" which is simply the ratio of the outside diameter of the pipe to its minimum wall thickness.

Injection moulded PVC fittings have irregular profiles and more complicated shapes than a simple extruded pipe. For this reason the precise relationship between the dimensions of the fitting and the HDB of the material cannot be drawn. Standard C907 requires that each fitting configuration, and each size, must be subjected to the long term testing that is carried out on the pipe compound. In other words, the fittings themselves are tested instead of the compound from which the fittings are made. These qualification tests must produce a long term *pressure* strength (LTPS) (equivalent to the HDB found in the pipe standard) of 470 psi. What this proves is that PVC fittings meeting the requirements of AWWA C907 can be pressurized to 470 psi for over 11 years without failure. Other tests have shown that the

CONTINUED ON PAGE 7

About the Author

Hugh R. Fraser, P.E. is a graduate of the University of Toronto and has followed a career in Civil Engineering since he became associated with the pipe industry in 1960. During his career in the pipe business Fraser has been active in a number of standards-writing organizations such as ISO, Canadian Standards Association, ASTM and the American Water Works Association. Fraser recently retired from Scepter Manufacturing Co. Ltd. 807 Pharmacy Avenue, Scarborough, Ontario M1L 3K2 and continues to represent the company at the Technical Committee of the Uni-Bell PVC Pipe Association and at the American Water Works Association where he serves as chairman of the Sub-committee on PVC Pressure Fittings.

Real Life Application

City of Scarborough chooses PVC fittings for PVC Pipe

Martin Bugden and Dave Jordon from the Scarborough PUC used Scepter's PVC fittings.

Fittings meet AWWA, CSA, FM, UL and OPS requirements.

The City of Scarborough, Ontario has grown at a tremendous rate since World War II. When it joined Metropolitan Toronto in 1953, its population stood at 79,000. By 1967, Scarborough's population was 275,000. Today, its population has swelled to over 500,000.

The Scarborough Public Utilities Commission has had the task of providing water to this growing community. In 1991, they ambitiously undertook the installation of a 1.9 km water line.

"Replacement of the 30 year old cast iron line on Sylvan Avenue is expected to cost $500,000," according to Martin Bugden, Superintendent of the WaterWorks Operation for the Scarborough Public Utilities Commission.

Why replace a system that young? Over the last 30 years, the cast iron watermain has failed 123 times. "This far exceeded our normal failure rate of about 0.5/km/year," according to Bugden. "We would normally reline such a watermain, but because of the high frequency of breaks and persistent water quality complaints, it was decided that replacement was the most economical solution."

Scarborough Public Utilities Commission crews began to replace the cast iron watermain in June of 1991. Class 150 Polyvinyl Chloride Pipe was chosen as the replacement Pipe. The project was unique however in that all tees, elbows and tap couplings were also made of PVC.

"We wanted to replace the old system with a system utilizing the latest technology," said Mr. Bugden. "Our municipality has been using PVC pipe for years, but we wanted to take this opportunity to see how PVC Tees and Tapped Service Couplings would work."

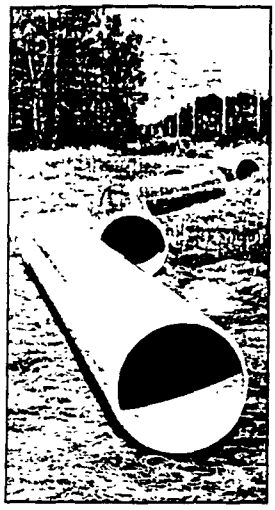
Class 150 injection moulded fittings offer a corrosion proof, easy to install fitting that eliminates the need for costly cathodic protection. All fittings were certified to CSA standard B137.2, "PVC Injection-Moulded Gasketed Fittings for Pressure Applications." The fittings also conform to the new AWWA standard C907-91, "Standard for Polyvinyl Chloride (PVC) Pressure Fittings for Water."

How have the residents coped with the construction? "We've worked very hard to anticipate problems," says Bugden. "We've had no complaints to date, and we're proud of that."

And so they should be. A quality job, with quality fittings, at a price taxpayers can be happy about.

CTL029112

A Long and Winding Road...



Stringing the pipe along the route prepares the way for speedy installation.

Integrity is not common to all things. But when it becomes apparent in a product - large diameter PVC pressure pipe for example - it quickly helps establish a reputation. That is one good reason, among many, for the wide acceptance gained by PVC pressure pipe.

"The pipe is the wave of the future. It's why we chose it," says Jim Hembree, Division Manager of Grand Strand Water & Sewer Authority (GSWSA) in South Carolina. He also serves as system project manager of the highly touted Bull Creek Regional Water System which recently went into full operation near Bucksport, South Carolina. At the dedication of all project facilities, key note speaker, South Carolina Senator Strom Thurmond stated, that this project could well serve as the model for the state and nation in water system construction.

The Bull Creek project is a joint venture of several partners: GSWSA, the City of Conway, Little River Water & Sewerage Company, and the town of Surfside Beach.

The system boasts a water treatment plant capable of treating 21 mg/d of water, additional storage for seven million gallons of water, pump stations and close to 50 miles of large diameter water transmission pipe. All told, Bull Creek serves a population of 120,000 with quality drinking water. (Also on the system are the town of Loris, the city of Aynor, and the Georgetown County Water & Sewer District).

The entire project including all facilities was completed in just 24 months. "We're told that's unheard of for a system of this size," Hembree points out. "Pipe installation alone generally takes much longer."

Good design, planning and proper product choice were all key factors. The Bull Creek project, according to Hembree, came in at about $4 million, or 10% under budget.

Some of those savings could be attributed to the large diameter PVC pipe which accounted for about 34 miles of the complete transmission installation.

Hembree notes that use of alternate materials such as steel or ductile iron would have necessitated application of special coatings or poly-wrapping, both of which would have increased costs. PVC became the product of choice on the basis of reduced costs, and because the pipe is impervious to soil corrosion. Not to mention ease of installation.

In total, 145,000 ft. of 24-inch and 44,000 ft. of 20-inch DR 25, pressure-rated 165 psi pipe was supplied. The delivery was accomplished in over 400 truck loads. It is believed that this is the largest single PVC pressure pipe project to-date.

GSWSA's Project Manager, Jim Hembree, acknowledges cost-savings were generated by the choice of PVC over alternate pipe materials — "our savings were about 5%," he estimates. "But what was critical to us was a commitment by the manufacturers to guarantee the supply of pipe."

Pipe installation proceeds quickly and efficiently.

Installation was generally fairly routine for the two GSWSA crews and one contractor. Hembree estimates the pipe went in at an average rate of 1,000 ft. per day, due in part to its light weight and gasket system which provides fast and easy coupling of pipe sections.

There are other benefits Bull Creek can expect down the road. PVC will reduce their energy costs because of the good hydraulic characteristics of the pipe, initially as well as long term.

However, all the benefits in the world can be tossed out the window if the system doesn't work the way it was designed.

"The day of reckoning is the day you test it," says Hembree. The project required 24 permits consisting of State Health Department, Corp. of Engineers, Water Resources and Coastal Council. There were 10 permits in the transmission line alone, varying in sections of three to twelve miles.

On completion of the 50 miles transmission line, a final test was carried out at 150 psi, which is well above normal usage requirements. The pipe sections were tested and approved within the very limited time schedule.

Now, Bull Creek is delivering fresh, high quality drinking water throughout the county. ■

...to the Bull Creek Project

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PVC fittings match C900 Pipe

instantaneous burst pressure of PVC pressure components actually increases with time when they are held for up to 10 years at HDB or LTPS. This long term pressure strength can be used in design applications in several ways, as follows:

1 Municipal Distribution Systems

In Municipal use PVC fittings meeting AWWA C907 will have a pressure denomination of Class 150. Nominal Class 150 fittings have a working pressure rating of 150 psi plus a surge pressure allowance of 35 psi, all enclosed within a factor of safety of 2.5 to 1 (that is, 150 + 35 = 185 psi which, divided into 470 psi, = 2.5). This very conservative approach to fitting applications is not necessarily appropriate in all cases.

2. Water Supply Lines

PVC fittings meeting C907 have a pressure rating of 235 psi when employed in the special contact of a supply line or with pipes other than C900 classes. Where the operating conditions in a water supply line are known beforehand, or can be predicted accurately, the imposition of unstated reserves for conditions that will not arise is unnecessary. Long term applications where the pressure in the fittings will be 235 psi will result in a factor of safety of 470 divided by 235, or 2 to 1

3 Fire Lines

Most looped fire lines can be analyzed with accuracy. Two conditions of service are normally encountered: the steady-state or stand-by condition and the full demand condition with its attendant surge potential. In these cases the pressure rating of the fittings (235 psi) can be safely assumed. For example, a system that will see a maximum operating pressure of 175 psi can easily make use of the C907 fittings with an assured safety factor of 470 divided by 175, or 2.7 to 1. Referring to condition 1, this is even more conservative than the AWWA standard envisages.

If the supplier of Class 150 PVC fittings can provide assurance that the requirement of AWWA C907 have been met then the use of these fittings represents a logical extension of the benefits of PVC pipe to the entire system. ■

CONTINUED FROM PAGE 4

20 miles of PVC needed

- Compaction of sand to springline: 95% proctor density
- Compaction of select material one foot above pipe: 95%
- Average footage per day for 3 crews: 380 meters (1,247 ft.)
- Best day installation and backfill for single crew: 280 meters (918 ft.)
- Construction completed: October 4, 1991
- Pressure test completed: October 23, 1991

The trench conditions ranged from: High water table, Sand stone, Shale, Gravel pits, Coal seams, Reclaimed mined coal areas, Clay-rich alluvium, Sandy-clayey alluvium and Bedrock.

With conditions such as these, a strict quality control inspection of all materials was put into place by Hamm Construction, to ensure that everything was satisfactory before being installed. Cornie Hamm stated, "Considering the quality of the pipe, and the people putting it in, I expected no leaks in any of the 3,860 joints involved in the 23 kilometers project." He further states, "We had some tough areas where leaks could have shown up due to the wet conditions. It was hard to keep everything clean in the muddy conditions, but the quality of the pipe and the care that was taken during installation, paid off."

The pipeline was installed using the come-along method instead of the bucket of the hoe. The joints were

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CTL029113

LOAD TESTING RESULTS

Profile Pipes under shallow cover

By John M. Maheu, P.E.
Research and Development Branch
Ministry of Transportation of Ontario

Editor's Note: The following is a reprint of work recently conducted by the Ontario Ministry of Transportation. The purpose of the work was to evaluate the shallow bury performance of profile wall PVC pipes under aggressive live loading. I've deleted brand and manufacturer names as is the policy of the PVC Pipe News. Out of respect for the Canadian Government, I have left metric conversion to the readers!

TEST PIPES

Two PVC pipe culverts were load tested. Both were tested after installation and backfilling, but prior to paving. The cover over the pipe was well compacted by the construction equipment passing over it, but densities were not measured.

The first pipe, identified as Culvert #14 in this contract, was a 762 mm inside diameter closed profile PVC pipe. At the time of testing, there was approximately 200 mm of granular cover over the sections of the pipe which were load tested. Two sections were tested: Section 3C-4A, at the joint between two lengths of pipe, and Section 4B, midway between two joints.

The second pipe, Culvert #25, was a 610 mm inside diameter open profile PVC pipe. There was approximately 470 mm of granular cover over the test section. One section was tested, Section 2C-1A, at the joint between two lengths of pipe.

INSTRUMENTATION

Four linear variable displacement transducers (LVDT's) were installed inside the pipes in the vicinity of each test section. They were monitored continuously during the application of the load to measure the change in diameters. They were oriented roughly in the vertical, horizontal, and two diagonal directions. One end of each LVDT was attached by screws inserted into a mounting block glued to the pipe surface. The other end of the LVDT was not attached, but was kept in contact with the pipe surface by a compressed spring in the housing. Because of the dimensions of the LVDT's, they could not all be installed in the same plane. Rather, they were installed over a length of pipe approximately 300 mm long.

In addition to the data from the LVDT's, deformations were also monitored by means of photogrammetric analysis. Permanent reflective targets were installed around the inside surface at various sections. Coordinates of the target points can be calculated from two photographs of each section from different viewpoints using a proprietary computer program. The targets were installed primarily for the purpose of monitoring long-term deformations of the pipes in service, but it was decided to include photogrammetric analyses of those sections near the test sections to supplement the test data.

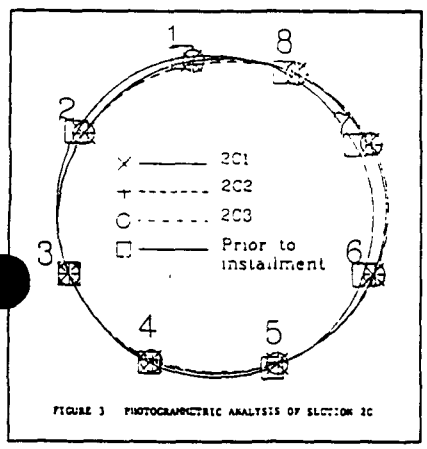

FIGURE 3 PHOTOGRAMMETRIC ANALYSIS OF SECTION 2C

It was not possible nor intended to use the photogrammetric results to verify the LVDT readouts for several reasons. First, the targeted sections for photogrammetry were not at the same locations as the test sections for load testing, since the LVDT's would obscure the targets in the photographs. It was necessary to locate each test section behind a targeted section, but usually within 300 mm. Second, the targets were installed in the pipes prior to the installation of the pipes. After installation, the targets did not necessarily coincide with the vertical, horizontal, and diagonal orientations of the LVDT's.

LOADING

Load was applied to the cover above the test sections by means of a hydraulic ram mounted to the underside of a flatbed trailer loaded with concrete blocks. As the ram was extended, the weight of the trailer would transfer from the axles to the ram. A load cell was used to measure the magnitude of the applied load.

The footprint of the load pad was two 250 mm squares, modeling a dual truck tire. The trailer was positioned to locate the pad directly over the test sections, as close to the centreline of the pipe as possible.

At each test section, loading was applied in two cycles with peak loads of approximately 250 kN. The load was not applied in a strictly monotonically increasing fashion, since the extension of the ram was stopped at intervals to allow the pipe interior to be inspected and photographed.

TEST RESULTS

Test results are presented for each test section.

Culvert #25, 610 mm I.D. Open Profile Pipe/ Section 2C-1A, Joint Section

Figure 1 shows the change in inside diameter (as percent of nominal diameter) vs applied load, for each of the four LVDT's for load cycle #1 only. Figure 2 shows the change in vertical diameter only, for both load cycles #1 and #2. Maximum deformation is less than 2% under 250 kN applied load. Less than 1% residual deformation after removal of load, although additional recovery likely occurred with time (i.e., deformations are time-dependent, both during loading and unloading).

Tables 1, 2, and 3 summarize results of photogrammetric analysis. A maximum 2.8% deformation was recorded at Section 2C during installation. A maximum 1.4% deformation was recorded under load testing. Negligible residual deformations after testing. Figure 3 is a graphical representation of the photogrammetric results.

Culvert #14, 762 mm I.D. Closed Profile Pipe/ Section 3C-4A, Joint Section

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FIGURE 1
CULVERT #25, 610 mm I.D. OPEN PROFILE
SECTION 2C-1A (JOINT), LOAD CYCLE 1
Change in Inside Diameter (%)

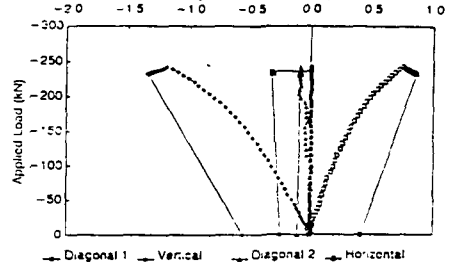
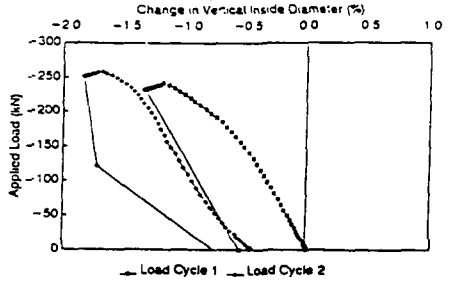


FIGURE 2
CULVERT #25, 610 mm I.D. OPEN PROFILE
SECTION 2C-1A (JOINT), LOAD CYCLES 1 AND 2
Change in Vertical Inside Diameter (%)



RESULTS OF PHOTOGRAMMETRIC ANALYSIS

CULVERT #25, 610 mm I.D. OPEN PROFILE
SECTION 2C, NEAR JOINT

TABLE 1: CALCULATED DISTANCES BETWEEN TARGET POINTS

DISTANCE BETWEEN TARGETS	LOAD CASE 2C#0 (Distance in m)	2C#1	2C#2	2C#3
1-5	0.578	0.562	0.554	0.562
2-6	0.583	0.586	0.588	0.586
3-7	0.575	0.600	0.604	0.602
4-8	0.576	0.578	0.578	0.580

TABLE 2: CHANGE IN LENGTHS AFTER INSTALLATION

TARGET ENDPOINTS	CHANGE IN LENGTHS FROM 2C#0 TO 2C#1 (m)	(%)
1-5	0.016	2.8
2-6	0.003	0.5
3-7	0.025	4.3
4-8	0.002	0.3

TABLE 3: CHANGE IN LENGTHS UNDER LOAD TESTING

TARGET ENDPOINTS	FROM 2C#1 TO 2C#2 (m)	(%)	FROM 2C#1 TO 2C#3 (m)	(%)
1-5	0.008	1.4	0.000	0.0
2-6	0.002	0.3	0.000	0.0
3-7	0.004	0.7	0.002	0.3
4-8	0.000	0.0	0.002	0.3

LEGEND		
	2C#0	PRIOR TO INSTALLATION
	2C#1	INSTALLED PRIOR TO LOAD TESTING
	2C#2	UNDER TEST LOAD 250 KN
	2C#3	AFTER LOAD TESTING

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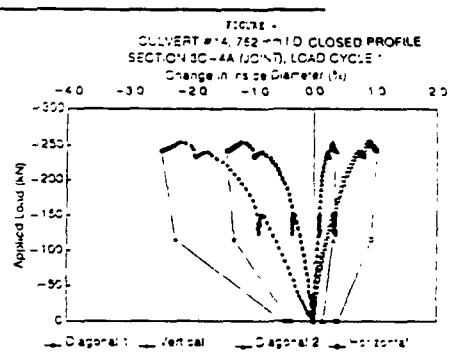
FIGURE 4
CULVERT #14, 762 mm I.D. CLOSED PROFILE
SECTION 3C-4A (JOINT), LOAD CYCLE 1
Change in Inside Diameter (%)



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Load testing results of Profile Pipes

Figures 4 and 5 show changes in inside diameter vs. applied load. Maximum deformation is 3.2% under 250 kN applied load. Residuals less than 1% after unloading.

Photogrammetry results for section 3C are summarized in Tables 4, 5 and 6, and Figure 6. Table 5 indicates a small increase in diameter after installation (1.1%), which is questionable. Maximum deformation under load was 1.4%, and maximum residuals after unloading were less than 1%.

Culvert #14, 762 mm I.D. Closed Profile Pipe/ Section 4B, Midway Between Joints

Changes in inside diameter vs. applied load are shown in Figures 7 and 8. Because of the highly localized nature of the deformation, three of the four LVDT mounting blocks detached during the second load cycle, and loading was stopped. The maximum deformations recorded were just over 5%. The maximum residual deformations were less than 1% after load cycle #1, no values available after load cycle #2.

Photogrammetry results for section 4B are summarized in Tables 7, 8 and 9, and Figure 9. Maximum deformation of 1.1% was recorded after installation. Maximum deformations during load testing were 3.4%. Residuals after unloading could not be measured since the disengaged LVDT's blocked several of the targets in the photographs.

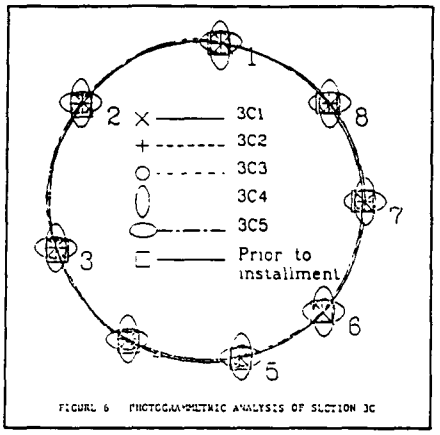


FIGURE 6 PHOTOGRAMMETRIC ANALYSIS OF SECTION 3C

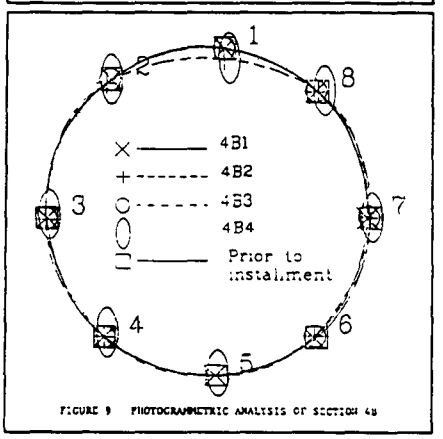


FIGURE 9 PHOTOGRAMMETRIC ANALYSIS OF SECTION 4B

DISCUSSION

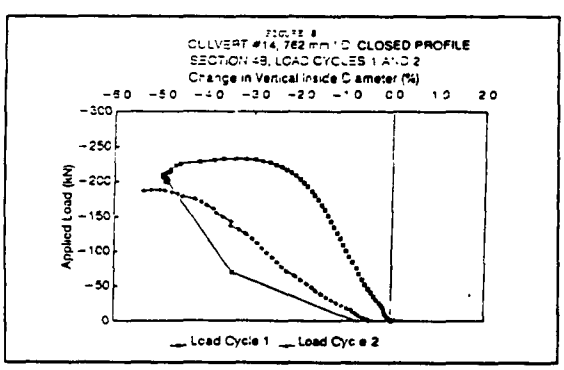
Some general observations can be made regarding the test results. As expected, the photogrammetric analyses yield smaller deformation than the LVDT readings because the targeted sections are not directly below the load points, and the deformations are very localized.

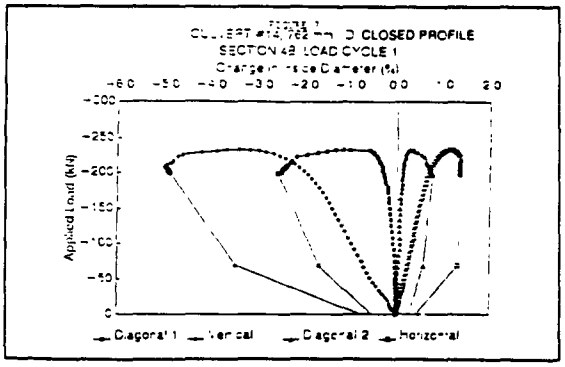
The plots of load vs. deformation are typically non-linear, and in many cases the deformations are seen to be increasing under decreasing load. This would suggest the pipes are failing under the test loads, but this was not the case. Rather, the shapes of the curves are influenced by other factors:

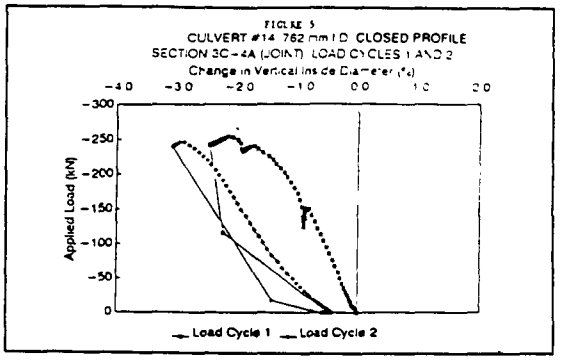
- The load-deformation characteristics of the bedding, backfill, and cover, which are time-dependent and nonlinear-elastic.
- The loading rate was not constant, nor was it possible to maintain a constant load level. Whenever the extension of the hydraulic ram was temporarily stopped to allow inspection of the pipe interior, deformations continued to increase with time. As the hydraulic ram pushed further into the fill, the flatbed trailer would move lower, thereby transferring load from the ram back to the trailer axles. This reduction in applied load was not the result of diminishing capacity of the pipe.

The residual deformations after unloading were typically less than 1%, and there were no other signs of distress in the pipes after testing. It can be concluded that the pipes did not fail under the test loads.

■







RESULTS OF PHOTOGRAMMETRIC ANALYSIS

CULVERT #14 762 mm I.D CLOSED PROFILE
SECTION 3C, NEAR JOINT

TABLE 4: CALCULATED DISTANCES BETWEEN TARGET POINTS

DISTANCE BETWEEN TARGETS	LOAD CASE 3C#0 (DISTANCE IN m)	3C#1	3C#2	3C#3	3C#4	3C#5
1 - 5	0.729	0.730	0.722	0.720	0.720	0.726
2 - 6	0.736	0.744	0.738	0.745	0.745	0.748
3 - 7	0.727	0.736	0.731	0.736	0.734	0.736
4 - 8	0.723	0.727	0.722	0.722	0.719	0.722

TABLE 5: CHANGE IN LENGTHS AFTER INSTALLATION

TARGET ENDPOINTS	CHANGE IN LENGTHS FROM 3C#0 TO 3C#1 (m)	(%)
1 - 5	0.001	0.1
2 - 6	0.008	1.1
3 - 7	0.009	1.2
4 - 8	0.004	0.6

TABLE 6: CHANGE IN LENGTHS UNDER LOAD TESTING

TARGET ENDPOINTS	FROM 3C#1 TO 3C#2 (m)	(%)	FROM 3C#1 TO 3C#4 (m)	(%)	FROM 3C#1 TO 3C#5 (m)	(%)
1 - 5	0.008	1.1	-0.010	1.4	-0.004	-0.5
2 - 6	-0.006	-0.8	0.001	0.1	0.004	0.5
3 - 7	0.005	0.7	0.000	0.0	0.000	0.0
4 - 8	-0.005	0.7	-0.005	0.7	0.005	0.7

LEGEND:
- 3C#0 PRIOR TO INSTALLATION
- 3C#1 INSTALLED PRIOR TO LOAD TESTING
- 3C#2 UNDER TEST LOAD CYCLE #1 250 KN
- 3C#3 AFTER CYCLE #1 NO LOAD
- 3C#4 UNDER TEST LOAD CYCLE #2 250 KN
- 3C#5 AFTER LOAD TESTING

RESULTS OF PHOTOGRAMMETRIC ANALYSIS

CULVERT #14 762 mm I.D CLOSED PROFILE
SECTION 4B MIDWAY BETWEEN JOINTS

TABLE 7: CALCULATED DISTANCES BETWEEN TARGET POINTS

DISTANCE BETWEEN TARGETS	LOAD CASE 4B#0 (DISTANCE IN m)	4B#1	4B#2	4B#3	4B#4
1 - 5	0.737	0.738	0.734	0.736	0.743
2 - 6	0.742	0.738	0.737	0.739	0.742
3 - 7	0.744	0.738	0.742	0.741	0.745
4 - 8	0.739	0.739	0.738	0.737	0.741

TABLE 8: CHANGE IN LENGTHS AFTER INSTALLATION

TARGET ENDPOINTS	CHANGE IN LENGTHS FROM 4B#0 TO 4B#1 m	%
1 - 5	0.001	0.1
2 - 6	0.004	0.5
3 - 7	0.008	1.1
4 - 8	0.000	0.0

TABLE 9: CHANGE IN LENGTHS UNDER LOAD TESTING

TARGET ENDPOINTS	FROM 4B#1 TO 4B#2 m	%	FROM 4B#1 TO 4B#3 m	%	FROM 4B#1 TO 4B#4 m	%
1 - 5	0.024	3.3	0.008	1.1	0.025	3.4
2 - 6	0.001	0.1	0.001	0.1	0.004	0.5
3 - 7	0.006	0.8	0.002	0.3	0.009	1.2
4 - 8	0.00	0.1	0.002	0.3	0.002	0.3

LEGEND
- 4B#0 PRIOR TO INSTALLATION
- 4B#1 INSTALLED PRIOR TO LOAD TESTING
- 4B#2 UNDER TEST LOAD CYCLE #1 250 KN
- 4B#3 AFTER CYCLE #1 NO LOAD
- 4B#4 UNDER TEST LOAD CYCLE #2 250 KN

NOTE NO PHOTOS TAKEN AFTER FINAL LOAD REMOVED

CTL029115

PVC community benefits from PRO and Uni-Bell Alliance

PVC pipe and fittings account for more than 37 percent of the over 8 billion pounds of PVC consumed annually in North America. This makes pipe and fittings the largest single market for PVC. To help address the information needs of the ever-growing population of PVC pipe users, the Pipe Resource Organization (PRO) was established in 1988 as an operating unit of the Vinyl Institute. The Vinyl Institute is the national trade association representing the manufacturers of PVC (polyvinyl chloride or vinyl) plastics, raw materials, additives, and film and sheet products.

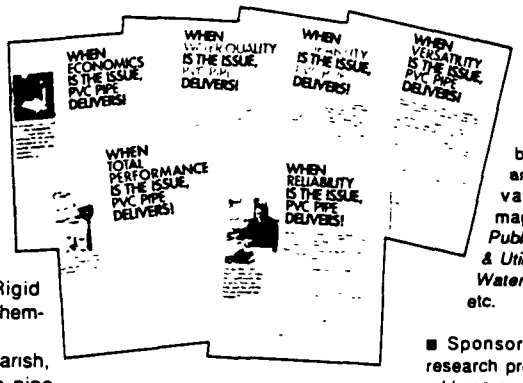
A division of The Society of the Plastics Industry, Inc., The Vinyl Institute (VI) is helping to service the pipe user community with reliable information and support. To that end, PRO and Uni-Bell are working together to provide pipe specifiers, contractors, utilities, and operations managers with information important to the proper use of PVC pipe and fittings.

One of the many ways that PRO is servicing pipe users is through direct support for Uni-Bell technical services. This support helps Uni-Bell be responsive to technical inquiries on a daily basis, and to conduct local and regional educational seminars.

PRO also oversees other programs that benefit the pipe user community. The current chairman of PRO is Mike Barish, Industry Sales Manager-Rigid PVC, for Borden Chemicals & Plastics.

According to Barish, PRO services the pipe market in three basic ways. "First, we work to build awareness of PVC's strengths, especially those unique to PVC pipe and fittings. Second, we work to overcome misperceptions about PVC's performance capabilities by highlighting installations that demonstrate PVC's ability to excel, long-term. Third, we seek to work with and complement the efforts of related pipe associations that responsibly service PVC pipe customer needs, such as Uni-Bell."

PRO's most visible recent contribution to the waterworks industry has been a series of full-page PVC pipe user testimonials appearing in the American Water Works Association (AWWA) Journal and other industry publications. These testimonials from consulting engineers and water utility officials help raise the awareness of how PVC pipe solves utility piping problems.



PVC Pipe User testimonials published by the PRO.

Upon request, PRO provides interested individuals with an information kit, "PVC Pipe for All The Right Reasons," which includes product performance information, illustrated case history information, copies of the user testimonials, a bibliography for technical information about PVC pipe and fittings available from a variety of sources, and general information about the usefulness and versatility of vinyl.

Other useful PRO service accomplishments include:

- Developed and published a technical report documenting PVC pipe's safety with regard to drinking water quality. This report highlights PVC's resistance to leaching and absence of taste or odor. Unlike traditional water pipe materials, PVC pipes will not chemically react with even the most aggressive water or soil conditions.
- Placed a number of technical and user articles in various industry magazines, such as: *Public Works, Pipeline & Utilities Construction, Water & Waste Digest,* etc.
- Sponsored independent research projects to properly address misperceptions about PVC pipes' fire safety, total installed cost, and permeation.
- Provided an educational grant to Utah State University's Piping Systems Institute (PSI). The PSI is an in-depth short school for pipeline designers, owners and installers.
- Provided both technical support and financial assistance to a committee established to address the lower solvent cement emission levels being developed by California's South Coast Air Quality Management District.
- Sponsored independent survey of PVC pipe users to optimize PRO's effectiveness.

From these and related activities, PRO has helped a great deal in responsibly servicing the tens of thousands of consulting engineers, utility officials, contractors and other industry influentials who use PVC pipe and fittings.

"PVC pipe has a strong future. We are seeing a growing preference for it in both new and replacement piping systems," Bansh says. "Our goal is to continue this trend by providing accurate and timely information about PVC pipe to both current and prospective users, by mobilizing PVC resin and pipe producers behind our efforts and by maximizing the efforts and investment of all other organizations with a stake in our success."

The following is a listing of Vinyl Institute Member Companies: Akzo Chemicals, Inc.; BFGoodrich Company; Borden Chemicals and Plastics; CertainTeed Corp.; Dow Chemical Co.; Elf Atochem, N.A.; Exxon Chemical Co., U.S.; Exxon Chemical Canada; European Vinyls Corp.; Georgia Gulf Corp.; G.E. Specialty Chemicals; Kaneka Texas Corp.; Mitsubishi Kasei Vinyls Co.; Occidental Chemical Corp.; Petroquimica Colombiana; PPG Industries Inc.; Rohm and Haas Co.; Shintech Inc.; Vista Chemical Co.; Westlake Polymers Co. and Witco Corp. Argus Division.

For more information about PRO please contact the Vinyl Institute, Wayne Interchange Plaza II, 155 Route 46 West, Wayne, New Jersey, 07470.

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Professional News

Moser offers ready-to-apply pipe design

Buried Pipe Design by A. P. Moser shows engineers and contractors exactly how to achieve proper, cost-effective designs of buried water systems, sewage collection systems and all other systems that carry materials underground.

The author's years of study, testing and research in the general areas of pipe performance and pipe installation design are apparent in this outstanding resource. Ready-to-apply, proven methods for designing buried pipe systems efficiently and economically are presented.

Thorough discussions are devoted to a wide range of important considerations, including soil mechanics, soil pressure, strength of materials, pipe hydraulics, wastewater systems, longitudinal loading, wheel loading (live loads) and frost loadings. Also explained in detail are such aspects as rigid pipe and flexible pipe analysis, pipe design criteria, pipe wall stresses and strains and finite element methods of design.

A. P. Moser, Ph.D., is the head of the mechanical engineering department at Utah State University and the founder and director of the Piping Systems Institute. Author of more than 30 technical papers and reports on buried pipe design and installation, Dr. Moser has served as a consultant to such companies as U.S. Pipe and Foundry, Owens-Corning Fiberglass Corporation and Johns-Mansville Corporation.

Readers may order this

book from McGraw-Hill by calling 1-800-2-MCGRAW.

Buried Pipe Design by A. P. Moser, 219 pages; 62 illustrations; 6" by 9"; $42.50; McGraw Hill. Publication: May, 1990.

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CONTINUED FROM PAGE 7

20 miles of PVC needed

made by simply aligning the spigot of the new length of pipe, with the bell end of the installed pipe.

The come-along method was preferred by Hamm Construction for a couple of reasons, notes Cornie Hamm. "First, this method didn't tie up the hoe, and second, for all three crews, the same individual operated the come-along to get the feel of the spigot being inserted into the bell."

The project also included four highway and two railway crossings. These crossings were achieved by the Hamm Construction crews, using their own hydraulically operated boring machine. The size of the steel casings installed were 36" and the longest bore hole was 32 meters (105 ft.).

On October 18, 1991, 8 kilometers (4.97 miles) of 24" DR 25 C.I.O.D. PVC was tested, from control valve chamber number 1 to valve chamber number 2.

The test requirements called for a water pressure test of 160 psi (1100KPA) for two hours, and an allowable leakage of 60 gallons. Test results: passed - no leaks. On October 23, 1991 the entire system, 23 kilometers (14.3 miles) was water pressure tested for two hours at 100 psi (690 KPA). Test results: passed - no leaks.

Sask Power site inspector Dave Barnes said, "We tested all 23 kilometers in one shot, and it was the first time in my life I have ever seen a test pass that easy. I believe that Sask Power has a good line, which will be serviceable for a long time, with relatively no maintenance."

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CTL029116

CONTINUED FROM PAGE 1

Understanding PVC pressure capacity

used for pipes is capable of meeting the long-term physical and chemical performance needed for potable water distribution pipe.

Users of PVC pipe need to be assured that it will operate reliably for a long time. Fifty years is usually quoted as the design requirement for water distribution systems, but in practice systems are often expected to provide reliable service for a hundred years or more.

Most materials used in engineered structures, such as steel, aluminum, wood, glass and plastics, "creep" under a constant load, and load-bearing designs have to take this into account. PVC is no exception.

The effect of creep can be easily shown. If a sample of one of these materials is tested in a tensile testing machine, which applies a steadily increasing load, it will fail at a characteristic stress, known as the ultimate tensile strength. If an identical sample is loaded to just under the tensile strength, and the stress is this time kept constant, the sample will creep for a few minutes or hours and then fail. If a third identical sample is loaded and kept at a yet lower constant stress, it will creep for a still longer time before it fails. If this process is repeated, each time at a lower constant stress, the results can be plotted as a graph of applied stress against time to fail, known as a stress-rupture graph. It can be used to show just how long the material can be expected to last at any load, and is the design basis used for critical load-bearing applications.

Creep tests lasting many years are often carried out for important applications in which a service lifetime of several tens of years is needed. Once the material has been thoroughly characterized, it is only necessary to ensure that subsequent batches of the material conform to the original data. To perform this quality control, engineers have to use shorter tests because of the limited time available. It is possible to compensate for the short test time by running the tests at a higher temperature, so that the creep rate is accelerated.

The PVC industry has adapted this accepted technique to the problem of developing a sound design basis for PVC pipe by testing many thousands of PVC pipe samples at various constant pressures and measuring the time to failure. The results are plotted as hoop stress in the pipe wall against time to failure. Hoop stress is calculated from the Barlow formula.

Barlow formula:

$$s = \frac{P(D-t)}{2t}$$

Where:
s= hoop stress
P= internal pressure
D= average outside diameter
t= minimum wall thickness

Typical results of these tests are shown in Fig. 1. A problem with the data in this form is that the results of tests lasting under after a few years cannot be extrapolated to give a reliable prediction of failure stress at over ten years - the slope of the curve is quite different.

The research work carried out in the 1950's showed that the underlying creep mechanism obeys laws similar to those of viscous liquid flow, and mathematical equations describing them contain logarithmic functions. These equations can be used to extrapolate creep data accurately. The mathematics can be visually demonstrated - and avoided for everyday use - by plotting the creep data on a graph in which both axes are logarithmic. The data then appear on a straight line, and can be extrapolated to a longer time than the last failure point by calculating the straight-line "least squares" regression of the time-to-failure data on the hoop stress data. The plot is commonly called the stress-rupture regression line.

Statistical analysis of the data is used to calculate the 95% confidence limits. These are lines, above and below the regression line and parallel to it, within which 95% of all failure points can be expected to occur. Thus 5% of all failure points can be expected above and below the confidence limits, and only 2.5% of all failure points below the lower confidence limit. The lower line is therefore known as the 97.5% lower confidence limit, or 97.5% LCL. It is the line used in practice to predict long-term time to failure at any stress.

The top line in Fig. 2 is the 97.5% LCL of the logarithmic plot of the data in Fig. 1., and is obviously a more convenient presentation of the same data.

Practical engineers are naturally concerned about the validity of extrapolating the regression line to fifty years or more, since it can be speculated that the slope of the line may in fact become steeper if the tests are carried out for a long enough time. This natural caution is reinforced by the fact that some plastics materials, such as polyethylene, have been shown to behave in just this way. There are three reasons for having confidence in the validity of the straight-line extrapolation of the regression line for PVC.

First, the reason for the "knee-bend" regression characteristic of polyethylene is well understood. It is because there are two distinct failure mechanisms operating at two different rates. This is in turn due to the structure of polyethylene, in which the crystalline regions occur as independent spherulites separated by amorphous regions. In PVC, the structure is a three-dimensional crystalline network in which layered crystalline regions are interconnected throughout an amorphous matrix. The failure mechanism of PVC is consistent and operates at a consistent rate.

Second, there has been so much testing of PVC pipe by the industry in the USA and in Europe that long-term test data is now available to over 315,000 hours. No sign of a "knee-bend" has been seen in well made pipe.

Third, stress-rupture performance can be accelerated by testing at a higher temperature - a technique successfully used to locate the position of the knee-bend in the regression line of polyethylene pipe and thus to determine safe working pressures at normal temperature. PVC pipe has been tested at 60°C for over 10,000 hours without sign of a change in the slope of the regression line.

Figure 1

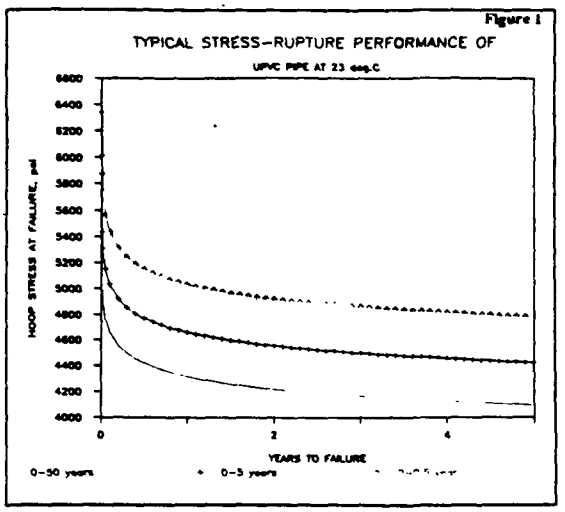
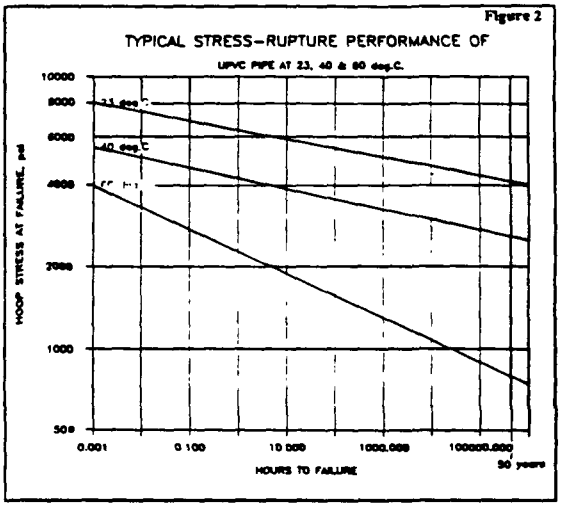


Figure 2



The stress-rupture performance of unplasticized PVC, shown in Fig. 2, can therefore be accepted with confidence. The predicted failure stress at 23 degrees C of over 4000 psi at 100,000 hours (11.4 years) and 438,400 hours (50 years) is confirmed by many years of laboratory testing, by thousands of quality control tests carried out in PVC pipe factories all over the world and by thirty to fifty years of satisfactory service.

This method of test became standardized in the USA by the issue of ASTM D1598-58T, revised in 1986. The treatment of the data and the method of extrapolation became standardized as ASTM D2837-69, revised in 1990. D2837 also specifies the method of characterizing the Long Term Hydrostatic Strength (LTHS), or 100,000 hour failure stress, of a pipe material. D2837 also specifies how to derive the Hydrostatic Design Basis (HDB), which is the basic information needed for designing pressure pipe.

The Plastic Pipe Institute (PPI) monitors the testing of plastic pipe materials in the United States according to D1598 and D2837. It oversees the validity of the data submitted and ensures that tests are run for sufficient time before HDB values are assigned by its Hydrostatic Design Stress Committee.

AWWA C900 and C905 specify tests to ensure that PVC pipe is properly manufactured and conforms to the basic performance norms established by ASTM D1784 Class 12454-A or -B, ASTM D1598, D2837 and the HDB assigned by the PPI. They also apply safety factors to these HDB values which are considered appropriate for potable water pipe service conditions and to allow for surge pressures.

After all the safety factors in C900 and C905 have been taken into account, the final working stresses of PVC pipe are under 40% of the 97.5% LCL of the fifty-year failure stress. A practical lifetime well in excess of fifty years can be confidently expected.

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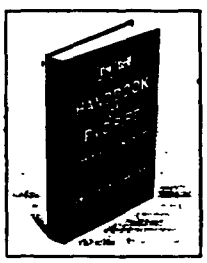

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Uni-Bell video discusses "Tapping PVC Pressure Pipe"

Recently the Uni-Bell Board of Directors approved a project to produce the first-ever video offering from the PVC Pipe Industry Association. "Tapping PVC Pressure Pipe," is the successful culmination of that project now available in VHS format.

The intended audience of the tape is the actual workers who perform the tapping operations. This is based on the fact that tapping successes and tapping failures are defined by the procedures and equipment used.

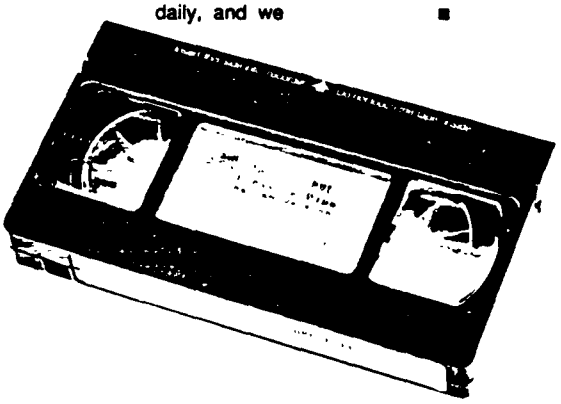
The video demonstrates tapping specifics, from equipment and site preparation, to machine assembly and cutting to safety precautions.

Direct tapping and tapping through a saddle are both covered. Sleeve selection criteria is provided for large taps up to size-on-size.

"The success of tapping PVC has been excellent given the huge volume of use. This video realizes that one problem is one too many when an individual's safety may be involved," says Uni-Bell's Deputy Executive Director, Dave Eckstein. "We know we have new PVC pressure pipe users literally daily, and we know the workforce is changing. This video is a tool for the users as an ongoing instructional piece as well as a refresher to those involved intermittently."

The video in English, French or Spanish can be obtained for $10 by completing the accompanying order blank.

■



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