Westlake
Pipe & Fittings

PVC Pipe: Safety & Sustainability Webinar Q&A

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Questions for Westlake Pipe & Fittings, answers provided by Angie Bidlack, PE, MBA, Specification Engineer, Westlake Pipe & Fittings

1. How resilient is PVC in the face of ground movement?
    a. PVC pipe should be considered for ground movement areas. Utility pipelines need to remain intact and to function properly when the ground moves. The evidence favors PVC pipe due to:
    b. Movement-accommodating joints
    c. Ability to bend
    d. Available joint-restraint systems.
    e. Reference.
2. When you are placing a piece of plastic pipe into an iron fitting does the plastic have to be cut before installation?
    a. To ensure proper sealing, the bevel at the end of the PVC or PVCO pipe should be removed and the end of the pipe should be cut square. MJ Fittings have a shallow insertion depth, so the pipe's insertion line should be ignored. For more info please visit this link.
3. Please discuss the pressures that can be sustained when using PVC pipe for drinking water distribution? Can a 30" + PVC pipe be used for a drinking water system?
    a. PVC pipe can handle the long term working pressures associated with the pressure class associated with it's dimension ratio. For example, a DR18 PVC pipe has a working pressure rating of 235psi and is designed to withstand 235psi of constant pressure for at least 100 years. There are numerous examples of 30"+ PVC water mains used in drinking water systems. Please let me know if you would like to discuss examples.
4. What is the relationship between pvc and it's degradation?
    a. According to AWWA M23, PVC and PVC pipes are resistant to almost all types of corrosion - both chemical and electrochemical - that are experienced in underground

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piping systems. As such, the common mechanisms of metallic pipe degradation do not apply to PVC. PVC is also nearly totally resistant to biological attack. In response to an applied stress such as internal pressure, PVC and PVCO pipe will gradually yield to a point and at a rate that depends on the level and duration of applied stress. The rate of creep in response to a constant internal pressure decreases with the passage of time. Research has shown that PVC pipes held at their pressure ratings continuously for 11.4 years (100,000 hours) will exhibit no perceptible rate of creep at the end of that time. The response of PVC and PVCO pipe to applied internal hydrostatic pressure essentially stabilizes at 100,000 hours when considering the design life of 100 years and when looked at on the stress regression curve the variation in hoop strength appears insignificant from 100,000 hours to 500 years. It is important with PVC and PVCO pipe to design to eliminate stresses on the pipe outside of the allowable parameters. Care should be taken to ensure that cyclic pressures and occasional surge pressures fall within the allowable constraints and that stress concentrations from things like point loads due to poor bedding or over-inserted joints are eliminated.

5. A bullet on Slide 11 says "Expected longevity of at least 100 years." How do we know if PVC can reach the century mark since the usage of C-900 has been in widespread usage but for perhaps only 4 or 5 decades? The "JM Eagle experience" didn't do much to inspire confidence in C-900's longevity.
    a. Refer to the longevity report here.
6. What is the failure mode of PVC pipe at the end of useful life?
    a. Refer to the longevity report here.
7. What we'd like to see is a class for contractors and engineers on the correct installation procedure. In Florida I have pipe that's been in service successfully for 40 yrs. In Kentucky, I'm lucky if it's not replaced in 11. Obviously PVC is the cheapest to install . Transportation costs should murder the closest competitor,
    a. The PVC Pipe Association regularly offers training on installation of PVC Water and Sewer Piping Systems, with the next being scheduled for December 13, 2023. See https://www.uni-bell.org/Events/Educational-Webinars for more information and to register.
8. There is no stupid question, right? What is the difference between HDPE & PVC?
    a. Correct, there is no stupid question. I will address this on a molecular level and then on a piping systems applications level. A polymer is a long chain of monomers. With polyethylene, the monomer is four hydrogen atoms bonded to two carbon atoms. This monomer is then made into a long chain of the same six atoms in a repeating pattern.
    b. With PVC, the monomer is made of three hydrogen atoms, one chlorine atom, and two carbon atoms.
    c. Both polyethylene and PVC require additives in order for them to be used as a raw material in an extruded pipe. The combination of the resin and the additives is called a compound. Both HDPE and PVC are thermoplastics and share some general properties such as corrosion resistance and lightweight. As far as differences, PVC has a higher tensile strength than HDPE. Both are quantified with their Hydrostatic Design Basis (HDB). The HDB for PVC is 4000 psi, and the HDB for HDPE is 1600 psi. This results in HDPE needing a thicker wall to achieve the same pressure class. The modulus of elasticity for PVC is 400,000 psi, and for HDPE, it is between 110,000 psi and 160,000

psi. This means that PVC is stiffer than HDPE. For buried pressure applications, the typical means by which the two types of pipe are joined together are different. PVC has a gasketed bell-and-spigot joint. In the plumbing world, the bell is known as the female end, and the spigot is known as the male end. HDPE uses butt fusion for joining one length of pipe to another.

   d. There are many other similarities and differences between the two plastics. Let us know if there is a particular application or property that you'd like to learn more about.

9. What pipe would you recommend for a directional drilling application?
   a. We would need to see the project requirements and the project constraints before we can adequately recommend a pipe for a directional drilling application. Depending on the required pipe size, the soil conditions and site layout, we could consider Westlake's AquaSpring C900 Certa-Lok Restrained Joint integral Bell pipe (RJIB). Certa-Lok RJIB is designed for trenchless applications with robust tensile strength for pulling multiple pipe segments underground. Certa-Lok RJIB is a segmented PVC pipe solution, it reduces the jobsite footprint and minimizes community disruption with a reduced need for jobsite staging area and traffic control- it's perfect for Urban settings. The smooth curve at the bell specifically reduces friction during pulling and the patented restrained joint allows for quick and easy assembly- less than 2 minutes per joint! Pipe assembly can be achieved without interrupting the pulling process. It is currently available up to 18" (CSA up to 12"), and it is available in Blue, Green or Purple. Please contact us to discuss your project requirements.

Questions for Dr. Ronald Brecher, answers provided by Ronald W. Brecher, PhD, DABT, C.Chem., Toxicology, Risk Assessment & Risk Communication Specialist, Independent Consultant

1. This question may be addressed later on in the presentation(s): what research has been done on the effects of fires on these pipes? If so any effects to groundwater, air, the overall effects on the water system, such as toxins entering the water system. Thank you!
   a. Please see this Technical Brief about the behavior of underground PVC pipe in fires. According to the Uni-Bell PVC Pipe Association, "No benzene or other contaminants are released from PVC water pipes during wildfires. Wildfires do not impact PVC water and sewer infrastructure pipe since it is buried underground, insulated from heat generated above ground. The primary source of benzene in forest fires is from wood combustion. Burning homes and other structures are secondary sources." I have not personally evaluated the toxicology of combustion products of any pipe material.
2. What are your thoughts on PVC pipe safety when cities go through fire tragedies?
   a. Please see this Technical Brief about the behavior of underground PVC pipe in fires. According to the Uni-Bell PVC Pipe Association, "No benzene or other contaminants are released from PVC water pipes during wildfires. Wildfires do not impact PVC water and sewer infrastructure pipe since it is buried underground, insulated from heat generated

above ground. The primary source of benzene in forest fires is from wood combustion. Burning homes and other structures are secondary sources." I have not personally evaluated the toxicology of combustion products of any pipe material.

3. Recent speculation has pondered if poly pipe will be a cause of any PFAS.
    a. Answer about PVC not Poly: PFAS stands for Poly- and Per-Fluoroalkyl Substances. PFAS are not used to make PVC pipe. Therefore, PVC pipe cannot introduce PFAS into water or wastewater that flows through the pipe. Note that all of the ingredients in PVC pipe are publicly listed (see page 1, and this related information).
4. What about toxicology resulting from pipes (PVC vs DIP) burning from a fire. Is this something that you have investigated?
    a. Please see this Technical Brief about the behavior of underground PVC pipe in fires. According to the Uni-Bell PVC Pipe Association, "No benzene or other contaminants are released from PVC water pipes during wildfires. Wildfires do not impact PVC water and sewer infrastructure pipe since it is buried underground, insulated from heat generated above ground. The primary source of benzene in forest fires is from wood combustion. Burning homes and other structures are secondary sources." I have not personally evaluated the toxicology of combustion products of any pipe material.
5. What is Dr. Brecher's reaction to "The Perils of PVC Plastic Pipes" April 2023 report (by Beyond Plastics)?
    a. The report misrepresents what is known about the safety of not only PVC pipe, but the alternatives as well, and it does so in many different ways. Its conclusions and recommendations are simply not supported by the available scientific information. Various organizations in North America and Europe have posted detailed critiques and rebuttals, including NSF International, PVC4Pipes, the Vinyl Institute, Dr. Chris DeArmitt (President of Phantom Plastics), and others.

Questions for Tad Radzinski, answers provided by Tad Radzinski, PE, SEP, LEED AP, SFP, President and Co-Founder, Sustainable Solutions Corporation

1. Did the life cycle comparison include ancillary components (e.g. restraint devices) needed to restrain PVC pressure pipe?
    a. When we completed the LCA study we followed the Product category rule: Product Category Rules for Rigid and Flexible Building Piping Systems in North America (PCR-1002). The PCR did not require the inclusion of restraints, however, we needed to include fittings. Pressure pipe is designed with belled joints at the end of each pipe with a gasket provided so that individual pipe units can be installed easily. However, the Product Category Rule states that 258 fittings must be included in each system. Since fittings were included and not actually required, the overall LCA impacts reported are somewhat higher than the actual system.

2. How do you simulate 100 years? Any control pieces in place to observe over the next decades? One of the first slides showed stats on pipe. Any materials with lower eutrophication? PVC was still very high.
    a. The service life of PVC is expected to exceed 100 years. Based on over 60 years of field experience and laboratory testing, a 100-year service life is used for PVC in this study. The service life of a product is the time over which the product can be used economically. The new standard or goal of a sustainable service life for underground pipe infrastructure is considered to be 100 years. When determining a pipe's service life, external and internal pipe performance measures and service levels must be taken into account.
    b. General Consideration for Assigning Pipe Lives:
        i. Historical failure/replacement data
        ii. Average soil conditions in the U.S.
        iii. Pipe thickness
        iv. Corrosion rates
        v. Brittleness
        vi. Water loss and infiltration
    c. For more information, see the PVC Pipe Longevity report at this link.
    d. Regarding the eutrophication potential for PVC Pipe, this is driven primarily by the use stage of the pipe. Unfortunately, at the time of the study, there were no publicly available full LCA studies published for other pipe products such as ductile iron, concrete, etc. We were unable to compare the eutrophication potential of those pipe products to PVC. The PVC pipe LCA and EPD is the only ISO-compliant, peer-reviewed, industry-wide EPD for water and sewer pipe in North America. Source here.
3. On page 10/slide 20, replacement energy is assumed for HDPE, DI, and PCCP but not PVC. Does PVC have a higher expected lifespan, and assumed it won't need to be replaced over 100 years?
    a. The service life of PVC is expected to exceed 100 years. Based on over 60 years of field experience and laboratory testing, a 100-year service life is used for PVC in this study. The service life of a product is the time over which the product can be used economically. The new standard or goal of a sustainable service life for underground pipe infrastructure is considered to be 100 years. When determining a pipe's service life, external and internal pipe performance measures and service levels must be taken into account.
    b. For the purposes of this 100-year modeling and evaluation of sustainable underground water infrastructure, the following pipe service lives have been assigned as shown in Table 8.3.

i.

TABLE 8.3 : SERVICE LIFE ASSUMPTIONS OF SELECTED PIPES FOR COMPARISON

Pipe Lives Before Replacement for LCA		
Pipe Material	Standard	Service Life (Years)
PVC	AWWA C900	100
PVC	AWWA C905	100
PVC	ASTM D3034	100
PVC	ASTM F679	100
PVC	ASTM F794	100
DI	AWWA C151	50
DI	AWWA A746	50
HDPE	AWWA C906	50
HDPE	ASTM F2306	50
PCCP	AWWA C301	75
PP	ASTM F2736	50
VCP	ASTM C700	50
NRCP	ASTM C14	50

c. General Consideration for Assigning Pipe Lives:
   i. Historical failure/replacement data
   ii. Average soil conditions in the U.S.
   iii. Pipe thickness
   iv. Corrosion rates
   v. Brittleness
   vi. Water loss and infiltration
d. TABLE 8.3 : SERVICE LIFE ASSUMPTIONS OF SELECTED PIPES FOR COMPARISON
e. Since PVC pipe is life span is expected to exceed 100 years the other pipe materials would fail based on the service lives in Table 8.3 from the LCA study report which means the pipe systems would need to be reinstalled with completely new pipe in order to meet the 100-year reference service life essentially doubling the impacts for the installation phase and pipe manufacturing stage.
f. For more information, see the full LCA report here.
g. For the PVC Pipe Longevity see the report here.

4. It seems odd that PCCP pipe is lower than PVC for Cradle to Gate. The weight would be expected to have a huge impact on manufacturing and transportation.
   a. This is a good observation. When we completed the original study in 2015, we were also surprised by this since cement is one of the most carbon intensive materials produced and the PCCP is much heavier than equivalent length of PVC. Unfortunately, at the time of the full comparative LCA study there was limited publicly available information of a full LCA report for PCCP. More recently there have been other studies published in Europe for PCCP that show higher impacts.
5. Is PVC recyclable? And if so, how much energy is required to recycle PVC compared to recycling metals such as iron?
   a. PVC is a highly recyclable material. Recycling of rigid PVC pipe materials would require washing, grinding and or pelletizing the pipe to allow the material to be reintroduced to

the extrusion process to produce new pipe. So relatively low inputs of energy (primarily electricity that can be generated from renewable or carbon free sources) for recycling PVC. Metals recycling will require remelting of the metal and then processing and casting the metal into pipe which requires a significant amount of energy inputs (primarily fuels like natural gas). In addition, Metal recycling has the potential for higher levels of dioxin formation because the scrap metal usually contains paints, oils, coatings, plastics and other impurities that may provide both chlorine and carbon. In this case, dioxins can be generated during scrap pretreatment to remove these impurities or during metal refining in the furnaces (smelting). Dioxins may also originate from fuels combusted in the furnaces. In addition, casting operations involve melting and pouring the hot metal into molds. These high-temperature processes can also result in dioxin emissions, depending on the mold material.

6. Why was cost more or less overlooked in these studies/conclusions?
    a. Cost of the piping materials was not included in the study since life cycle assessment studies focus on the potential environmental impacts of the pipe. A life cycle costing study would evaluate the costs of the pipe materials. However, there is some information in the report on life cycle costing on Service life. Service life is an important consideration in calculating life cycle costs in order to demonstrate the ability to manage assets at the lowest life cycle cost. These costs are included in projected repair and replacement strategies and in funding projections as published in an asset management plan. A key element of this service life focuses on the energy requirement and pumping energy costs associated with the operations of a pipe system.
    b. The overall total cost of ownership includes the initial capital outlay, maintenance costs and the operational costs of a pipe system. Life cycle cost analysis is applied to compare various pipe selection alternatives. In this type of comparable analysis, the embodied energy, and other social and environmental impacts can be evaluated while considering public health and financial risks. As this process matures, performance-based pipe selection can be added to the procurement process to ensure that the water ratepayers can benefit from the user defined requirements Section 10 of the LCA report focuses on energy costs. Energy usage translates into cost when electrical power for pumping is considered. The three pipe scenarios consider the cost of pumping energy using current average electrical rates and escalating them by one cent per decade over the 100-year life cycle.
    c. The total 100-year pumping energy cost differences for PVC and the alternate material are illustrated in the report at the link here.