



HDPE FABRICATED STRUCTURES & MANHOLE GUIDE

HDPE EXPERTISE AND MORE

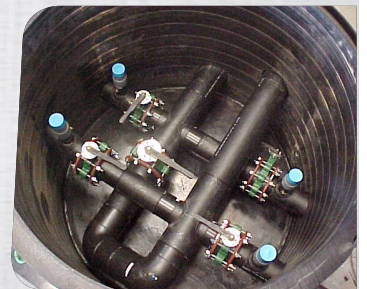


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SECTION 1

INTRODUCTION / ABOUT ISCO INDUSTRIES

COMPANY HISTORY

ISCO Industries has become a worldwide leader in high-density polyethylene (HDPE) piping products for various industries and applications. As with so many great companies, ISCO started with a simple idea. Jim Kirchdorfer, Sr., an avid golfer, wanted to find a way to improve golf course irrigation. He started selling pipe out of the back of his family's hardware store in the heart of Louisville, Kentucky in 1962. That small side project turned into a global operation that never lost the intention of that original concept: finding new ways to do things better. Now, through our global footprint and ISCO's professional and experienced staff, we can offer innovative ideas and engineered cost-efficient packages that will deliver longer service life while reducing the total cost of operations. From fresh water to the most extreme solids transport, ISCO provides piping solutions.

The ISCO team continuously updates the product offerings to ensure that our customers receive the latest information when it matters most. ISCO supplies HDPE piping products and systems capable of meeting standards like ASTM International (formerly the American Society for Testing and Materials), ISO (International Organization for Standardization), AWWA (American Water Works Association), FM (Factory Mutual), and ASME (American Society of Mechanical Engineers) including NA and NPT stamps for nuclear applications. More importantly, these products are backed by hundreds of skilled professionals in over 35 locations who are dedicated to providing exceptional customer service across all areas including:



Sales



Technical Support



Fusion Equipment Sales,
Rental, Leasing, Repair
and Training



Global Shipping and
Logistics

TOTAL PIPING SOLUTIONS FOR MANY APPLICATIONS

- Aggregate/Slurry
- Culvert Rehabilitation
- Geothermal/District Energy
- Golf and Irrigation
- Industrial
- Landfill
- Large Diameter
- Marine
- Mining
- Municipal Gas
- Oil Patch
- Power/Energy
- PP-RCT
- PE-RT
- Snap-Tite®
- Trenchless Applications
- Water/Sewer
- Waterworks

FABRICATION CAPABILITIES

Custom fabrication is at the core of our business. Anyone can sell pipe, but we have gathered an exceptionally skilled team that can create customized solutions for your piping project. ISCO has long been a world leader



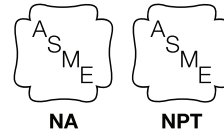
in HDPE fabrication. Our dedicated team along with a reinvestment program in machinery and equipment give us unmatched capabilities. Over the years, what began with simple elbow and fitting production has evolved by adding innovative machines, such as sidewall fusion units, tee/wye machines, specialty saws, completely automated perforating and slotting equipment, and a pipe “ovaling” machine. These additions only increase our efficiency and offerings to you, our valued customer.

Examples of our HDPE fabricated products include:

- Manholes
- Tanks
- Sumps
- Fittings
- Dual Containment Pipe, Fittings, and Structures
- Floats/Pontoons
- Side Slope Risers
- Perforated Pipe
- Slotted Pipe
- Snap-Tite®
- Prefabricated Piping/Spools
- Manifolds
- Geothermal Circuit Maker Vault®
- Pig Launchers and Barred Tees
- Customized Products

QUALITY APPROACH

ISCO's Quality Policy is to provide products and services that are accurate and on time to ensure a satisfied customer. ISCO is a manufacturer with a quality management system registered to ISO 9001:2015 and certified by a third-party registrar with documented annual audits. Additionally ISCO is an approved HDPE manufacturer of FM fittings used for underground firewater piping systems. ISCO possesses ASME NA and NPT stamps that allow for the production of HDPE fittings and installation of HDPE welded pipe at nuclear sites



for safety related service water systems, the only HDPE piping company with that designation.

ISCO provides confidence to its customers. To deliver this assurance, ISCO conducts vendor

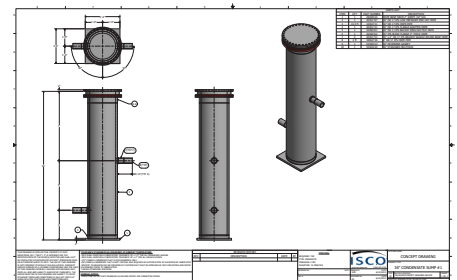
audits, trains fabricators and field technicians, reviews all hydraulically made butt fusions, and has material traceability mechanisms in place. ISCO maintains a system for recording non-conformances and instituting corrective actions as part of its daily business. When projects dictate specific requirements, ISCO can develop a specific Inspection and Test Plan (ITP) that assures fabricated products meet all specified examinations, reviews, and quality assurance items.

CAD CAPABILITIES AND DRAWINGS

ISCO uses the latest 3D CAD programs to translate customer needs into submittal/shop drawings. After ISCO sales and technical support teams gather information from our customers about their needs, we discuss constructability and functionality. ISCO offers assistance and recommendations

based on our years of experience in various industries, involving jobs around the world. The ISCO CAD team creates and assembles all components to

scale in a 3D environment that allows for analysis of each fabrication design. From the 3D assembly, the CAD team creates drawings with enough detail for customer review/approval and shop fabrication. Drawings will include tolerances and will list testing requirements when applicable.



APPLICATIONS/MARKETS/SERVICES

Types of Structures and Uses

In this document, the term “structures” generally refers to various fabricated products of similar construction for a wide array of applications, including the different types listed below. The high-density polyethylene (HDPE) piping industry uses the word “manhole” in the same manner, while in some industries manhole is a more narrowly defined term. It should be noted that this distinction is not well defined, and the terms “structure” and “manhole” may be used interchangeably in industry literature or when discussing this topic.

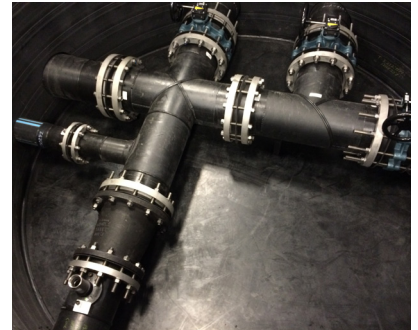
MANHOLES, CATCH BASINS, AND JUNCTION BOXES

Typically, the most common structure involves a large diameter barrel or riser. The riser serves as a mesh point for connecting pipes. Inlets and outlets are potentially at different angles and/or elevations and the manhole may possibly serve as a change of direction of pipelines without the use of fittings. Manholes and junction boxes typically have a manway for access, inspection, or even debris removal while some catch basins may be smaller and used as a collection point for surface drainage with or without entry access.



VALVE VAULTS, VALVE BOXES AND ACCESS POINTS

The protection of valves and flow measurement instrumentation is an excellent use of HDPE structures, especially compared to concrete materials that can allow groundwater infiltration. These “valve vaults or boxes” allow easy access to valves, flow instrumentation, pressure gauges, sample ports, cleanouts, and other piping system components. ISCO Industries can fabricate some of these structures as complete units with all valve and instrumentation components factory installed to make on site installation simple, fast, and efficient.



RESERVOIRS, WET WELLS, AND HORIZONTAL STORAGE TANKS

Collection and storage tanks are available for surface drainage, water, sewage, landfill leachate, and industrial process mediums. Excess runoff and hazardous liquids can be stored with confidence. Single tank storage is available in volumes up to 25,000 gallons. ISCO can also connect multiple tanks mechanically or by fusion for increased capacity. HDPE materials in underground applications offer more seismic resistance compared

to other materials like FRP and concrete. HDPE offers corrosion resistance without the added cost of liners or coatings, or cathodic protection required of metal storage tanks.

PUMP STATIONS

Pump stations, lift stations, sumps, and wet wells are cost effective uses of HDPE manhole structures. Typically, these structures are much lighter in weight than other material alternatives. This often means less equipment or lighter capacity is required for structure installation. Factory prefabrication of piping and penetrations can result with higher quality and less on-site labor. Since HDPE is a tough ductile material, it has the potential to reduce or mitigate pump vibration when properly installed.

POND RISERS

Golf courses and other irrigation applications use pond riser structures to manage the water elevation in retention ponds. The durable black pipe often used for the riser blends in visually, and can be adapted to accept inlet grates.



MANHOLE TEES

A relatively newer approach uses a tee or reducing tee configuration of an HDPE pipe system to create a riser to ground service. The riser can be small for service equipment, or larger to allow manway access and entry. The riser is well suited for light duty loading or customized for installations involving full traffic loading applications.

DUAL CONTAINMENT, LOW POINT, AND LEAK DETECTION MANHOLES

Dual Containment manholes and structures are available in many configurations and ISCO can help with design options that are effective for your application. Manholes can function as an extended annular space providing several different leak detection options including configurations that serve as containment for carrier/primary pipe and valves. Often the carrier pipe from double wall piping can continue through the manhole itself. This allows for installation of piping system equipment, such as flow control and measurement devices, in a structure that serves as a secondary containment vessel. HDPE manholes can provide a low-point for the annular space in dual containment piping system. The low point “sump” provides a leak detection monitoring point that may contain a float switch or level sensor normally connected to an electronic leak indicator or monitoring alarm.

Markets and Applications

INDUSTRIAL

Plants with corrosive chemicals use underground HDPE pipes because of the benefits of corrosion resistance, abrasion resistance, and the superior service life of polyethylene materials. Combining HDPE structures with HDPE piping results in a homogenous system achieved through welded joints to prevent leaks. HDPE structures are custom fabricated to create a full piping system whether they use valve boxes, process manholes, reservoir tanks, or dual containment structures.

Industrial plants with process water and plant effluent lines have used HDPE manholes to complete a discharge system. HDPE pipe and manholes work well for many industrial and chemical applications, including the pulp and paper industry where the effluent is most often corrosive and may be abrasive as well.

MUNICIPAL

Municipalities are increasingly turning to HDPE piping as the leak free solution to long time troublesome corrosion and leakage issues. HDPE piping and structures have a proven potential for long service life and the no-leak properties means the elimination of both groundwater infiltration and exfiltration of service fluid, including the ability to design for reducing or eliminating the escape of hazardous odors and fumes. Leak free systems can be incredibly important in preventing exfiltration and leakage of sewage to surrounding environmentally sensitive areas. Additionally, infiltration from high groundwater into sewer systems can increase cost by adding treatment volume.



ISCO's polyethylene piping and structures are highly resistant to hydrogen sulfide (H₂S) corrosion and have a long trouble-free service expectancy. The highly aggressive action of H₂S in a wastewater environment, especially in systems operating at low flow conditions, can severely reduce the service life of many piping materials such as ductile iron and concrete, resulting in leakage and premature failure.

LANDFILL

ISCO Industries is a leader in HDPE pipe, fittings, and structures for landfills in North America. HDPE is the industry-preferred material for leachate collection and methane gas piping from collection to treatment. The chemical resistance of piping materials is very important in landfill applications because leachate (water that has percolated through trash and garbage) can have a wide range of chemical properties, but HDPE is virtually inert to most dilute acids and bases.



Additionally, the toughness and strength of HDPE is important. As waste increases in a landfill, the loads increase and settlement occurs in piping systems. HDPE pipe and manholes have proven to withstand the demands in these harsh applications, commonly used in conjunction with leachate collection and transport lines. Typical HDPE structures

used in leachate collection include single wall and dual containment leachate manholes, sumps and pump stations, wet wells, catch basins, and leachate storage tanks.

Additionally, HDPE structures can be an integral part of gas collection systems in mature landfills. Removing moisture is essential to efficiently process or burn methane gas, the largest component of landfill gas. Before burning gas in landfill flare systems, condensate manholes and knockout structures help filter and remove moisture. Figure 2-1 shows an HDPE gas collection condensate "knock-out" used for condensing moisture from landfill gas.



Figure 2-1 : Typical Knock-Out Pot

GEOHERMAL AND DISTRICT ENERGY

ISCO developed the Circuit Maker Vaults® to be the central control point of a geothermal well field that connects circuit and header manifolds with all the advantages of HDPE structures. Custom-fabricated geothermal Circuit Maker Vaults® are strong, leak-free



structures that keep valve systems and other equipment clean and safe along with offering easy purging and isolation of circuits. Vaults include pressure/temperature (P/T) ports on all outlets and offer optional H-20 (Highway Traffic) load rating capability.

WASTEWATER TREATMENT PLANTS AND ODOR CONTROL

ISCO offers diverse yard piping solutions for many projects. With the development of increasingly larger diameter HDPE piping systems, designers of wastewater treatment plant and odor control system projects are turning to HDPE as the solution to long troublesome corrosion and leakage issues. The highly aggressive action of hydrogen sulfide (H₂S) in a wastewater environment can severely reduce the service life of many piping materials such as ductile iron and concrete, resulting in leakage and premature failure. HDPE piping systems are much more flexible and durable than FRP options that can be sensitive to demanding installation conditions.

OTHER

HDPE structures are ideal for marine and saltwater environments, along with mining applications. Increased diameters make HDPE a consideration for hydroelectric intake and penstock structures, inspection chambers, and utility tunnels for pipe and cabling access.



Service Considerations

UV EXPOSURE

Polyethylene piping material normally contains a minimum of 2% carbon black for resistance to degradation from ultraviolet light. This allows black HDPE piping and manholes to operate unprotected in above-ground applications for an indefinite period in direct sunlight, typically in excess of 20 years. It should be noted that exposed HDPE piping and structures may experience an increase in temperature due to absorption of solar energy, especially in warmer climates. Insulation, metallic tape, or periodic painting offers protection against solar absorption and helps deter heating from direct exposure to sunlight.

Non-black manholes are an option for underground installations where visible interiors offer workers an inspection or operation advantage like geothermal valve vaults. Gray or white cylinders typically contain some sacrificial additives that provide resistance to UV degradation for up to 5 years of outdoor storage or exposure. Periods extending beyond this limit would require preventative measures against direct exposure.



PRESSURE AND GRAVITY SERVICE

Most HDPE manholes operate under gravity flow drainage and atmospheric conditions. Some structures are capable of handling pressure service but the pressure capacity will decrease as the diameter of the structure increases. Typically, pressure capacity is limited to 63" diameter or smaller vessels. Vessels designed for gravity or vacuum service are capable of tests ranging from 1-4 psi for leak free verifications. Please contact ISCO for specific size, pressure, and vacuum limitations.

TEMPERATURE RANGE

HDPE materials are suited for operating from -50°F (-45°C) or lower, up to 140-180°F (60°-82° C) range depending on circumstances. Operating conditions above 73°F should factor in the mechanical strength properties of HDPE, as elevated temperatures reduce service pressure ratings and affect mechanical design properties. HDPE materials are well suited for many freeze/thaw cycles compared to other materials, but freezing liquids may be a source of potential damage when expansive forces are constrained without relief. Heat tracing may help with low-end temperature conditions.



ENVIRONMENTAL RESISTANCE

HDPE materials have one of the broadest ranges of resistance to corrosive acids and bases, along with salts and seawater environments. Polyethylene does not rust, rot, corrode, or tuberculate like traditional metal or concrete piping and manholes. In addition, polyethylene materials have surfaces that are non-wetting and exhibit excellent abrasion resistance. HDPE is unaffected by most biologic attack from bacteria and fungi and will not provide any nutrition to support growth. Polyethylene is resistant to aggressive soils and is not subject to galvanic or hydrogen sulfide corrosion. Advancements to HDPE resins in the last decade have improved the resistance to environmental stress cracking (ESCR) over earlier generation HDPE materials by more than 10 times.

HYDROCARBON EXPOSURE AND CONTAMINATED SOILS

Questions arise about the use of HDPE products where trace or low levels of hydrocarbons may be found in the process fluids, contained in the HDPE piping and structures, or in contaminated soils and groundwater around HDPE systems. Direct exposure to high concentrations of hydrocarbons may cause swelling and/or softening of the polymer matrix that comprises HDPE pipe. As hydrocarbons saturate or permeate the pipe wall, a reduction in the pressure rating and load capacity for pressure piping systems may occur. That is why it is common practice to “re-rate” HDPE pipe to a lower level when considering its use in pressure applications when handling of these types of chemicals. However, note that the use of polyethylene containers is common for commercially transporting and storing of hydrocarbon products like gas and motor oil.

Keep in mind that the use of HDPE products to convey these types of chemicals is considerably different from systems that convey water, sewer, or other mediums through soils potentially contaminated with residual hydrocarbons. Additionally, the nature of the hydrocarbon exposure plays a role in the possible saturation or permeation of HDPE pipe in these types of applications. The lower molecular weight hydrocarbons are smaller by nature and, as a result, may permeate the HDPE pipe wall more readily than exposure to heavier molecular weight hydrocarbons. Fortunately, these lighter hydrocarbon residuals tend to evaporate out of the soil over time and generally pose less concern in many installations. In most situations, passive exposure to soils contaminated with residual hydrocarbons do not have a significant effect on HDPE pipe as there is not driving pressure gradient to accelerate saturation or permeation of the hydrocarbons into the wall of the HDPE pipe. Osmotic solvation does occur but only to a concentration level comparable to the surrounding soil envelope. Contact ISCO for industry reports on the potential impact hydrocarbons have on HDPE piping products.

MATERIALS AND COMPONENTS

Material

CHARACTERISTICS AND PROPERTIES

High-density polyethylene (HDPE) manholes and other structures offer the same advantages realized when utilizing HDPE piping systems as compared to traditional materials. Those advantages include a hydraulically smooth surface that is corrosion resistant. Additionally, HDPE is chemically resistant in a broad range of services including hydrogen sulfide and other sewer gases. HDPE manholes and structures have a proven potential for long service life and the no-leak properties means the elimination of both groundwater infiltration and exfiltration of service fluid, including the ability to design for reducing or eliminating the escape of hazardous odors and fumes. Factory prefabricated structures offer high quality and the potential for shop or field testing to meet QA/QC requirements. With the proper embedment materials, HDPE has sufficient strength for deep burial depths, but HDPE structures are also flexible, tough, impact resistant, and lightweight for easier installation. Compared to other available materials, lighter HDPE structures potentially reduce site equipment requirements and the carbon footprint associated with transportation and related construction activities.

RESIN

Two important standards help specify or define polyethylene pressure piping materials: ASTM D3350 for cell classification and ASTM F412 for thermoplastic piping material designation code. The ASTM D3350 identification method consists of a series of six digits followed by one letter. The six digits equate to the specified level of performance required in six separate physical properties, such as density, melt index, flexural modulus, and tensile strength defined within the standard. Increasing numerical values for each specific property indicates increased product performance. The final letter specifies the color or UV-resistance requirement. When using carbon black, the letter "C" follows the 6-digit

performance code. However, color pigments (other than black) and chemical additives used to address UV light exposure have a designation of "E" for colored with a UV stabilizer. Taken together the ASTM D3350 cell classification establishes a minimum range of technical performance and UV-resistance for the PE compound used to produce the pipe.

The ASTM F412 thermoplastic piping material designation code is a more generic nomenclature for pressure rated pipe produced from a particular PE compound. This code consists of an abbreviation for the basic material as defined within the ASTM standards. The standardized abbreviation for polyethylene is the term "PE". A series of four digits follows this basic polymer/material designation. The first two digits relate directly to specific physical properties for the compound as defined within ASTM D3350. The last two digits relate to the pressure capacity of the compound, indicating the long-term hydrostatic stress rating as recommended by the Hydrostatic Stress Board of the Plastic Pipe Institute in hundreds of psi. The long-term hydrostatic stress rating is the hydrostatic design basis (HDB) multiplied by the appropriate design factor (DF).

Although the use of manholes or structures in pressure applications beyond head pressure storage is not common, the component materials are pressure-piping grade, classified by the standards above. Most of the base raw black materials classify as PE4710, with a minimum cell classification of 445474C as shown below in Table 3-1. Profile wall products discussed on page 12 can have cell classes 334433C (or E) or higher.

Table 3-1 : **Pipe Properties and Cell Class Limits Per ASTM D3350-14**

PROPERTY	TEST METHOD	0	1	2	3	4	5	6	7	8
1. Density, g/cm ³	D1505	Unspecified	.925 or lower	>.925-.940	>.940-.947	>.947-.955	>.955	...	Specify Value	
2. Melt Index	D1238	Unspecified	>1.0	1.0 to .4	<.4 to .15	<.15			Specify Value	
3. Flexural modulus, Mpa (psi)	D790	Unspecified	<138 (<20 000)	<38- <276 (20 000 to <40 000)	276- <552 (40 000 to <80 000)	552- <758 (80 000 to <110 000)	758- <1103 (110 000 to <160 000)	>1103 (<160 000)	Specify Value	
4. Tensile strength at yield, Mpa (psi)	D638	Unspecified	<15 (<2200)	15-<18 (2200-<2600)	18-<21 (2600-<3000)	21-<24 (3000-<3500)	24-<28 (3500-<4000)	28 (>4000)	Specify Value	
5. Slow Crack Growth Resistance										
I. ESCR	D1693	Unspecified								
a. Test Condition (100% Igepal.)			A	B	C	C	...	...	...	Specify Value
b. test duration, h			48	24	192	600				
c. Failure, max %		Unspecified	50	50	20	20				
II. Pent (hours) Molded plaques, 80oC, 2.4 Mpa Notch depth, F1473, Table1	F1473	Unspecified	...	...	...	10	30	100	500	Specify Value
6. Hydrostatic Strength Classification										
I. Hydrostatic design basis, Mpa (psi), (23oC)	D2837	Not Pressure Rated	5.52 (800)	6.89 (1000)	8.62 (1250)	11.03 (1600)	...	...		
II. Minimum required strength, Mpa (psi), (20oC)	ISO 12162	...	...	...	...	...	8 (1160)	10 (1450)		

Note: Section 4 of this guide further discusses additional physical properties important to design calculations.

SIZE AND DIMENSIONS

Manholes and other structures are available in a range of diameters from below 18" up to 120". Standard structure height/length is limited to about 50 feet, normally governed by common shipping limitations but longer/deeper dimensions are potentially available. HDPE structures and manholes from ISCO Industries are customizable for each project, application, or service with component options including outlets, bases, tops, manways, and accessories.

¾"-63", but domestic production of pipes as large as 3000mm (118.1") has become an option recently. Most manufacturers make extruded pipe 3" (nominal) and larger to meet ASTM F714 with a controlled outside diameter (OD) and dimension ratio (DR), which is the ratio of outside diameter to minimum wall thickness. A lower DR value increases the wall thickness and decreases the ID of the structure. DR 32.5 wall thickness is suitable for many applications, but design constraints like increased burial depth or operating pressure may require an increase to a lower DR (i.e. a thicker wall pipe).

SOLID PIPE

Using extruded solid wall pipe as barrels/cylinders for the body of HDPE manholes and structures is a common practice. Solid wall pipe is commonly available in sizes

PROFILE PIPE

For the body of larger HDPE manholes and structures, using profile wall pipe as barrels/cylinders is more likely. While profile wall pipe is available in sizes as small as 18", primarily the range for structures is sizes from 60" to 120". Profile pipe is manufactured by wrapping extruded plates and/or profiles around a solid mandrel. Profile wall pipe typically has a smooth inner surface and some additional strengthening elements added to the outside wall of the inner core. Profile wall pipe has a controlled inside diameter (ID) and ring-stiffness constant (RSC) utilized to help define the pipe's strength and loading capacity. A higher RSC value results in a higher strength and usually results in a larger OD. Manufacturers produce profile wall pipe to ASTM F894 "Standard Specification for Polyethylene (PE) Large Diameter Profile Wall Sewer and Drain Pipe".

RECTANGULAR OR BOX STRUCTURES

Box or rectangular shaped structures are more commonly available with rigid construction materials such as concrete or fiberglass. Polyethylene box structures of this type are not common and typically have very low bearing capacity for external loading from surrounding fill or groundwater when constructed of solid wall HDPE sheet products. Additionally, box structures have more joints and may not sustain loads from internal media without reinforcement. Reinforcement and structural support for box type structures typically use framework from metal or other rigid materials. For this reason, round structures made from cylindrical pipe are much more common and much more preferred than box type structures manufactured from sheet materials. Contact your ISCO representative for discussion and consideration regarding appropriate applications and alternatives to box structures.

FABRICATED VS ROTATIONALLY MOLDED TANKS

HDPE manholes and structures discussed in this guide are typically appropriate for below ground applications, incorporating industrial grade HDPE pipe (for risers/ barrels) and sheets (for bases and tops) in these fabrications. Designing the wall thickness of pipe along with the thickness of plate materials enables those components to handle anticipated demands. HDPE structures as fabricated by ISCO can be used in above ground applications but should not be confused with tanks that are traditionally used for above ground storage tanks and manufactured by rotationally molded construction.

Rotationally molded tanks are typically translucent or white in appearance and would typically have wall thicknesses approximately ½" or thinner, depending on diameter. Manufacturers sometimes produce rotationally molded products using cross-linked polyethylene or Ultra High Molecular Weight (UHMW) polyethylene, which behave like thermosetting resins. This means these products are not suited for reheating, melting, or joining via welding once production of the tank is completed. This makes it difficult to repair or customize a rotational molded tank. Consequently, less demanding storage applications like agriculture or low-end process applications are often better for rotationally molded tanks, and are economically suited to match. The fabricated structures made by ISCO use HDPE resins that are thermoplastic products that have the ability to be melted and reformed after the resins have solidified. This produces structures that are highly adaptable to customization, allow for future modifications to the structure, and facilitates repairs in the unlikely event that damage occurs to an HDPE manhole.



DESIGN

Introduction

ISCO Industries has successfully used high-density polyethylene (HDPE) piping products for decades to fabricate a multitude of structures including manholes, vaults, collection chambers, pump stations, process tanks and dual contained sumps. Typically, ISCO utilizes a round cylindrical polyethylene pipe for the primary component of the structure, either as a vertical riser or as a horizontal chamber. The pipe can be manufactured using solid wall construction or as a profile wall product. Occasionally a manhole may have an open top or bottom, but it is much more common to have the pipe ends closed or capped off using pipe grade HDPE sheet. Attaching flat sheets to the pipe barrel using extrusion welding is normally sufficient for structures with atmospheric venting or that operate under gravity flow conditions with low head pressures. However, for applications that require a pressure rated vessel, HDPE caps are butt fused to the pipe barrel (typically 63" or smaller). Consult with your ISCO representative if you require a pressure rated vessel for a particular project or application.

ABOVE GRADE INSTALLATIONS

The design approach for freestanding tanks installed inside a factory or outdoors in open-air environments can vary considerably to the approach used for buried manholes. In above ground installations, design considerations may possibly include wind loading, seismic resistance, UV resistance, and the ability of the structure to remain upright including design of external supports. Governing codes and standards for above ground structures may apply. The use of FEA software along with other modeling design tools may be prudent

in the analysis and evaluation for these installations. The owner and designer should consider the impact that thermal swings may have on above grade structures and determine ways to mitigate length change or axial loads to ensure that temperature changes do not adversely affect the manhole structure or any of its related equipment or connections.

DESIGN FOR UNDERGROUND INSTALLATION

Buried HDPE manholes can be complex subsurface structures. Designers must evaluate that structures can accommodate external loads such as pressures from soil or embedment fill, groundwater/hydrostatic pressure, and any other live or static loads anticipated in the life of the system. Consideration may also be required for the temperature of the application, especially if operating or environmental conditions may result in elevated temperatures during the life of the system. ISCO Industries recommends designing and installing vertical HDPE manholes in accordance with the most recent publication of ASTM F1759, "Standard Practice for Design of High Density Polyethylene (HDPE) Manholes for Subsurface Applications". This standard addresses the material performance properties of the polyethylene, and structural design requirements of the manhole barrel and the manhole base plate or bottom in the burial condition. Equations in the standard help evaluate ring compressive strain and ring bending strain from radial



pressure, downdrag from settlement, and axial loading from compressive strain. If a water table exists, the standard assists with calculations for upward buoyancy of the structure and estimated bottom plate deflection. The standard does not provide guidance on the design of the top enclosure or lids, which requires independent evaluation by the design engineer. One independent evaluation would be the design of a concrete traffic pad that distributes H-20, H-25, or similar vehicle loading anticipated during the life of the manhole.

Manhole risers typically extend from the base of the manhole to the top of the structure often providing operational or maintenance access to any service fluid or internal plumbing, fittings, valves or related equipment in the manhole. In open flow applications, the manhole can provide means to access, monitor, or measure fluid flow in the manhole or, additionally serve as a control device to create or facilitate directional or elevation changes in the proposed piping conveyance system. The riser must be able to withstand downdrag and radial loading from the surrounding soil and groundwater. Proper design requires knowledge of many factors including the strength of embedment material and the in situ (or native) soil, along with the groundwater elevation. ISCO can assist in understanding the basic design principals and relevant material properties for buried HDPE manholes as provided in ASTM F1759.

ASTM F1759 addresses vertically-oriented HDPE structures installed in backfill consisting of Class I, Class II or Class III material, as defined in ASTM D2321, compacted to a minimum of 90% standard proctor density. The backfill should extend 3.5 feet from the perimeter of the structure for the full height of the manhole's buried section and extend laterally to undisturbed soil. Geotextile fabrics or other separation materials may be of benefit to segregate the designed and engineered backfill from surrounding in situ soils that pre-exist in the field, especially if the existing soils have a lower strength or fill modulus or if they consist of finer grained materials. Alternatively, using products such as flowable fill or low-density cellular concretes (LDCC) can provide structural support and embedment of the polyethylene structure. Properly designed, the flowable fill material may provide greater support than a granular fill, while also allowing excavation for future maintenance activities. When using flowable fill materials for embedment, evaluate the allowable external loads on the structure while in an unconstrained condition, since the flowable fill will place a hydrostatic load on the riser and the bottom plate prior to set-up or cure. Additionally, restraint of the structure could be necessary since flowable fill will create buoyant forces until cure or set-up has occurred.

Place manholes on a base of stable soil, a reinforced concrete pad, or controlled granular bedding. This bedding typically should be a minimum 12 inches in depth or more and compacted to 95% standard proctor density or greater. The foundation materials must provide adequate bearing strength to sustain the weight of the manhole, all internal equipment or piping, and media content, along with anticipated live loads and downdrag loads.

While ISCO Industries has created this guide to assist those who wish to utilize polyethylene manholes and structures, ISCO is unable to control the operational and environmental conditions upon installation. Therefore, it is the owner, design engineer, or purchaser's responsibility to determine and evaluate all applicable loads, along with any other information required to verify the design and suitability of service for any structure. This could include, but may not limited to, the environmental or service conditions and physical characteristics of the site including soil properties, groundwater levels, operating temperature ranges, and type of media conveyed. ASTM F1759 considers the burial conditions most generally encountered to assist designers in determining bottom plate thicknesses and riser wall thicknesses for HDPE buried structures.

Upon request, ISCO will provide sample calculations in accordance with ASTM F1759 for review by the design engineer for evaluation of the structure as a direct result of the known or anticipated burial loads. The design engineer or owner is ultimately the party responsible for ensuring that the structure is correctly designed, suitable for their particular application, and will meet the requirements for successful operation at the point of placement. The owner, engineer, or a construction inspector should ensure proper installation of the manhole so that it meets or exceeds the design assumptions used for evaluation. ISCO as a manufacturer is responsible for providing a finished fabrication that meets material requirements as determined by the engineer of record and dimensions indicated on approved shop drawings. ISCO will prepare and submit shop drawings of the structure for approval to the engineer/purchaser prior to fabrication.

HORIZONTAL TANKS VS VERTICAL STRUCTURES

There are different orientations in which to install HDPE fabricated structures. While many structures are buried in an upright position with surface access to the structure, buried horizontal chambers with a vertical manway access riser may be better suited for specific applications. The ISCO Circuit Maker Vault™ used in geothermal applications is an example of a buried horizontal structure.

ASTM F1759 specifically addresses HDPE structures installed in a vertical position. When installing horizontal tanks, Chapters 6 and 7 in the Plastic Pipe Institute (PPI) Handbook of Polyethylene Pipe may be useful for the evaluation as if it were a buried HDPE pipeline. These guidelines utilize the Modified Iowa Formula and the Marston-Spangler load analysis formulas for burial evaluation. Vertical risers are typically positioned perpendicular to the axis of the pipe barrel.



SECTION 5

HANDLING AND INSTALLATION

Shipping, Handling, and Storage

ISCO Industries generally ships high-density polyethylene (HDPE) manholes on flatbed trucks. Structures can ship standing up if they do not exceed shipping height restrictions. Taller structures ship on their sides (horizontally) with cribbing as needed to ensure outlets or other components are not overstressed.

It is standard practice to include lifting lugs on all manholes fabricated by ISCO unless special circumstances

prohibit their use. When lifting lugs are present, it is required that all of the lugs be used in unison to lift the manhole. Use nylon lifting straps of the appropriate size and quantity as well as lifting equipment sized for the structure to accomplish all lifting. Do not use wire rope, chains, steel cables or other devices for lifting that may cut in to the HDPE manhole or lifting lugs. Park all stationary lifting equipment and shipping trucks on level ground with stabilizers and wheel chocks utilized where applicable. Take care when working around HDPE manholes as the material can be slippery especially when wet.





Use lifting lugs for loading and unloading manholes that are shipped standing upright. Use nylon lifting straps wrapped around the barrel for manholes shipped horizontally. To stand a manhole up that was shipped and unloaded on its side, wrap straps around the structure and lift so that the straps are restrained by the lifting lugs. To install manholes with lifting lugs, thread nylon lifting straps or metal shackles through the holes in the lifting lugs and join all straps to the lifting equipment. Apply equal loading to all lifting lugs provided on the manhole during lifting, handling and placement of the structure. Do not attempt to handle or place the manhole without lifting equally across all the lifting lugs provided. Do not lift or handle manholes using outlet penetrations. A spreader bar or similar may be required to insure the straps do not put excess pressure on the manhole lid. To install manholes without lifting lugs, nylon lifting straps should be choked around the barrel and on the underside of a butt fused or sidewall fused component on the outside of the structure (tee outlet on side, flange adapter on top, branch saddle on side, etc.). During field handling, use caution if outlet lengths exceed 24" length. ISCO recommendation is to limit outlet length to maximum 24" when repositioning. Do not fill manholes with concrete, liquid, or other materials prior to final placement.



To store HDPE manholes on a site, position the structure so that the center of gravity is as low as possible. Vertical manholes that are taller than they are wide should be stored on their side and vertical manholes that are wider than they are tall should be stored upright. Take care to prevent water or other contaminants from entering manholes. Remove any water or other debris that collects in the manhole during storage before moving and installing the manhole. HDPE structures have buoyancy potential and may float in areas where water collects beneath them, including their final installation location. Keep storage and installation areas dry until final backfill and anti-buoyancy measures are complete.



Environmental Considerations

The service temperature range for HDPE manholes is (-) 40 degrees F to 140 degrees F. For applications up to 180 degrees F, contact ISCO technical support. While the temperature range for HDPE manhole service is expansive, the material will handle differently in each condition. In temperatures near or below freezing, the stiffness of the material will increase and the resistance to impact damage will decrease. In cold temperatures, take care not to drop or impact manholes and allow more time for bending and flexing of pipes connecting to manholes. While ice, rain, and snow will not damage HDPE manholes, they will cause the surfaces to become slippery and difficult to handle. Carbon black additives protect HDPE products from the sun and UV deterioration.

Connection Methods

ISCO can construct HDPE manholes with a variety of different outlet connections. The installation environment and the existing or future piping material/ end connections and layout will all contribute to the specified connection.



BUTT FUSION – PLAIN-END HDPE PIPE OUTLETS

Butt fusion is the most common connection method used to join to polyethylene pipe and fittings. Follow standard butt fusion procedures, but take special considerations for field conditions and piping layout. Joining components requires the use of a butt fusion machine and the movement of at least one of the components (Figure 5-1). Generally, the manhole is stationary so the piping to be connected must be able to move, deflect, or have some “slack” as it lays in the trench.

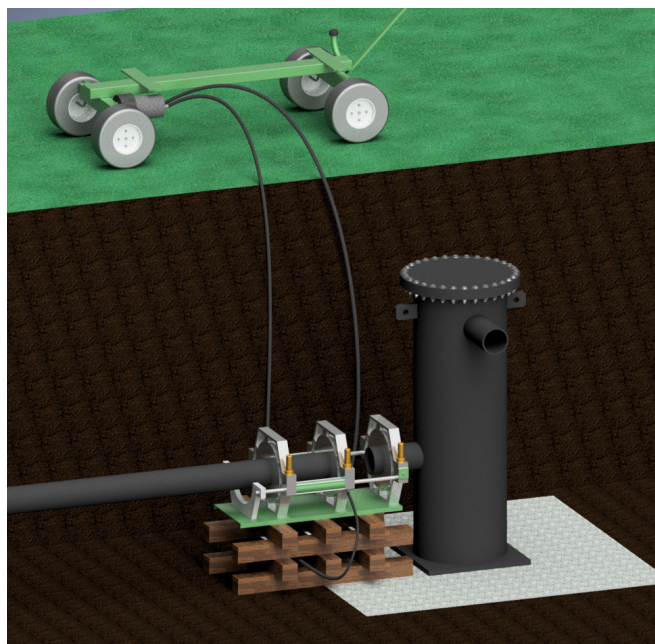


Figure 5-1: In-Ditch Fusion Setup

FLANGE CONNECTIONS – HDPE FLANGE ADAPTER AND BACKUP RING OUTLETS

Flange connections allow for connection to other HDPE piping with flange adapters and backup rings or dissimilar piping material with flanges. HDPE flanged outlets provide a standard method for connecting to valves or other flanged piping accessories. Flange connections require no special equipment in the trench. The mating flanged pipe needs to be the correct length, but does not need to be moveable. Follow the recommendations of PPI TN38 regarding bolt torques and installation guidelines. Tighten bolts in star pattern and retighten bolts after 8-24 hours of initial tightening. Gaskets are not required for HDPE Flange to flange connections.

ELECTROFUSION – PLAIN-END HDPE PIPE OUTLETS

Electrofusion is another connection method used to join to polyethylene pipe and fittings. Electrofusion couplers are corrosion resistant and require less pipe movement than butt fusion. ISCO suggest limiting the use of EF connections to sizes 12” and smaller unless other conditions warrant.

MECHANICAL COUPLING – PLAIN-END HDPE PIPE OUTLETS

Mechanical couplings can connect HDPE piping to HDPE piping or to dissimilar materials with similar ODs. Mechanical coupling require no special tools and less pipe movement than butt fusion.



CONNECTION TO OUTLETS WITH TRANSITION FITTINGS

Various fittings are available to transition from HDPE to other materials. Transition fittings allow shop welding of the HDPE portion to the HDPE manhole while providing for field connection of a dissimilar piping material at the transition end. The connection of the field piping varies based on the other end of the HDPE transition fitting. The most common transition fittings offered are threaded metal (steel, brass, and stainless steel), but steel weld end, PVC, and corrugated HDPE end fittings are also available. For threaded transitions, use thread sealant to help promote the seal and protect the end from twisting while connecting to it.

Testing Methods and Limits



Intentionally designed manholes can be field tested in a variety of ways. Specify similar shop testing to ensure the manhole is free of defects and is capable of passing the field test before

installation. If field-testing is required, specify ports for inclusion on shop drawings. Consider either testing before connecting the manhole to the system or isolating the manhole from the system during testing. Properly cap and seal all outlets to allow pressurization or filling of the manhole.

When using standard manhole construction, low-pressure air tests or standing water (or fill) tests are available. For structures 63" in diameter or smaller, the maximum allowable air test pressure is 4 psi for a maximum of 15 minutes provided the design is sufficient. Allowable air test pressures for larger structures are lower. Additionally, hydrostatic testing is possible on structures designed with all pressure-rated components and connections.

Embedment and Backfill

The latest version of ASTM F1759, "Standard Practice for Design of High Density Polyethylene (HDPE) Manholes for Subsurface Applications", specifies installation using



embedment materials in accordance to ASTM D2321. Install manholes in backfill consisting of Class I, Class II, or Class III material, which has been compacted to a minimum of 90% standard proctor density and providing a fill modulus of 1000 psi or greater. Backfill should extend at least 3.5 feet (1 m) from the perimeter of the manhole for the full height of the manhole and extend laterally to undisturbed in situ soil (Figure 5-2). Place manholes on a stable base consisting of at least 12 in. (30.5 cm) of Class I material compacted to at least 95% standard proctor density or a concrete slab. The foundation soils under the base must provide adequate bearing strength to carry downdrag loads.

Flowable fill or controlled low strength material (CLSM) is another option for manhole embedment when used correctly. CLSM is a self-compacting backfill that is poured from a ready mix truck or pumped from a pump truck. There can be many benefits to CLSM versus traditional backfill methods including a quick backfill using less equipment and a safer environment for workers. Take care if using CLSM to avoid buckling or flotation of the manhole. Observe precautions such as placing the CLSM in lifts or supporting the inside of the manhole help avoid buckling or floating.

Vehicular Loads



When installing HDPE manholes under roadways or areas subject to vehicular traffic, a concrete pad that rests on the soil surrounding the manhole is required. Design the pad to disperse the live load into the surrounding soil.

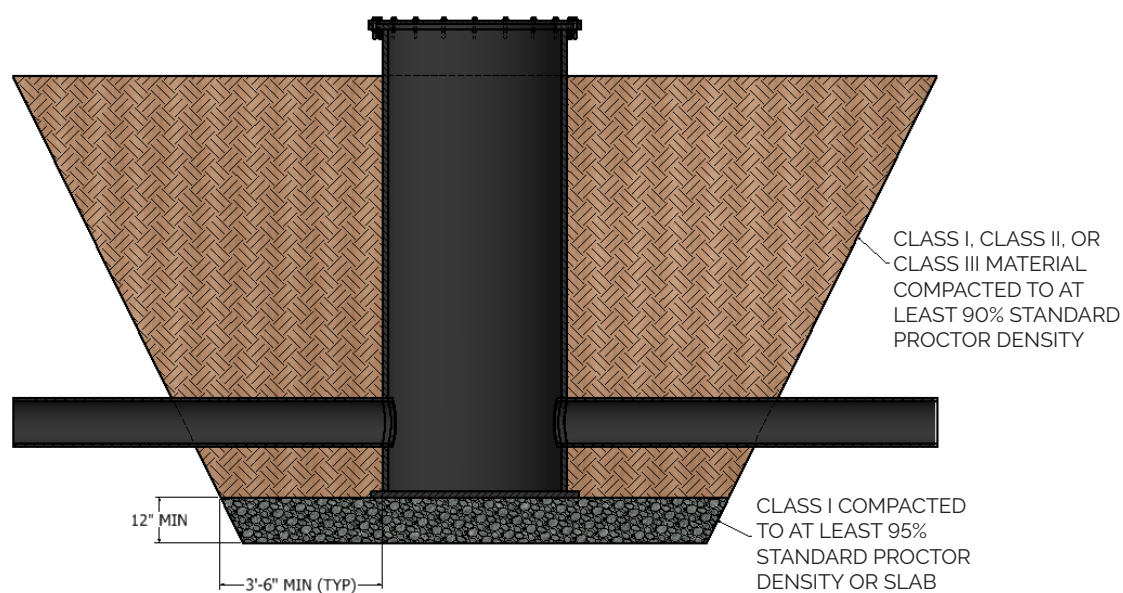


Figure 5-2: Typical Installation Recommendations

SAMPLE SPECIFICATION

Specifications for High Density Polyethylene Manholes and Structures

1. SCOPE OF WORK

This specification covers the material, fabrication, and general installation practice for high-density polyethylene pipe (HDPE) manholes and structures. ISCO Industries, Inc. or another approved manufacturer with an ISO 9001 Quality management system shall fabricate manholes and structures.

2. SUBMITTALS AND QUALITY ASSURANCE REQUIREMENTS

2.1. DOCUMENTATION

- 2.1.1. The fabricator of the manholes/structures shall submit shop drawings for approval as part of the submittal data showing overall configuration including details such as the position of the inlets, outlets and the overall dimensions along with any other special features such as manways, ladders, internal piping, valves, etc.
- 2.1.2. The fabricator shall submit documentation for review by the project engineer, or owner, indicating that the vertically installed manholes and structures are consistent with the guidance of ASTM F1759, "Design of High Density Polyethylene (HDPE) Manholes for Subsurface Applications".
 - 2.1.2.1. The documentation shall contain information related to ring compressive strain, combined ring compressive and ring bending strain, ring buckling, axial strain, axial buckling, and the thickness of the bottom based on acceptable stress and deflection limits. Bottom or top plates may have additional support ribs, gussets or and bracing as methods to reduce stress and deflection to acceptable levels.
 - 2.1.2.2. The Engineer of record (or owner) shall provide the depth and groundwater elevation, and verify all site conditions and soil properties are accurate.
 - 2.1.2.2.1. Design service conditions, including installation environment and operating parameters, will determine the wall thickness, Pipe DR, and/or RSC of pipe. The project engineer or the owner shall be specify or verify the service conditions.
- 2.1.3. The project engineer will review and approve the documentation supplied as part of the submittal package. The project engineer will review documentation for accuracy, including any site-specific variables, and confirm the structure is suitable for the intended service including installation and operating conditions.
- 2.1.4. When requested, the fabricator shall submit the Quality management system certificate for the manufacturing facility and/or the written Quality management system manual.
- 2.1.5. When required, test the manholes, structures, and pipe in accordance with section 4.8 of this specification and, if requested, provide test documentation.
- 2.1.6. When requested, attach an identification plate indicating, the job number, testing data, and build date and fabrication organization, to the manhole/structure.

2.2. APPROVAL OR REJECTION

- 2.2.1. Engineer of record (or owner) will review submittal information and provide written approval or rejection of submittal data, shop drawings, and verify proposed manhole or structure will meet installation and service requirements.
- 2.2.2. Engineer of record (or owner) reserves the right to require changes to the proposed product to meet intended installation and service conditions. In the event such changes affect costs or timing, adjustment to the purchase contract will reflect those changes.

3. HDPE PRODUCT REQUIREMENTS

- 3.1. The products used in the fabrication of the manholes and structures shall conform to the following requirements:
 - 3.1.1. HDPE extruded solid wall pipe requirements – Solid wall pipe supplied under this specification shall be a minimum grade of PE 4710 with a minimum cell classification value of 445474C per ASTM D3350. Pipe sizes 3" and larger shall have a manufacturing standard of ASTM F714, while pipe smaller than 3" shall be manufactured to the dimensional requirements listed in ASTM D3035. Dimension Ratio (DR) and Outside Diameter (IPS/DIPS) shall be as specified on plans.
 - 3.1.2. HDPE profile wall pipe requirements – Profile wall pipe supplied under this specification shall be manufactured to the dimensions and material requirements of ASTM F894 with a minimum cell classification value of 334433C per ASTM D3350.
 - 3.1.3. HDPE sheet material Requirements- HDPE sheet or plate shall be pipe grade material with a minimum equivalent designation of PE 3608 or a minimum cell classification value of 345464C per ASTM D3350.
 - 3.1.4. HDPE fitting requirements – HDPE fittings shall be a minimum grade of PE 4710 with a minimum cell classification value of 445474C per ASTM D3350 and conform to either ASTM D3261 for molded or machined fittings or F2206 for fabricated fittings.

4. HDPE FABRICATION REQUIREMENTS

- 4.1. The fabricator shall construct the HDPE manholes and structures based on project engineer or owner approved drawings.
- 4.2. The inlets and outlets shall be extrusion welded on the inside and outside of the structure, where access is available. Two gussets shall be provided for 2"-8" extrusion welded inlets and outlets and four gussets shall be provided for 10" and larger extrusion welded inlets and outlets unless impractical.
- 4.3. Join all manhole/structure connections larger than 4" nominal OD pipe by butt fusion, electrofusion, or flanged connections using an HDPE flange adapter and metallic backup ring with a bolt pattern per ASME B16.5 or B16.47 Series A. For 4" OD pipe and smaller, threaded transition fittings can also be used as well as the connections for 4" and larger. Employing mechanical couplings or similar connections requires approval by the project engineer.
- 4.4. Make all butt fusion welds as described in ASTM F2620 and all butt fusion welds performed with hydraulically operated butt fusion equipment shall be recorded using a data acquisition device. The fabricator shall maintain records of the temperature, pressure, and graph of the fusion cycle for a minimum of 3 years.
- 4.5. Except when impractical, lifting eyes are integral to the manhole/structure body and located on shop drawings.
- 4.6. Manhole/structure and outlets are not for use as anchor points against excessive axial loads or movement. When expecting large changes in temperature, design restraints to isolate the structure and prevent strain at the inlets or outlets. Cast restraints into a concrete block or collar around the pipe. If required as an integral part of the manhole/structure, the fabricator/manufacturer shall provide anti-flotation and/or anti-settling measures such as anchor lugs, rings, or collars.
- 4.7. Reinforced concrete pads at surface level spanning the HDPE manhole/structure footprint are required when used in traffic areas. The pad shall transfer live loads to the surrounding fill and remove direct loading to the manhole/structure riser or manway. A traffic rated frame and cover will be required. A professional engineer shall approve the design of the concrete pad. Integration of the pad with the manhole/structure will be coordinated with the manufacturer.

- 4.8. When practical and required, manholes/structures shall be factory tested with water or with air. Provide testing requirements to the manufacturer prior to fabrication. The owner or a representative of the owner may request to observe the test.
 - 4.8.1. Pressure rated vessels may be tested with a hydrostatic pressure test. Minimum test duration will be one hour. Maximum test duration will be three hours.
 - 4.8.2. When approved, conduct a water fill test by filling the structure and checking for leaks. Approval drawings and testing documents will specify the level of water and test duration. Minimum test duration will be one hour.
 - 4.8.3. A low-pressure air test may be used instead of testing with water. In this case, use a minimum of 1-PSI test pressure for 15 minutes. It is possible to test structures with a 60" inside diameter or smaller up to 4 PSI with approval of the fabricator.

5. SITE HANDLING AND CONNECTIONS

- 5.1. Handling of Manholes/Structures. Take care during loading, transportation, and unloading to prevent damage to the pipe. HDPE manholes/structures shall be stored on clean, level, and dry ground to prevent undue scratching or gouging of the pipe. Handling HDPE manholes/structures in such a manner to minimize damage, such as the use of nylon slings. The PPI Handbook of Polyethylene Pipe Chapter 2 offers guidance on handling of HDPE pipe/fittings and is appropriate to consider for HDPE manholes and structures.
- 5.2. Pipe Joining. Perform HDPE joining by butt fusion as described in ASTM F2620 or by electrofusion.
 - 5.2.1. A data acquisition device shall record all connections to the structure made by butt fusion and hydraulically operated butt fusion equipment. The contractor shall maintain records of the temperature, pressure, and graph of the fusion cycle for all butt fusions to the structure at the jobsite.
- 5.3. Handling of Fused Pipe- The handling of the pipeline should be in such a manner to minimize damage to the pipe. Nylon slings are preferred. Refer to the PPI Material Handling Guide for HDPE Pipe and Fittings for recommendations, guidelines, and instructions regarding the handling, lifting, loading, storing, and installing polyethylene pipe and fittings.
 - 5.3.1. Remove or repair sections of the pipe with cuts and gouges exceeding 10 percent of the pipe wall thickness or kinked sections with a procedure approved by the engineer or owner.
 - 5.3.2. Limit bending of the pipe welded to fittings or manholes/structure.
- 5.4. Flanged Connections- Flanged connections to the structure should use a connection with a 150# bolt pattern per ASME B16.5 or B16.47 Series A
 - 5.4.1. Bolted connections should follow recommendations from the Plastic Pipe Institute (www.plasticpipe.org) TN-38, Bolt Torques For Polyethylene Flanged Joints, including the following recommendations:
 - 5.4.1.1. Tighten bolts in a "star pattern" to recommended torque values.
 - 5.4.1.2. Bolts should be tightened a second time after 8-24 hours to ensure a positive seal.
 - 5.4.1.3. Gaskets are not required between HDPE to HDPE flanged connections.
- 5.5. Equipment Mounting- Special provisions should be considered when mounting pumps in an HDPE manhole or structure. Bolting directly to the wall of the HDPE structure is not recommended.

6. DIRECT BURIAL INSTALLATION

- 6.1. Trench Construction- Construct the trench and trench bottom in accordance with ASTM D2321. Install the HDPE manhole/structure on a concrete pad or a stable base consisting of 12" of Class I materials compacted to 95% proctor density per ASTM F1759. All required safety precautions for manhole/structure installation are the responsibility of the installation contractor.
- 6.2. Embedment materials- Embedment materials shall be Class I or Class II materials as defined by ASTM D2321. Class I or flowable fill (controlled low strength material /CLSM) materials are preferred. Backfill and bedding materials shall be free of debris.

- 6.3. Bed and compact beneath the manhole or structure in accordance with ASTM D2321.
- 6.4. Backfilling shall be done to conform to the ASTM F1759. Backfill should extend at least 3.5 feet beyond the edge of the manhole/structure for the full height of the manhole/structure and extend laterally to undisturbed soils. Compaction shall be minimum 90% proctor density with a minimum fill modulus of 1000 psi.
- 6.5. H-20 Highway Loads- When section 4.7 applies to the project and using HDPE manholes or structures in traffic areas, reinforced concrete pads with a traffic rated frame and cover shall be required. The contractor must submit a drawing showing the dimensions of the pad, including thickness of the pad and the placement of rebar, and the location in relation to the HDPE manhole/structure to the engineer.

ISCO Industries, Inc. has taken every effort to check the accuracy and standards used in the preparation of these sample specifications, ISCO does not guarantee or warranty piping, manhole, or structure installations, nor their final design. Sample specifications are for use as a guide to assist engineers and owners of piping systems containing HDPE manholes or structures. Sample specifications do not cover all situations or applications. These specifications do not intend to provide installation training or instructions. Since every job is different, use a trained professional engineer to determine the needs of a particular job.

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