The Alliance for PE Pipe
Insider's Guide to PE Pipe

The purpose of this document is to establish a functioning glossary that provides insight into how a word or phrase is used in addition to providing a straight definition. Note, there are two parts to every definition, the basic definition (basic) and then the insider's guide statement.

Abrasion and Scratch Resistance

Basic: The ability of the pipe to resist minor blemishes such as scratches and grooves.

Insider tip: PE is incredibly tough. It can withstand up to a 10% cut or abrasion to its outside diameter before it must be repaired or de-rated. "*When in doubt, cut it out"* is the saying many contractors use if they come upon a gouge or deep scratch in a pipe. PE pipe is also abrasion resistant and is well suited for the solids environment in mining applications.

Ref: *https://plasticpipe.org/pdf/chapter-7_durability_service_life.pdf*

Apparent Tensile Strength

Basic: A measurement of tensile strength taken by testing pipe rings under ASTM D 2290 in which a bending moment is induced in the pipe's shape. Where tensile strength is measured as the amount of force an object can withstand without breaking, *apparent tensile strength* measures the yield of the pipe's shape, its breakage or both.

Insider tip: When designing with HDPE understanding *apparent tensile strength* will help when planning on bending or straining a pipe during the when conducting actions such as a pipe bursting installations, prepping a line for installation and having to bend the pipe around a cul-de-sac or conducting an HDD installation project.

Ref: *https://plasticpipe.org/pdf/chapter03.pdf*

ANSI

Basic: As the voice of the U.S. standards and conformity assessment system, the American National Standards Institute (ANSI) empowers its members and constituents to strengthen the U.S. marketplace position in the global economy while helping to assure the safety and health of consumers and the protection of the environment. ANSI oversees the creation, promulgation and use of thousands of norms and guidelines that directly impact businesses, including the HDPE industry. ANSI is also actively engaged in accreditation - assessing the competence of organizations determining conformance to standards.

Insider tip: ANSI recently approved the process by which AWWA acknowledged and approved HDPE pipe (4710 resin) for potable water applications from 4" to 65". The standard is known as C906-15.

ASTM

Basic: The American Society of Testing and Materials is an international standards organization that collects and publishes information on technical standards of materials, products, systems and services in terms of their characteristics and performance.

Insider tip: ASTM establishes procedures for many things in the HDPE industry including the manufacturer of pipe and fittings, performance of fusion and test procedures. Please see the *"List of Applicable Standards"* document included in the Engineer Package 2020.

Bead, The

Basic: The heating process begins with a "heater plate" that is heated and melted at a heater plate temperature between 400 – 450° Fahrenheit ambient or outdoor conditions do not negatively affect these conditions (wind, cold, dust, etc). When the pipe comes in contact with the heater plate, the HDPE pipe clamped ends are melted in a controlled state to create two surfaces that will be able to fuse together. After the prescribed "heat soak" the heater is removed, the ends are inspected quickly and the ends are pushed together under prescribed fusion pressure. The result is the double rollback bead is formed on both the outer wall and inner wall of the pipe due to the displacement of molten material that creates the fusion interface.

HDPE Pipe OD	Min Melt Bead Size
< 2.37"	1/32"
≥2.37 to < 3.5"	1/16"
> 3.5 to < 8.62"	3/16"
> 8.62 to < 12.75"	1/4"
> 12.75 to ≤ 24"	3/8"
>24 to < 36"	7/16"
> 36 to ≤65"	9/16"

Insider tip: Operators need to know the recommended melt bead dimensions for each size of pipe they are fusion in conjunction with the specified heating time, so they know when to remove the heater plate and initiate fusion. The chart above is a reminder to those trained in butt fusion.

Bead, The Internal

Basic: The internal bead is a raised profile on the interior flow path. It should be noted that the pipes C factor of 150 takes into account the bead so engineers do not need to reduce flow rates during the design process because of the bead. This bead does not need to be removed but may be removed if necessary within the specified cooling cycle of the fusion process Bead removal requires proper training and tools due to the fact reaching the fusion bead internally is a significant distance.

Ref: *https://plasticpipe.org/pdf/chapter09.pdf*

Insider tip: Questions arise about the bead on regular occasions. In pressure applications the bead presence is inconsequential and it does not harm flow. For those who are curious on the topic, it is more expensive (contractor time) to remove the bead so most do not. However, common practice on the west coast is to remove the bead in both pressure and non-pressure applications. In the case of gravity wastewater applications, a build-up may occur at 1% grade or less. The build-up usually is pushed along when velocities increase. It a gravity system when diameters become larger it must be

noted that the bead size becomes larger as well. Higher flow rates will wash anything built up behind the bead and nothing can adhere to the HDPE so it is easily washed away. Typically, the bead is not a flow concern. However, it can be removed if necessary using proper protocols.

Bead, External and Internal

Basic: The external bead is an indicator of the butt fusion process and it is used as one indicator of proper alignment, heating and pressure of the pipe ends. An even external bead appearance with good roll back contact on the surface of the pipe.

Ref: *https://plasticpipe.org/pdf/mid-pe-field-manual-municipal-water-applications.pdf*

Insider tip: The external bead serves as evidence of butt fusion. Although it is not recommended to remove the external bead, it may be removed once the pipe has been adequately cooled. Removing the bead after the pipe adequately cools using the appropriately designed tools and procedures is critically important to avoid gouging the pipe in anyway. A pipe gouge can potentially cause the pipe to fail adding a stress riser or impeding minimum wall requirements. The internal bead will not restrict flow unless the pipe is in a gravity situation and grade is 1% or less.

Ref: *https://isco-ahmcelroy.com/products-and-services/?amp%3Bcategory_id=3*

Bead Removal

Basic: It is uncommon to remove internal beads, as they have little or no effect on flow, and removal is time consuming. The C factor remains constant at 150 with the bead intact. To reiterate, beads must be removed at ambient temperature as when the pipe is warm, it would be easy to penetrate beyond the pipe wall, thus damaging the pipe.

Insider tip: Internal beads may be removed from pipes after each fusion with a cutter fitted to a long pole. Since the fusion must be completely cooled before bead removal, assembly time is increased.

Bending Radius

Basic: The minimum radius a contractor can bend HDPE without damaging or kinking it.

Insider tip: The tight bend radius of HDPE makes it the preferred HDD, bursting and lining product. If the pipe DR is ≤9 the bending radius is 20x the pipe OD. If the pipe DR is ≥ 21 the bending radius is 30x the pipe OD.

Brittle Failure

Basic: A pipe failure with no visible deformation, such as stretching or necking down, where the pipe broke. Brittle failures any also be represented as a slow crack growth (SCG) failure or "slit" failure as demonstrated as the "Knee" in a high density polyethylene regression curve. With newer bimodal or PE4710 products today the Knee as being pushed beyond 10,000 hours on the regression curve to meet pressure requirements of these materials. The polyethylene industry understands the

failure mechanisms of HDPE pipe. Understanding these failures help us better understand the performance of these pipes and more importantly the limitations.

Ref: *https://plasticpipe.org/pdf/tr-3-2012.pdf*

Insider tip: HDPE pipe is ductile at a prescribed temperature and not brittle. Brittle failure is a primary failure mechanism of other materials, but HDPE is not brittle until it reaches -130° F. Interestingly, HDPE pipe can freeze with a full water load at -20° F and not crack, break or fail. Brittle failure is not a failure mode of HDPE in common practice.

Butt Fusion – see Fusion

Bypass

Basic: A temporary pipeline created to accommodate pipe flow around a system that is not working or has been shut off.

Insider tip: HDPE is the preferred pipe material for bypass projects. Bypasses are frequently used during replacement and rehabilitation projects when water or sewer services must be stopped for both short and long periods of time. HDPE is a common candidate to keep the line running during replacement or repair because it can be run above grade for miles in rights of way and not leak. Contractors who do sewer bypass work, fuse the pipe for a job, use it, then cut it into lengths again and bring it back to the storage yard for subsequent use on the next job.

C Factor

Basic: The classic Hazen-Williams roughness constant is known as the CM factor. It is a constant in the calculation used to determine the head loss for a given pipe flow. The C-Factor for HDPE pipe is 150.

Ref: *http://hdpeapp.com/#/terms*

Table 7 Hazen-Williams Friction Factor, C

Pipe Material	*Values for C*		
	Range High / Low	*Average Value*	*Typical Design Value*
Polyethylene pipe or tubing	160 / 150	150-155[A]	150
Cement or mastic lined iron or steel pipe	160 / 130	148	140
Copper, brass, lead, tin or glass pipe or tubing	150 / 120	140	130
Wood stave	145 / 110	120	110
Welded and seamless steel	150 / 80	130	100
Cast and ductile iron	150 / 80	130	100
Concrete	152 / 85	120	100
Corrugated steel	–	60	60

[A] Determined on butt fused pipe with internal beads in place.

Insider tip: When designing with HDPE the engineer is not required to lower the C factor for the life time of the pipe like they are for other pipe materials given tuberculation and build up issues. The 150 C factor remains constant for the over 100-year life of PE pipe.

Carbon Black

Basic: A black pigment created when natural gas or oil is not burned completely. The pigment provides highly effective protection against ultraviolet rays. Carbon Black is manufactured and tested within the formulation matrix of polyethylene pipe. It tested for optimal UV protection within the grade formulation but also ensures the additive does not affect other cell classification or and pressure requirements.

Insider tip: A common question during roadshows is why are there two different colors of resin going into the pipe manufacturing process. The black resin is an additive that permits the pipe to last indefinitely in an above ground situation. It also means it does not have a shelf life in a pipe yard. Black pipe will last indefinitely outdoors even when exposed to the sun.

Ref: *https://plasticpipe.org/pdf/chapter-8_quality_control_quality_assurance.pdf*

Ref: *https://plasticpipe.org/pdf/tr-18_weatherability_thermo_pipe_systems.pdf*

Cathodic Corrosion

Basic: Corrosion of a pipeline accelerated by cathodic reactions that create corrosive alkaline conditions. Leads to accelerated deterioration of ductile iron pipe (DIP.)

Insider tip: Does not apply to HDPE as HDPE pipe is a thermoplastic and thermoplastics do not corrode. Key distinguishing feature of HDPE vs DIP. In fact, DIP people recommend wrapping their pipe in HDPE for cathodic protection. Why not just use HDPE?

Ref: *https://plasticpipe.org/pdf/tr-19_thermoplastic_pipe_for_transport_of_chemical.pdf*

Cathodic Protection

Basic: Cathodic protection is a technique used to control the corrosion of a DIP using special cathodes and anodes to avoid corrosion of a pipeline by an electric current.

Insider tip: HDPE is often considered as a pipe option when with the typical incumbent material, DIP. To properly consider the cost of a DIP, the evaluator may consider cathodic protection in the evaluation. HDPE pipe does not require cathodic protection. In fact, the Ductile Iron Pipe Research Association (DIPRA) recommends the use of HDPE wrap to protect DIP.

Ref: *https://plasticpipe.org/pdf/hdpe_corrosion_resistance_dc_answer.pdf*

Cell Classification

Basic: Criteria for distinguishing thermoplastic materials that include density, melt index, flexural modulus, tensile strength at yield, environmental stress crack resistance, and hydrostatic design basis.

Insider tip: The cell classification is not typically a design issue for the design engineer. However, it is an important classification to understand and compare polyethylene materials. It is important for the engineer who is designing process piping and transporting water or chemicals throughout a water plant. Each PE material property is assigned into a "Cell Range" and each cell range consists of a number of "Classes." ASTM D3350 is the standard that classifies these PE piping materials. In addition, the ASTM D3350 also categorizes chorine resistance (see Chlorine, Chloramines below).

Chemical Resistance

Basic: The ability of a pipe to transport a chemical up to a certain concentration and temperature without degrading.

Insider tip: Process piping design and civil engineers who design with HDPE may choose to understand the chemical resistance of HDPE Pipe. The failure mechanism of incumbent materials are

well known. PE pipe solves all of them with its fused joint, flexibility and lack of tuberculation. The only significant cause of HDPE failure could be chemical attack. However, the chemical concentrations, fluid temperature and system pressure commonly found in PE pipe will not cause failure for well over 250 years according to laboratory tests. It is well understood which chemicals affect PE and these can be found in the following link.

Ref: https://plasticpipe.org/pdf/tr-19_thermoplastic_pipe_for_transport_of_chemical.pdf

Chlorine, Chloramines

Basic: HDPE Pipe made from the 4710 resins is designed and produced to withstand the presence of chlorine/chloramines under normal operating conditions. These oxidizers affect any and all materials, knowing at what degree is the question. The PE industry has studied, developed prediction models and classified polyethylene pipe products and they understand how these oxidizers affect the product. Design engineers need to understand these mechanism of oxidation for all products and compare the best product for use in their system designs. Newer polyethylene (PE 4710) is categorized for the design engineer's benefit.

Insider tip: Understanding the concentrations, temperatures and pressures in our nation's water systems is critically important in design. They vary greatly and pipe resistance to such oxidizers will vary based upon those factors. However, if an agency is operating within federally mandated guidelines, the PE 4710 HDPE pipe system life is projected to exceed 100 years.

Ref: https://plasticpipe.org/pdf/evaluating-disinfectants-on-pe-pipe-nana-awwa.pdf

DataLogging

Basic: Datalogging technology exists for both butt fusion and electro fusion. The methods for harvesting the data differs by manufacturer. ASTM F3124 covers datalogging for Butt Fusion. The technology allows stakeholders (inspectors, design engineers, owners) to monitor and/or review a record of fusion details. Given the fusion process is operator centric, datalogging permits those not present to review, maintain and refer to a record of individual fusions.

Datalogging technology brings accountability to a new level as owners and inspectors can monitor operator performance in real time from down the block or from across the continent.

Insider tip: In order to assure accountability in the PE fusion process, the industry developed datalogging technology and the ASTM Standard 3124. The implementation of this technology means that owners and their engineers can monitor fusion quality remotely either in real time, hourly or in daily uploads.

Ref: https://www.mcelroy.com/en/fusion/datalogger.htm

Dimension Ratio (DR)

Basic: The Standard Dimension Ratio is the outer diameter of the pipe divided by the minimum wall thickness. Pipe is purchased in lengths or coils by Outer Diameter and Dimension ratio.

$$DR = \frac{OD}{t_{MIN}}$$

Insider tip: The lower the DR number the more pressure the pipe will take. If a contractor buys a 6" DR 11 pipe, he is buying a six-inch 200 working pressure class pipe. The market is moving toward a pressure class system which makes it easier for designers who typically work with other materials to select the appropriate pipe. That way they can talk in terms of pressure class versus DR which requires more product knowledge.

Ductile Failure

Basic: A pipe failure term that consists of some form of material distortion along a breakage spot, such as stretching, elongating or necking down.

Insider tip: Ductile failures can occur in HDPE during testing and/or over pressurization. Failure looks like a "duck bill" and is caused by 4x - 5x over pressurization or less if pipe temperature exceeds 73° F.

Ref: *https://plasticpipe.org/pdf/chapter06.pdf*

Environmental Stress Cracking Resistance

Basic: Environmental stress cracking resistance (ESCR) in HDPE means the failure due to continuously acting external and/or internal stresses in the presence of a surface active substances (known as reagents) such as alcohols, soaps, dyes and chemicals. It is measured but the PENT test (Pennsylvania Notch Test - Dr. Norman Brown ASTM F1473) of historically by the Bent Strip ESCR ASTM D1693. This failure mechanism is commonly stated as Slow Crack Growth (SCG), which does not necessarily require a reagent.

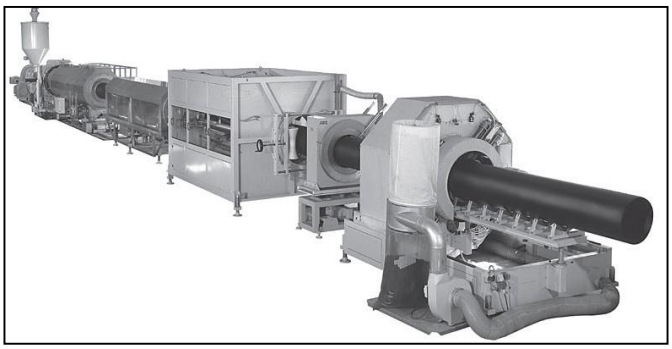
Insider tip: The most common area where ESCR concerns the design engineer is in the presence of contaminated soils. The engineer must know what chemicals are present as chemicals can have a deleterious effect on HDPE pipe and cause ESCR. It is important to know that with the development of improved resin quality to resist reagents to form brittle type failure or the slow crack growth (SCG) failure the BENT Stripe method does not accurately define the products but the PENT does. This failure mechanism is well understood in the polyethylene industry and has many references and publications.

Ref: *https://plasticpipe.org/pdf/chapter-1_history_physical_chemistry_hdpe.pdf*

Ref: *https://www.ineos.com/globalassets/ineos-group/businesses/ineos-olefins-and-polymers-usa/products/technical-information--patents/environmental-stress-crack-resistance-of-pe1.pdf*

Extrusion

Basic: The process of blending, melting, mixing, extruding, shaping and re-cooling plastic through an extrusion system to make it into a specified pipe size under controlled and regulated requirements. Extrusion is the process used to make HDPE, a smooth or corrugated walled pipe profile.



Ref: https://plasticpipe.org/pdf/chapter-8_quality_control_quality_assurance.pdf

Insider tip: The extrusion process is immaterial to the user of pipe. However, when specifying certain pipe types, sizes, pressure ratings, applications or striping patterns it helps to understand the exact need and what of how the pipe is expected to perform and be identified, and in most cases how it is to be located. Manufacturers understand how the pipe is to be manufactured, quality controlled, inspected, and the specifications required to be followed.

Fittings

Basic: HDPE pipeline systems require fittings as do all pipeline systems. PE fittings are either molded or fabricated.

Insider tip: Molded fittings are generally available up to 12" in standard sizes and relatively inexpensive. Molded fittings are usually in stock at the distributor. The larger fabricated fittings are custom and made by Alliance members with a week or two lead time.

Flow Capacity

Basic: Flow Capacity Equation as provided in the PPI Handbook: $$Q = \frac{1.49}{n} A(r_H)^{2/3}\sqrt{S}$$

Insider tip: For comparison purposes the following table illustrates different flows through various pipelines.

Nominal Diameter	Pipe Material	Inside Diameter	Hazen6Williams C Factor	Flow, Q GPM
8" DIPS DR17	HDPE	7.92 in	150	367
8" CL50	Ductile Iron Cement lined	8.39 in	130	370
8" C900 DR18	PVC	7.98 in	150	374

Fusion, Butt

Basic: HDPE pipe is butt fused utilizing a specific procedure and equipment with trained technicians by applying heat to prepared pipe ends and then pushing the pipe ends together with a pre-determined force to make a permanent butt fusion joint. It is a process utilizing a properly sized butt fusion machine for the pipe size to be joined. The pipe is installed, clamped, and cleaned of contamination and debris in the fusion machine. With pipe supports on both ends of the machine to support the pipes on the machine center line the pipe is ready for the fusion process to begin. The PE pipe ends are then faced (machined) to mechanical stops to ensure clean, parallel pipe ends prior to the heat soak phase. The ends are then aligned using clamps on the fusion machine. A temperature controlled heater is checked to ensure it has balanced and appropriate heating and heat then placed in the machine and the pipe ends are heated according to ASTMF2620 (important for details of heating process). Once the heating criteria is met, the heater is removed and the pipe ends are brought together at the pre-determined force. This force is held on the joint for the appropriate time required by the standard. At this point, the pipe can be removed from the machine without affecting the newly fused joint.

Insider tip: Butt fusion is the primary joining method in the US, Canada and all over the world. Operators must be trained properly if they are to work on any job. The fusion technician should have "proper documentation" qualifying that they are capable of conducting the fusions and which demonstrates his/her credentials. A "card" is usually presented and is good for 24 months after last qualification. Fusion is a skill taught by experts to operators who develop the skill over time through experience. These skills and training not only help them understand the process and equipment but also the materials they are working with.

Fusion, Electro

Basic: Electro-fusion (EF) is a method of joining HDPE pipe by using special fittings that have built- in electric wire which is used to melt the resin then join the pipe together. The pipes to be joined are cleaned, inserted into the electrofusion fitting (with a temporary clamp if required) and a current is applied for a fixed time depending on the fitting in use. The built in heater coils then melt the inside of the fitting and the outside of the pipe wall, which weld together producing a very strong connection that is fully pressure rated.

Insider tip: As with butt fusion, the operator must be trained in electro-fusion for the owner to have confidence in the integrity of EF joints. Electro-fusion is not a complicated process, but operators who are trained in it, know that it is a skill that is learned and one which is taught by experts. Owners must require operators to receive EF training. Fusion is a skill taught by experts to operators who develop the skill over time through experience.

Fusion, Sidewall

Basic: Sidewall fusion is similar to butt fusion in that a heater plate is used to melt two sides of the pipe in preparation for fusion. Only in this instance the fusion process is performed on the side of the pipe rather than in line with the pipe. Sidewall fusion is typically employed for installation of lateral lines with saddle fittings.

Insider tip: PPI TR-41 covers sidewall fusion as does ASTM F2620. Only trained operators should perform sidewall fusion. Fusion is a skill taught by experts to operators who develop the skill over time through experience.

Ref: *https://plasticpipe.org/pdf/tr-41.pdf*

HDPE

Basic: High Density Polyethylene Pipe (PE or HDPE) is a thermoplastic pipe known for being leak free joints, resistance to corrosion, flexibility, low maintenance, seismic resistance, and outstanding durability. High density polyethylene pipe is made from a plastic resin derived from oils and gases extracted from the ground which during the "cracking" process of raw fossil fuels generates an ethylene by product (2 double bonded carbons and four hydrogens). The ethylene is then processed into polyethylene by various reaction processes and techniques. Please keep in mind these processes are well understood and the science and engineering behind this process is complicated and well documented. HDPE for piping products are well controlled and formulations are specific for generating and meeting the cell class and specification requirements (ASTM PPI, TR3, AWWA, API, CSA ANSI, etc). Pressure class polyethylene have been in existence for over 50 years.

Insider tip: HDPE has long been in use in the natural gas industry because of its leak free joints, and it is growing in the water and sewer markets and is an excellent choice for these applications. What makes HDPE stand out from other pipes is its resistance to corrosion, toughness, flexibility, less maintenance, seismic resistance and trenchless installation. Sections of HDPE are connected by butt fusion or electrofusion, which provide HDPE with its leak-free, continuous length. Once fused together aboveground, HDPE can be installed by pipe bursting, sliplining, horizontal directional drilling, or open cut. The life costs of HDPE are significantly lower than other pipe materials.

The key with HDPE is to understand how different it is from all of the other pipe materials. It is a fundamentally different, yet superior material with its own unique set of features, benefits and considerations which inherently save in installation, repair and life expectancy costs.

Hoop Stress

Basic: Hoop stress is the circumferential force per unit area internal pressure exerts on a pipe wall (measured in PSI).

Horizontal Directional Drilling

Basic: Horizontal directional drilling (HDD) is a trenchless method of installing HDPE pipes. It is used when traditional methods are not appropriate. HDPE is prepared above grade in a long string so a single bore can be made. HDD is useful for minimizing surface disruption and dealing with grade and sub-grade challenges such as roads, railroads, wetlands and river crossings.

Insider tip: There are many experienced HDD operators in the US and this is a method where a good prequalification list makes sense for the design engineer. This is a method that places a premium on experience as three significant areas of expertise come into play: fusion experience, boring and traditional underground utility construction. See ASTM F1962 for Use of Maxi- Horizontal Directional

Drilling HDD for Placement of HDPE pipe and *Handbook of PE Pipe*, Chapter 12, PPI-TR 46 for Mini-HDD applications.

Ref: https://plasticpipe.org/pdf/tr-46-hdd-guidelines.pdf

Hydrostatic Design Basis (HDB)

Basic: A series of set stress values for plastic pipe that categorizes the long-term hydrostatic strength in the hoop direction for a given tested pressure and temperature conditions. HDB is used when determining the pressure rating of HDPE pipe.

Insider tip: The design engineer may find it helpful to understand these concepts as full appreciation will convince even the most cynical of users that the science behind HDPE pipe is solid and defensible. For further information consult the *Handbook of PE Pipe.*

Ref: https://plasticpipe.org/publications/pe-handbook.html

Hydrostatic Design Stress MRS (HDSMRS)

Basic: The maximum tensile stress (PSI) that can be sustained in a pipe's wall from hydrostatic pressure with a high degree of certainty that the pipe will not fail.

Insider tip: The design engineer may find it helpful to understand these concepts as full appreciation will convince even the most cynical of users that the science behind HDPE pipe is solid and defensible. For further information consult the Handbook of PE Pipe published by PPI.

Inside Diameter (ID)

Basic: The inner diameter of a pipe. HDPE pipe is outer diameter controlled meaning the OD remains constant as pressure class (DR) varies. Thus, the ID varies based upon the pressure class, DR and/or wall thickness.

Insider tip: HDPE comes in IPS and DIPS with the OD for each varying slightly. So if the nominal pipe diameter is 8" and 8" DIPS pipe has an OD of 9.05" and an 8" IPS pipe has an OD of 8.625". The ID of an 8" DIPS PC 100 pipe is 8.14" and an 8" PC 100 IPS pipe has an ID of 7.76". The industry offers two different pipe sizes to accommodate the needs of its customers. See the pipe manufacturer's sizing charts for a complete table of pipe offering. So remember, inside diameter changes as pressure class (DR) changes and this will affect your flow calculation. But, given HDPE's constant C factor, often times HDPE will carry more fluid than other materials even with a smaller ID.

Impact Strength

Basic: The ability of HDPE pipe to withstand shock loading or sudden strikes by equipment.

Insider tip: HDPE is a ductile material and has exceptional impact strength. HDPE's superior impact strength provides a piping system that is near impervious to impact damage and to damage from improper tapping. Experienced design engineers and contractors understand that PE pipe is proven to be impact tough.

Injection Molding

Basic: When a material is melted and forced into the cavity of a closed mold to take shape. Injection molded fittings and elbows are commonly injected molded to 12" in diameter.

Insider tip: More and more injected molded fittings have entered the market dramatically increasing product availability. Injection molded fittings are generally available up to 12" diameter.

Insert Stiffener

Basic: A metal (usually stainless) still ring that is inserted into HDPE to reinforce the outer diameter from compressive forces seen from mechanical fittings.

Insider tip: Always specify insert stiffeners when using mechanical fittings that clamp or apply compressive forces to an outer HDPE wall. HDPE's flexibility makes this method imperative as if it is not used, the mechanical joint may fail. Flexibility is the feature that makes HDPE the trenchless pipe, but that flexibility also causes issues when forces are applied to HDPE. It "flexes" and "gives" so proper care must be taken when using mechanical connections.

Inspector

Basic: An authorized engineering representative who inspects and observes construction and project work and reports it back to the engineer.

Insider tip: Inspectors who are tasked to work on HDPE jobs must be trained in butt fusion and electrofusion as this is the area where expertise is critical. An untrained eye will not be able to pick up procedural errors made by an experienced, but improperly trained fusion operator. Inspector specific training classes are offered by the industry and strongly recommended.

IPS (Iron Pipe Size)

Basic: Iron Pipe Size (IPS) is the most common size for HDPE pipe. It was developed by the industry so it would be a good OD match for existing cast iron pipe systems.

Insider tip: IPS is a preferred size for many municipalities, as it is generally more available than DIPS sizes as other industries use IPS vs DIPS. IPS features a smaller ID and OD than DIPS.

Joint, Butt Fused

Basic: A joint made by applying heat and pressure to the ends of pipe to form a seamless, leak free bond. See Fusion, joint.

Insider tip: Butt fusion is the primary method that HDPE fusion occurs in North America. Two male pipe ends are clamped in a fusion machine and heated and quickly brought together under "fusion pressure." This process creates a homogenous bond. Joints connected by butt fusion are in fact stronger than the pipe itself. Many argue that they joint, once fused is no longer a joint. However, for purposes of clarity more often than not, it is referred to as a joint even after fusion. This fusion process allows for HDPE to be installed in continuous lengths to ensure a leak free system. Butt fusion can be

performed above ground at a jobsite and only needs a short amount of time to fuse and cool the pipe before it can be installed. Follow the ASTM F2620 standard to ensure a properly fused joint.

Joint, Electrofused

Basic: A joint made by inserting ends of pipe into an electrofusion fitting and heating and fusing them within the fitting.

Insider tip: Electrofusion joins lengths of HDPE pipe using heat and pressure to create a strong joint. Electrofusion is unique in that the two ends of pipe are inserted into a fitting and then heated and fused within the fitting, which remains on after the fusion process is completed. Like with butt fusion, electrofusion also creates tough, leak free joints. Electrofusion can be performed aboveground at a jobsite and only needs a short amount of time to fuse and cool and pipe before it can be installed. The pipe must be round in order for electrofusion to work. Fusion operators must be trained to a standard.

Joint, Mechanical

Basic: A mechanical connection between two pieces of HDPE pipe.

Insider tip: Mechanical connections to PE pipe are great ways to make temporary fixes when a failure occurs or when laterals need to be connected. However, as the system is no longer fully HDPE, the weakest part of the system will be at that mechanical connection. The offering of mechanical fittings and connections has grown tremendously over the last few years.

Joint, Saddle-Fused

Basic: A joint made by fusing together a pipe and the base of the saddle fitting with heat according to F2620.

Lateral

Basic: Any connection to a mainline. Typically a connection running to a residential address.

Insider tip: In the HDPE world, laterals should be connected using both butt fusion and electrofusion. Mechanical connections are permitted and sometimes preferred however, they become the weakest part of the system.

Long Term Hydrostatic Strength (LTHS)

Basic: The long-term stress that causes a pipe to fail at 100,000 hours when continuously applied.

Insider tip: Understanding LTHS will provide insight into the test that demonstrates the 250-year life of HDPE pipe.

Manning's Formula

Basic: An equation used to calculate flows in gravity channels and conduits. The formula can be used to calculate the value of c in Chézy Formula using the hydraulic radius and coefficient of roughness values.

Insider tip: A common formula for the design engineer, Manning's formula is a routine formula that we discuss often because often times flow rates are often higher in HDPE than expected because of the constant C factor in the equation. So in many cases, design engineers see higher flow rates in HDPE pipe with a smaller ID vs DIP because DIP uses a lower C factor because of tuberculation.

Values of n for Use with Manning Equation

Surface	n, typical design
PE pipe	0.009
Uncoated cast or ductile iron pipe	0.013
Corrugated steel pipe	0.024
Concrete pipe	0.013
Vitrified clay pipe	0.013
Brick and cement mortar sewers	0.015
Wood stave	0.011
Rubble masonry	0.021

Note: The n-value of 0.009 for PE pipe is for clear water applications.
An n-value of 0.010 is typically utilized for applications such as sanitary sewer, etc.

Mechanical Connections, see Joint mechanical

Medium Density Polyethylene Plastics (MDPE)

Basic: Polyethylene plastics with a standard density of 0.926M0.94 g/cm^3.

Insider tip: It is well known that the gas industry uses MDPE more than HDPE. In distribution, polyethylene is the dominant product yet the water and wastewater markets are relative newcomers to HDPE in the United States. HDPE is the dominant pipe in Europe for water and wastewater applications.

Modulus of Elasticity (E)

Basic: The modulus of elasticity is a measure of stiffness of a HDPE pipe, specifically a pipe wall.

Insider tip: It is useful in discussing how HDPE responds to external stresses. When engineers calculate the amount of hoop stress, dynamic loading or the forces of pipe bursting on a run of pipe, the modulus of elasticity of HDPE is a critical factor. ASTM D638 is a good resource.

Open Cut Excavation

Basic: Open cut is a non-trenchless method of installation in which a trench in the ground is excavated to install new pipe.

Insider tip: Open cut is a non-trenchless method of installation in which a trench in the ground is excavated to install new pipe. It is often utilized for very large diameter projects. Since HDPE can be fused aboveground, it saves excavation and reconstruction costs since workers do not need to go down into the trench to fuse the pipe together, allowing HDPE trenches to be smaller than those

required by other materials. PE Pipe is a very competitive pipe product on open cut jobs because trench widths are narrower and the new 4710 resin permits thinner walls at higher pressures.

Ovality

Basic: Deviation from a circular periphery. Round is the desired state in the PE world, not oval. Once the pipe ships from the factory it tends to go out of round, particularly in the larger diameters. This is an expected occurrence and is considered a normal state for PE pipe.

Insider tip: The importance in the HDPE world relates to the deviation in the pipe diameter when it comes time to fuse pipe. The pipe must be round to fuse whether you are butt fusing or electro fusing. Thus, the fusion machines have "jaws" to hold the pipe in place and in electrofusion the operator places a clamp around the pipe. If the pipe is oval and proper procedures are not used, the pipe will not fuse properly.

PE, HDPE, POLY, Polyethylene

Basic: Abbreviation for high density polyethylene, a plastic material. Common acronyms include HDPE, PE, poly and polyethylene.

Insider tip: HDPE quickly becomes PE, but means HDPE. The present day resin is 4710 and is much more stout and high performing than 3608. PE Pipe is the future for the water and wastewater markets in the US. Consider it on your next project!

PE3408

Basic: Abbreviation for polyethylene, a plastic material. Common acronyms include HDPE, PE, poly and polyethylene.

Insider tip: HDPE with 1600 PSI and an Environmental Stress Crack Resistance equal to or greater than 600 hours or a slow crack resistance (PENT) value equal to or greater than 10 hours (in accordance with ASTM D1693 and D1473).

PE4710

Basic: Fourth generation resin used to make HDPE pipe and fittings. Truly an amazing feat of using ethane or petroleum, this resin is far superior to previous generations.

Insider tip: The 4710 resin provides designers tremendous flexibility when design to save streetscapes, above grade development and existing utilities. The life expectancy alone is reason enough to use pipe made from this resin.

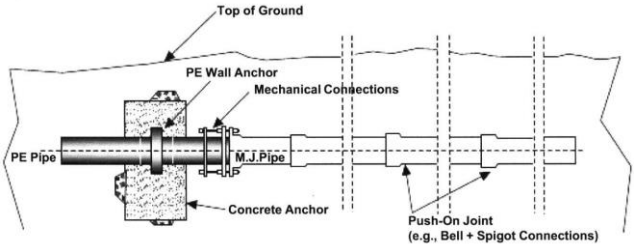
Pipe Bursting

Basic: Pipe bursting is a trenchless method of replacing buried water and sewer pipelines without the need for a traditional open cut trench. The "host pipe" is "burst" by mechanical equipment that is pulled through the host pipe from one end to the other. HDPE pipe is then pulled behind the "bursting head" replacing the host pipe.

Insider tip: This trenchless rehabilitation method is really "less trench." Entry and exit pits are dug, and bursting equipment is pulled through the pipe on a cable, breaking the old pipe and pushing it into the surrounding soil with an expander while simultaneously pulling in the new length of pipe behind. Note that parallel and crossing utilities may have to be exposed to eliminate risk of damage. Static pipe bursting is powered by a hydraulic power unit and can be used for water or sewer systems. A winch and pulling cable are used to pull the pilot, bursting head, hammer and HDPE. The alternative is pneumatic pipe bursting which uses a hammer to burst the pipe.

Poisson's Effect (Ratio)

Basic: The ratio in the decrease in lateral strain to the increase in axial strain is called Poisson's ratio.

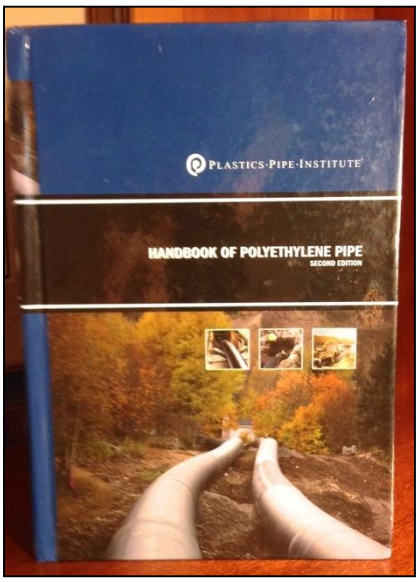


Insider tip: A primary feature that makes HDPE forgiving and flexible to ground movement and surge creates axial stress where the PE connects to the incumbent system. Consequently, it must be restrained at that point. The Poisson's effect as it is called if not properly addressed will cause pull out and line failure.

Plastic Pipe Institute, PPI

Basic: The Plastics Pipe Institute Inc. (PPI) is a technical association representing all segments of the plastics piping industry. PPI members share a common interest in broadening awareness and creating opportunities that expand market share and extend the use of plastics pipe in all its many applications.

Ref: https://plasticpipe.org/index.html



Insider tip: PPI organizes their areas of interest and advocacy into five categories: building and construction, conduit, corrugated pipe, energy piping systems and municipal and industrial. PPI continues to do a great job in developing technical data, obtaining certification for products and giving the industry the technical foundation to advance use of HDPE. PPI has now published two editions of the PE Pipe Handbook which serves as an excellent resource for the civil engineer who uses HDPE pipe, fittings and equipment. The book can be purchased for $50 at PPI's website or pdfs of each chapter are available online.

Pounds per square inch, PSI

Basic: a pressure unit used by the industry to describe the pressure capability of pipe and fitting products. It functions as the measure by how much pressure a pipe can and should withstand in use.

Insider tip: It is a given that pipe cost goes up as pressure capacity and requirements increases. In the HDPE world, the wall thickness increases as pressure class goes up. Pipe is sold by the pound, so the more resin that is used, means greater cost. Also, as pressure class goes up, wall thickness goes up, but ID goes down. Thus flow rates decrease as the ID declines. However, the C factor stays at 150 so flow rates may in fact be better than competing products. As an added tip, understanding surge is key to knowing what psi pipe to specify. Engineers are accustomed to using a higher pressure rating than working pressure because that is how incumbent pipe systems are designed. Not so with HDPE. A 100 psi HDPE pipe can handle occasional surges to 200 psi so no need to buy the 200 psi pipe. Use the 100 psi pipe and let the pipe do the work.

Pressure, Surge

Basic: Also known as water hammer, changes in the velocity of flow in an HDPE pipe system. Velocity changes can be caused by the operation of valves and pumps. Sometimes a fire event can cause surge in a pipe system.

Insider tip: Understanding how surge occurs is important, but recognizing how to design for surge in HDPE systems is critical to design success.

Pressure, Working

Basic: The maximum allowable operating pressure that a system can safely operate.

Insider tip: In the HDPE world, the working pressure refers to the typical pressure the agency sees in its system. It is helpful to know both working and surge: two psi numbers when determining which HDPE pipe pressure class (DR) to select.

Print Line

Basic: The print line appears on sticks and rolls of HDPE pipe so users can determine the specifications to which the pipe was manufactured. See ASTM F714 page 7M8, AWWA C906 page 23 and 29. specify minimum print line requirements. Most manufacturers provide information in excess of what is required.

Insider tip: Every manufacturers print line is a little different. For example, WL Plastics has series of numbers to identify their product. The print line shown below is a good example.

DIPS 12" DR17 – WL Plastics – UT – PE4710 PE445574C – PC125 – AWWA CM906 – ASTM F714 – [Shift/Line] – [MMM DDMYY] – NSFM61 – 50FT

Explanation:

Print line typically repeats at regular intervals like every 2'.
DIPS – Designated sizing system (other options IPS (iron pipe system), CTS (copper tubing sizes), ISO (metric mm sizes), DIPS (ductile iron pipe system))
12" – Nominal pipe outside diameter (note: nominal diameter may differ from actual measure diameter, ex: 12" DIPS nominal is equal to 13.20" actual measured diameter) **DR17** – Dimension Ratio (diameter/minimum wall thickness), 17 equates to 125 psig pressure class (see below)
WL Plastics – Pipe Manufacturer
UT – Location of Manufacturer
PE4710 – Pipe material designation code
PE445574C – Cell Classification per ASTM D3350 (pipe resin physical requirements)
PC125 – Pressure Class 125 psig
AWWA C906 – pipe meets American Water Works Association standard CM906
ASTM F714 – pipe meets American Society of Testing and Materials standard F714
Shift/Line – Shift that manufactured the pipe and which line it was made on (for product traceability)
MMTDDTYY – Date of manufacture
NSFT61 – pipe meets NSF M61, Product certified for use in potable water service
50FT – Pipe length designation

PSI, see Pounds per square inch

Quick Burst Test

Basic: A prescribed test conducted by pipe manufacturers to confirm the pipe they manufacturer conforms to NSF and ASTM requirements. It is a test of the internal pressure of a pipe meant to burst a pipe component in 60M70 seconds. The test is run in accordance with ASTM D1599.

Insider tip: Watch the video above and you will see a pipe burst at about 4 times its working pressure rating. This ductile failure is the proper failure mode for properly manufactured pipe and gives the viewer confidence to know that HDPE is a very strong and capable pipe system.

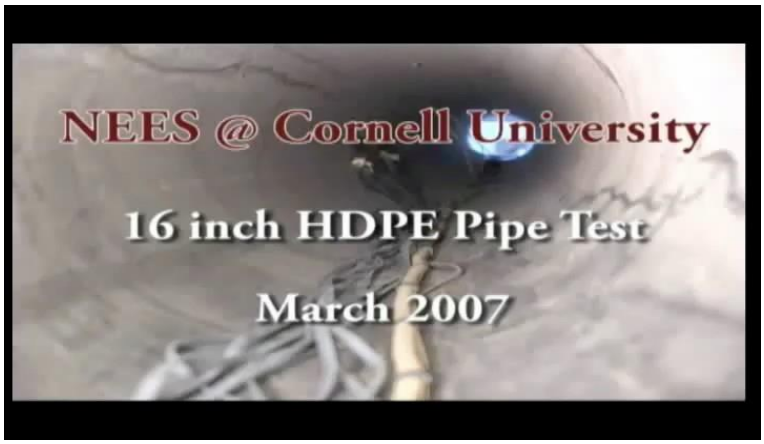
Rapid Crack Propagation (RCP)

Basic: A crack failure in a pipe typically initiated by a hard impact. RCPs are often experienced in conjunction with low temperatures and compressed gas media. RCPs run along a pipe at extremely high speeds and can be several feet in length.

Insider tip: Running cracks in HDPE occurred in extreme stress situations on occasion with previous versions of the resin. PE Engineers from Dow, Lyondell Basell and CPChem have perfected a resin that does not permit those kinds of failures to occur in the 4710 resin.

Seismically Resistant

Basic: HDPE pipe is seismically resistant as confirmed by the Water Research Foundation in their seminal report #4408 entitled Recent Earthquakes: Implications for US Water Utilities published in 2012. In other words, it will withstand earthquake activity, freeze thaw cycles, soil constriction, pressure spikes and typical ground movement that typically fractures incumbent pipe systems.



Cornell University Video simulation demonstrates how a 4' lateral shift in the soil affects a 35' long 16" diameter piece of

Insider tip: HDPE pipe is the seismically resistant pipe. It will withstand severe ground deformation without failure. That means that public agencies can specify a pipe that will withstand seismic activity and count on their pipeline infrastructure to remain intact and functioning after the seismic event.

Sliplining

Basic: A trenchless rehabilitation method for an old pipe system. Entry and exit pits are dug and a liner is pulled inside the host pipe. HDPE of a smaller diameter than the original pipe is then pulled through the liner and settled inside of the original pipe. Sliplining is an effective method if the existing system is still well intact.

Insider tip: The selection of DR is a design consideration as the host pipe provides structural integrity. There is some conversation in the industry on whether or not the annulus needs to be filled.

Specifications

Basic: Written technical descriptions in contract documents that outline the desired materials, lengths, equipment, construction methods, standards, practices and other relevant project details.

Insider tip: The Alliance will edit your specifications or provide model specifications for your use. Documents are available in editable format for easy integration.

Squeeze Off

Basic: A PE line can be squeezed off by a squeeze off tool which clamps down on the pipe to stop the flow.

Insider tip: Operator must turn the crank slowly on the manual machines and operate it slowly on the hydraulic machines in order not to damage the pipe. At release, the process must also occur slowly according to equipment manufacturer specifications.

Stress Relaxation

Basic: A decrease in stress levels over time at constant strain.

Insider tip: HDPE is a very forgiving material. That is what makes it so flexible and tolerant of ground movement. However, when mechanical connections and fittings are placed on HDPE pipe, the type of coupling, the fasteners and the method of connection all

Striping

Basic: HDPE stripe colors are coextruded into the pipe so that they cannot be removed. Stripe color is most commonly used as a pipeline identifier. For example; blue stripe is potable water, green stripe is sewer/waste water, purple is reclaimed/non-potable water, red stripe is fire water, and yellow stripe is gas.

Insider tip: The number of stripes and their location vary from manufacturer to manufacturer. Black pipe without stripes is the most commonly available pipe in the industry. A double stripe sometimes denotes DIPS pipe vs IPS.

Blue stripe – potable water
Green stripe – wastewater
Orange – conduit, cable, communication, signal, alarm
Purple stripe – reclaimed, raw water or irrigation water
Red Stripe – firewater
Yellow stripe – natural gas (all yellow HDPE pipe is also gas pipe)

Swagelining

Basic: Swagelining is a rehabilitation process that pulls thin-walled HDPE through an existing pipe with an ID than the HDPE's O.D. The HDPE forms a tight fit within the pipe, using the old pipe for support.

Insider tip: Swagelining is a trenchless method of installation of HDPE that, like sliplining, using an existing system to host the new pipe. Unlike sliplining, swagelining does not use a liner. Instead, HDPE is pulled through a die that restricts the diameter of the pipe. The HDPE is pulled through the old pipe into place and allowed to expand back out to its original diameter, forming a tight fit with the old pipe. Thin-walled HDPE is typically utilized for this, as it ensures a similar flow capacity to the old system and can use the support of the old pipe still in place.

Tensile Strength at Yield

Basic: The maximum tensile strength a pipe can withstand before yielding and elongating in a tensile test.

Insider tip: HDPE pipe can handle up to 3500 psi before yielding the pipe. This is an important number to keep in mind when designing pull in applications such as pipe bursting, or horizontal

directional drilling. The yield stress is multiplied with the pipes wall area and a safety factor applied for the pull strength.

Testing

Basic: Required testing is set forth by the applicable standards. The most common for potable water applications are AWWA C906, ASTM D3035/F714, and NSF61. Required testing varies from physical strength, to chemical makeup.

Insider tip: Testing plans, or testing reports can be requested from pipe manufacturers showing what testing is performed on the pipe that is ordered.

Water Research Foundation (WRF)

Basic: WRF sponsoring cutting-edge research and promoting collaboration, the Water Research Foundation helps our subscribers with practical solutions and long-range planning to meet those challenges.

Ref: https://www.waterrf.org/

Insider tip: WRF works with a variety of professional partners to identify, prioritize, fund, manage, and communicate scientifically sound research across the globe. Since 1966, they have managed more than 1,000 high-impact research studies valued at more than $500 million. WRF is a 501(c)3 nonprofit organization that carefully invests research dollars from more than 950 subscribing organizations in the U.S. and abroad to tackle an array of issues related to water. WRF funded the study which proved the seismic resistance of HDPE pipe and cemented its position as the seismically resistant pipe in North America. See WRF report Number #4408. WRF also published a landmark report on the environmental impacts of pipe bursting with HDPE to solve the AC pipe crisis.

Working Pressure (WP)

Basic: The maximum sustained operating pressure a pipe can handle, distinct from temporary pressure changes such as pressure surges.

Insider tip: When selecting a pipe dimension ratio (DR) it is important to know what the WP is and what the maximum surge pressure is in a given system. Proper pressure class (or DR) is a function of working pressure plus maximum surge.

Sources:

PPI Handbook PPI Website
Alliance for PE Pipe Website
AWWA M55
Various ASTM standards
Engineer'sEdge.com