HIGH-DENSITY POLYETHYLENE WATER/SEWER PIPING SYSTEM

AWWA C901, AWWA C906, ASTM D2239, ASTM D2737, ASTM D3035, F714

TECHNICAL & INSTALLATION GUIDE

JM Eagle™

Building essentials for a better tomorrow™

HIGH-DENSITY POLYETHYLENE WATER/SEWER PIPING SYSTEM

CONTENTS

WARRANTY

J-M Manufacturing Company Inc. (JM Eagle™) warrants that its standard polyvinyl chloride (PVC), polyethylene (PE), conduit/plumbing/solvent weld and Acrylonitrile-Butadiene-Styrene (ABS) pipe products ("Products") are manufactured in accordance with applicable industry specifications referenced on the Product and are free from defects in workmanship and materials. Every claim under this warranty shall be void unless in writing and received by JM Eagle™ within 30 days of the date the defect was discovered, and within one year of the date of shipment from the JM Eagle™ plant. Claims for Product appearance defects, such as sun-bleached pipe etc., however, must be made within days of the date of the shipment from the JM Eagle™ plant. This warranty specifically excludes any Products allowed to become sun-bleached after shipment from the JM Eagle™ plant. Proof of purchase with the date thereof must be presented to the satisfaction of JM Eagle™, with any claim made pursuant to this warranty. JM Eagle™ must first be given an opportunity to inspect the alleged defective Products in order to determine if it meets applicable industry standards, if the handling and installation have been satisfactorily performed in accordance with JM Eagle™ recommended practices and if operating conditions are within standards. Written permission and/or a Return Goods Authorization (RGA) must be obtained along with instructions for return shipment to JM Eagle™ of any Products claimed to be defective.

The limited and exclusive remedy for breach of this Limited Warranty shall be, at JM Eagle's sole discretion, the replacement of the same type, size and like quantity of non-defective Product, or credits, offsets or combination of thereof, for the wholesale purchase price of the defective unit.

This Limited Warranty does not apply for any Product failures caused by user's flawed designs or specifications, unsatisfactory applications, improper installations, use in conjunction with incompatible materials, contact with aggressive chemical agents, freezing or overheating of liquids in the Product and any other misuse causes not listed here. This Limited Warranty also excludes failure or damage caused by fire stopping materials, tread sealants, plasticized vinyl products or damage caused by the fault or negligence of anyone other than JM Eagle™, or any other act or event beyond the control of JM Eagle™.

JM Eagle's liability shall not, at any time, exceed the actual wholesale purchase price of the Product. The warranties in this document are the only warranties applicable to the product and there are no other warranties, expressed or implied. This Limited Warranty specifically excludes any liability for general damages, consequential or incidental damages, including without limitation, costs incurred from removal, reinstallation, or other expenses resulting from any defect. IMPLIED WARRANTIES OF MERCHANTABILITY OR FITNESS FOR A PARTICULAR PURPOSE ARE SPECIFICALLY DISCLAIMED AND JM EAGLE™ SHALL NOT BE LIABLE IN THIS RESPECT NOTWITHSTANDING JM EAGLE'S ACTUAL KNOWLEDGE THE PRODUCT'S INTENDED USE.

JM Eagle's Products should be used in accordance with standards set forth by local plumbing and building laws, codes or regulations and the applicable standards. Failure to adhere to these standards shall void this Limited Warranty. Products sold by JM Eagle™ that are manufactured by others are warranted only to the extent and limits of the warranty of the manufacturer. No statement, conduct or description by JM Eagle™ or its representative, in addition to or beyond this Limited Warranty, shall constitute a warranty. This Limited Warranty may only be modified in writing signed by an officer of JM Eagle™.

1.0 INTRODUCTION

The JM Eagle™ Municipal & Industrial Water or Sewer Pipe product line is manufactured from a black High-Density Polyethylene (HDPE) material. High-density PE 3408/3608/4710 is a preferred material for water distribution in municipal and industrial applications. It resists growth of bacteria, algae and fungi. Its strength and resilience provide long-term life against both internal pressure and intermittent surge and water hammer. PE 3408/3608/4710 excels in horizontal directional drilling, plowing, river crossings, sliplining, pipe bursting and other trenchless installation techniques. By following qualified heat fusion procedures, leak-free joints that are as strong as the pipe itself, work to protect our environment and conserve one of our most precious resources.

JM Eagle™ is a member of the Plastics Pipe Institute Inc. There are many helpful PE pipe articles available to the end user on PPI's Web site at www.plasticpipe.org.

The JM Eagle™ Municipal & Industrial Water or Sewer Piping System can be joined by butt fusion, socket fusion, sidewall fusion, mechanical fittings or electrofusion. All methods are reliable means of joining the JM Eagle™ Municipal & Industrial Water or Sewer Piping System. Generally, the choice of which system to use is at the discretion of the individual user. All fitting manufacturers' recommended installation instructions should be carefully followed.

Installer training for the proper use and installation of polyethylene pipe is a critical factor in its long-term performance. The JM Eagle™ Municipal & Industrial Water or Sewer Pipe System has ample safety factors included in its design for providing reliable long-term performance in service, if the system is properly installed and operated at design pressures. The importance of proper training in the installation and operation of polyethylene plastic piping systems cannot be overemphasized. Installation and operating recommendations are included in this bulletin to help the operator develop effective training programs.

Publications by the American Society for Testing and Materials (ASTM), American Water Works Association (AWWA) and the Plastics Pipe Institute (PPI) can also be helpful. Use of this information will minimize the potential for failure resulting from improper design and installation practices.

2.0 PRODUCT AND TECHNICAL INFORMATION

The JM Eagle™ Municipal & Industrial Water or Sewer Piping System is manufactured to meet the requirements of ASTM D3035, ASTM F714, AWWA C901 or AWWA C906. Potable water pipe is listed to ANSI/NSF 14/61. Consult your JM Eagle™ sales representative for advice regarding any questions concerning use of the JM Eagle™ Municipal & Industrial Water or Sewer Piping System.

Potable water pipe is available with highly visible blue stripes OR a blue print line.

2.1 EFFECT OF ENVIRONMENTAL EXPOSURE ON PHYSICAL PROPERTIES

2.1.1 CHEMICAL RESISTANCE

JM Eagle™ Municipal & Industrial Water or Sewer Polyethylene Pipe, for all practical purposes, is chemically inert. There are a few chemicals that will affect it, but it will not rot, rust or corrode by electrolytic action or require cathodic protection. Potable water pipe should be disinfected in accordance with ANSI/AWWA C651. Chemical solutions used for disinfecting new or repaired potable systems should not exceed 12 percent active chlorine. Higher concentrations can degrade polyethylene.

Chemical resistance data for polyethylene pipe can be found in the Plastic Pipe Institute's (PPI) Technical Report TR-19, found at www.plasticpipe.org.

2.1.2 WEATHER RESISTANCE

JM Eagle™ Municipal & Industrial Water or Sewer Pipe is protected against degradation caused by ultraviolet rays from direct sunlight. The polyethylene resin contains 2 percent to 3 percent of finely divided carbon black. This provides the black color for JM Eagle™ Municipal & Industrial Water or Sewer Pipe. Carbon black is the most effective additive for enhancing the weathering characteristics of polyethylene pipe. JM Eagle™ Municipal & Industrial Water or Sewer Pipe can be safely stored outside in most climates for periods of many years without danger of loss of physical properties due to ultraviolet (UV) exposure. In general, JM Eagle™ Co. recommends the use of a first-in first-out inventory management procedure.

2.1.3 INSTALLATION TEMPERATURES

JM Eagle™ Municipal & Industrial Water or Sewer Pipe can be installed at any ambient temperature condition in which normal installation operations would continue. In cold weather, however, special procedural recommendations, as outlined in this bulletin, should be followed.

2.1.4 THERMAL EXPANSION AND CONTRACTION

The coefficient of thermal expansion for JM Eagle™ Municipal & Industrial Water or Sewer Pipe is 9×10^{-5} inch/inch/degrees F. This translates to an easy rule of thumb: the pipe changes in length 1 inch per 10 degrees F change in temperature per 100 feet of pipe length. The effect of expansion and contraction must be considered when using compression and mechanical type fittings. The fitting must possess sufficient pullout resistance to counteract the thermal stress forces generated by the pipe.

2.1.5 EFFECT OF EXTERNAL LOADING STRESSES

Consideration must be given to the installation of all plastic piping systems, including the JM Eagle™ Municipal & Industrial Water or Sewer Piping System, to avoid failures caused by excessive external stress. Field experience has shown that excessive externally induced stresses can act independently or together with internal pressure to exceed material strength and cause failure. Excessive installed bending in plastic piping systems, particularly at joints, can exceed stress limits and result in failure. Pipe where joined to fittings should be laid true to line and grade and backfilled carefully to prevent differential settlement, and thus excessive bending. See “Permanent Minimum Bending Radius Limits.”

Excessive stresses and failure of plastic pipe can also result from impact, indentations or deflection. Avoid excessive compaction forces and particularly avoid installation of the pipe against a source of point loading. The bed for the pipe and fill materials around the pipe must be free of rocks, blocking materials or other sources of point loading or deflection. Heavy machine compaction as by roller or hydrohammer should be used only for consolidation of final backfill with a minimum of 18 inches of previously layered and compacted backfill.

ASTM D2774, “Standard Recommended Practice for Underground Installation of Thermoplastic Pressure Piping,” provides additional information for direct burial of JM Eagle™ Municipal & Industrial Water or Sewer Pipe.

2.1.6 PLASTIC PIPE DAMAGE & REPAIR

Industry surveys indicate the primary causes for repair of plastic piping are from third-party damage and poor workmanship in the initial installation. Repair can be minimized by using careful mapping and location methods and by proper training and inspection procedures. Repairing PE pipe is similar to repairing ductile iron and PVC water pipe. Mechanical couplings or fusion methods can be used for damage, such as puncture, rupture, or saddle repair. The first step in making a repair is determining the problem.

For smaller sizes, an electrofusion system is useful in making repairs to polyethylene pipe.

3.0 INSTALLATION GUIDELINES

3.1 HANDLING

JM Eagle™ Municipal & Industrial Water or Sewer Pipe is a tough flexible product that is able to withstand normal installation handling. However, unusually rough handling of JM Eagle™ Municipal & Industrial Water or Sewer Pipe can result in damage to the pipe wall. Care should be taken to avoid pushing or pulling JM Eagle™ Municipal & Industrial Water or Sewer Pipe over or around sharp projections. JM Eagle™ Municipal & Industrial Water or Sewer Pipe is subject to impact damage when dropped from excessive heights or when heavy objects are dropped upon it, particularly during cold weather. Kinking or buckling should be avoided and any section of pipe that has been damaged in this manner should be cut out. Based on pipe pressure tests, a good rule of thumb in determining if a scratched piece of pipe should be cut out of the piping system is: if the scratch depth is greater than 10 percent of the pipe wall thickness, then the section should be removed or repaired.

3.2 UNLOADING

The means by which PE Pipe is unloaded in the field is the decision and responsibility of the customer. Preferred unloading is in units using mobile mechanical equipment such as forklifts or front-end loaders with adequate forks. Ensure that the equipment can handle the weight of the pipes (use JM Eagle™ catalog for book weights) and able to lift the pipe bundles clear off the truck. Obtain and follow the handling instructions provided by the delivery personnel. Be extra cautious in handling pipe during inclement weather.

WARNING: Unsafe unloading and handling can result in damage to property or equipment, injury and death. Unloading and handling must be performed safely. Keep unnecessary people away from the area during unloading. Only properly trained personnel should operate unloading equipment.

Refer to the Plastic Pipe Institute's Material Handling Guide for additional guidance, available at www.plasticpipe.org/publications/material_handling_guide.html

3.2.1 UNLOADING SITE REQUIREMENTS

The unloading site must be relatively flat and level. It must be large enough for the carrier's truck, the load handling equipment and its movement, and for temporary load storage. Silo packs and other palletized packages should be unloaded from the side with a forklift. Non-palletized pipe, fittings, fabrications, manholes, tanks or other components should be unloaded with lifting equipment and wide web slings, or with a forklift.

3.2.2 HANDLING EQUIPMENT

Appropriate unloading and handling equipment of adequate capacity must be used to unload the truck. Safe handling and operating procedures must be observed.

Pipe must not be rolled or pushed off the truck. Pipe, fittings, fabrications, tanks, manholes and other components must not be pushed or dumped off the truck, or dropped.

Although polyethylene piping components are lightweight compared to similar components made of metal, concrete, clay or other materials, larger components can be heavy. Lifting and handling equipment must have adequate rated capacity to lift and move components from the truck to temporary storage. Equipment such as a forklift, a crane, a side boom tractor or an extension boom crane is used for unloading. Do not use chains or wire ropes, but use fabric slings.

When using a forklift, or forklift attachments on equipment such as articulated loaders or bucket loaders, lifting capacity must be adequate at the load center on the forks. Forklift equipment is rated for a maximum lifting capacity at a distance from the back of the forks. If the weight-center of the load is farther out on the forks, lifting capacity is reduced.

Before lifting or transporting the load, forks should be spread as wide apart as practical, forks should extend completely under the load, and the load should be as far back on the forks as possible.

WARNING: During transport, a load on forks that are too short or too close together, or a load too far out on the forks, may become unstable and pitch forward or to the side, and result in damage to the load or property, or hazards to people.

Lifting equipment such as cranes, extension boom cranes and side boom tractors should be hooked to wide web choker slings that are secured around the load or to lifting lugs on the component. Only wide web slings should be used. Do not use wire rope slings and chains for they can damage components. Spreader bars should be used when lifting pipe or components longer than 20 feet.

WARNING: Before use, inspect slings and lifting equipment. Equipment with wear or damage that impairs function or load capacity should not be used.

WARNING: When breaking down bulk packs, take care to stand clear of the pipe while strapping is being cut. Coiled HDPE pipe may contain energy as in a spring. Uncontrolled release, i.e., cutting of straps, can result in dangerous uncontrolled forces. All safety precautions and proper equipment is required.

3.3 STRINGING

Reel trailers can be helpful when stringing out coiled pipe for direct burial, plow-in, pull-in or insertion renewal. It is helpful when handling coiled pipe to string the pipe out on the ground upon arrival at the job site. This allows time for the coil set to relax, and will simplify handling and emplacement of the pipe.

When uncoiling pipe by hand, only cut those straps on the coils, which are necessary to uncoil outer rolls; cut internal bands whenever necessary as the coil is unrolled.

Always inspect the pipe as it is being uncoiled and during installation to make sure no damage to the pipe has occurred during shipment and subsequent handling at the job site.

3.4 DRAGGING

Occasionally, when long strings of pipe are joined together, it is necessary to drag the pipe to where it will be installed. When the pipe must be dragged over rocky terrain or hard pavement, take precautions to protect the pipe from abrasion. Sandbags, used tires or short logs may be used to support the pipe and prevent hard contact with sharp rocks or hard pavement.

3.5 CUTTING

For smaller sizes, JM Eagle™ Municipal & Industrial Water or Sewer Pipe should be cut with pipe cutters designed for plastic pipe. These tools easily provide the square cut ends that are necessary to provide satisfactory fusion joints. If carpenter or hacksaws are used to cut the pipe, special care must be taken to ensure square cut ends and to clean the resultant sawdust from inside the pipe.

WARNING: Before cutting coiled pipe, restrain both sides of cut. Pipe is under tension. Unrestrained pipe can spring back forcibly while being cut and could cause personal injury.

3.6 COLD-WEATHER HANDLING

Polyethylene is a tough piping material; yet colder temperatures below 40 degrees F can reduce resistance to damage from mechanical abuse, such as impact. Avoid dropping the pipe, especially in cold weather. The recommended method of unloading is to use a forklift or crane, in all cases the pipe should be inspected for damage.

When handling coiled pipe at temperatures below 40 degrres F, it is helpful to uncoil the pipe that is to be installed and let it straighten out prior to making the installation. This can be done by gradually uncoiling the pipe and covering it with dirt at intervals to keep it from coiling up again. Always be careful when cutting the straps on coils of pipe because the outside end of a coil may spring out when the strapping is removed.

In cold-weather conditions, more effort will be required to uncoil the pipe and piping will spring back more forcibly if the ends are not anchored or restrained. Carefully follow equipment manufacturer's recommendations and guidelines for cold-weather conditions.

3.7 OTHER HANDLING PRECAUTIONS

During the transport of pipe, it should be continuously supported in a manner so as to minimize movement between the pipe and its support. Any practice of carrying supplies or equipment on top of plastic pipe should be avoided because of damage from sharp edges and other projections.

Care should be taken to protect the pipe from excessive heat. Be particularly careful of open flames. Do not lay an open flame or torch across pipe surfaces.

3.8 TRENCHING

For direct burial of JM Eagle™ Municipal & Industrial Water or Sewer Pipe, trench bottoms should be relatively smooth, continuous and free of rocks and other debris. When ledge rock, hardpan or boulders are encountered, the bottom of the trench should be padded with sand or other fine-grained fill materials. The trench should be wide enough to allow (a) fusion in the ditch if required, (b) snaking of the pipe along the bottom of the trench if needed, and (c) filling and compaction of sidewalls. Minimum trench widths can be utilized in most instances by joining the pipe before lowering it into the trench. Refer to ASTM D2321, "Standard Practice for Underground Installation of Thermoplastic Pipe for Sewers and Other Gravity Flow Applications" and ASTM D2774 "Standard Practice for Underground Installation of Thermoplastic Pressure Piping" for additional information.

Generally, sufficient cover must be maintained to provide reasonable protection against anticipated external stress loads. Where frost penetration and surface loads need not be considered, a minimum depth to provide 18 inches of cover above the pipe is recommended. When surface loads are expected, a minimum of 3 feet of cover is recommended. Where frost is a factor, pipe should be buried 6 inches below greatest recorded frost penetration.

3.9 PIPE PLACEMENT IN TRENCHES

JM Eagle™ Municipal & Industrial Water or Sewer Pipe can be joined either above ground or in the ditch as the situation dictates. Though most joining can be accomplished above ground, joining that must be done in the ditch should be well planned to ensure that enough space is available and that proper alignment is achieved. Care should be taken to avoid buckling, gouging, and other mechanical damage when lowering JM Eagle™ Municipal & Industrial Water or Sewer Pipe into the ditch.

Align all pipe true to line and grade. As mentioned earlier, extremely cold weather makes JM Eagle™ Municipal & Industrial Water or Sewer Pipe stiffer and increases the likelihood of impact damage. When an unstable trench bottom is encountered and, in the opinion of the engineer, it cannot support the pipe, an additional depth should be excavated and refilled to pipe grade with material approved by the engineer.

Because plastic pipe contracts as it cools, it is desirable in warm weather to snake the pipe in the bottom of the trench. This provides for “slack” in the pipeline to be taken up as the pipe cools and contracts in the ditch prior to backfilling.

3.10 BACKFILLING & COMPACTION

Backfilling and compaction of installed JM Eagle™ Municipal & Industrial Water or Sewer Pipe must be accomplished so as to avoid induced bending stresses both as a result of the backfilling itself and from differential settling of fill materials subsequent to the backfilling operation. Additionally, care should be taken to avoid mechanical damage to the pipe from the fill material itself. Attention to careful emplacement, filling and compaction procedures will prevent such induced stresses and mechanical damage.

JM Eagle™ Municipal & Industrial Water or Sewer Pipe installations should be continuously supported beneath their entire lengths by clean and firm backfill materials (no rocks). Intermittent blocking should not be used to support pipe-excavated sections.

Relatively compactable and clean fill materials should be used to bed newly installed pipe with particular attention to filling voids beneath transition connections. Side-fill compaction should be utilized to develop lateral passive soil forces when backfilling larger diameter thin wall pipes. The first layer of fill material around and about 12 inches over the pipe should be free from rocks or frozen chunks, which could damage the pipe. This layer should be well compacted by hand. Successive layers should be spread uniformly to fill the trench completely. Large rocks, frozen earth and decomposable debris such as wood should not be included in the backfill. The maximum fill material particle size versus the pipe size is given in the following table.

MAXIMUM PARTICLE SIZE VS. PIPE SIZE	
NOMINAL PIPE SIZE (inches)	**MAXIMUM PARTICLE SIZE**
2 to 4	½
6 to 8	¾
10 to 15	1
16 and larger	1½

Table 1

Heavy rollers and large mechanical tampers such as hydrohammers should only be used to consolidate the final backfill and even then there should be a minimum of 24 inches of layered and previously compacted cover.

Minimum Cold (field) Bending Radius (long-term)
Reference: PE Pipe – Design and Installation M55 AWWA

PIPE DR	MINIMUM COLD BENDING RADIUS
≤ 9	20 times pipe OD
≥ 9-13.5	25 times pipe OD
≥ 13.5-21	27 times pipe OD
≥ 21	30 times pipe OD
Fittings or flange present or to be installed in bend *	100 times pipe OD

Table 2

** Observe the minimum cold bending radius for a distance of about 5 times the pipe diameter on either side of the fitting location.*

Tighter bends down to 10 times the pipe diameter can be made if they are temporary, such as in the plowing or the insertion method of installation.

4.0 TESTING

4.1 LEAK TESTING

The intent of leak testing is to find unacceptable faults in a piping system. If such faults exist, they may manifest themselves by leakage or rupture.

Leakage tests may be performed if required in the contract specifications. Testing may be conducted in various ways. Internal pressure testing involves filling the test section with a nonflammable liquid or gas, then pressurizing the medium. **Hydrostatic pressure testing with water is the preferred and recommended method.** Other test procedures may involve paired internal or end plugs to pressure test individual joints or sections, or an initial service test.

Joints may be exposed to allow inspection for leakage. Liquids such as water are preferred as the test medium because less energy is released if the test section fails catastrophically. During a pressure test, energy (internal pressure) is applied to stress the test section. If the test medium is a compressible gas, then the gas is compressed and absorbs energy while applying stress to the pipeline. If a catastrophic failure occurs, both the pipeline stress energy and the gas compression energy are suddenly released. However, with an incompressible liquid such as water as the test medium, the energy release is only the energy required to stress the pipeline.

WARNING: Pressure Pipe system testing is performed to discover unacceptable faults in a piping system. Pressure testing may cause such faults to fail by leaking or rupturing. This may result in catastrophic failure. Piping system rupture may result in sudden, forcible, uncontrolled movement of system piping or components, or parts of components.

WARNING: Pipe Restraint. The pipe system under test and any closures in the test section should be restrained against sudden uncontrolled movement from catastrophic failure. Test equipment should be examined before pressure is applied to insure that it is tightly connected. All low-pressure filling lines and other items not subject to the test pressure should be disconnected or isolated.

WARNING: Personal Protection. Take suitable precautions to eliminate hazards to personnel near lines being tested. Keep all personnel a safe distance away from the test section during testing.

REFERENCE: ASTM F2164, "Standard Practice for Field Leak Testing of Polyethylene (PE) Pressure Piping System Using Hydrostatic Pressure."

4.2 PRESSURE TESTING PRECAUTIONS

The piping section under test and any closures in the test section should be restrained or otherwise restricted against sudden uncontrolled movement in the event of rupture. Expansion joints and expansion compensators should be temporarily restrained, isolated or removed during the pressure test.

Testing may be conducted on the system, or in sections. The limiting test section size is determined by test equipment capability. If the pressurizing equipment is too small, it may not be possible to complete the test within allowable testing time limits. If so, higher capacity test equipment, or a smaller test section may be necessary.

If possible, test medium and test section temperatures should be less than 100 degrees F (38 degrees C). At temperatures above 100 degrees F (38 degrees C), reduced test pressure is required. Before applying test pressure, time may be required for the test medium and the test section to temperature equalize.

4.3 REFERENCES

The following reference publications provide pressure testing information:

ASME B31.1 Power Piping, Section 137, Pressure Tests.

Plastics Pipe Institute, ***Handbook of Polyethylene Pipes,*** *Dallas, Texas.*

ASTM F1417, Standard Test Method for Installation Acceptance of Plastic Gravity Sewer Lines Using Low-Pressure Air.

Uni-Bell® PVC Pipe Association Publication, Uni-B-6-98, "Recommended Practice for Low-Pressure Air Testing of Installed Sewer Pipe."

ASTM F2164, "Standard Practice for Field Leak Testing of Polyethylene (PE) Pressure Piping System Using Hydrostatic Pressure."

Other pressure testing procedures may or may not be applicable depending upon piping products and/or piping applications.

4.4 TEST PRESSURE

Test pressure may be limited by valves, or other devices, or lower pressure rated components. Such components may not be able to withstand the required test pressure, and should be either removed from, or isolated from the section being tested to avoid possible damage to, or failure of these devices. Isolated equipment should be vented.

- For continuous pressure systems where test pressure limiting components or devices have been isolated or removed, or are not present in the test section, the maximum allowable test pressure is 1.5 times the system design pressure at the lowest elevation in the section under test.

- If the test pressure limiting device or component cannot be removed or isolated, then the limiting section or system test pressure is the maximum allowable test pressure for that device or component.

4.5 TEST DURATION

For any test pressure from 1.0 to 1.5 times the system design pressure, the total test time including initial pressurization, initial expansion, and time at test pressure, must not exceed 8 hours. If the pressure test is not completed due to leakage, equipment failure, etc., the test section should be de-pressurized, and allowed to “relax” for at least 8 hours before bringing the test section up to test pressure again.

4.6 PRE-TEST INSPECTION

Test equipment and the pipeline should be examined before pressure is applied to ensure that connections are tight, necessary restraints are in place and secure, and components that should be isolated or disconnected are isolated or disconnected. All low-pressure filling lines and other items not subject to the test pressure should be disconnected or isolated.

4.7 RELIEVING AIR FROM PIPELINE

AIR SHOULD BE VENTED FROM ALL HIGH SPOTS IN THE PIPELINE BEFORE MAKING EITHER PRESSURE OR LEAKAGE TESTS. AUTOMATIC AIR RELEASE VALVES ARE RECOMMENDED. Compressed entrapped air causes difficulty in pumping to required pressure for strength tests. Furthermore, a pipeline may leak compressed air when it is actually water tight, and if this occurs during a leakage test it will cause erroneous results.

4.8 HYDROSTATIC TESTING

HYDROSTATIC PRESSURE TESTING IS PREFERRED AND IS STRONGLY RECOMMENDED. The preferred testing medium is clean water. The test section should be completely filled with the test medium, taking care to bleed off any trapped air. Venting at high points may be required to purge air pockets while the test section is filling. Venting may be provided by loosening flanges, or by using equipment vents. Re-tighten any loosened flanges before applying test pressure.

4.9 PNEUMATIC TESTING

WARNING: Pressure compressed air or any pressurized gas used as a test medium may present severe hazards to personnel in the vicinity of lines being tested. Extra personnel protection precautions should be observed when a gas under pressure is used as the test medium.

WARNING: Explosive Failure. Piping system rupture during pneumatic pressure testing may result in the explosive, uncontrolled movement of system piping, components, or parts of components. Keep personnel a safe distance away from the test section during testing.

Pneumatic testing should not be used unless the owner and the responsible project engineer specify pneumatic testing or approve its use as an alternative to hydrostatic testing. Pneumatic testing (testing with a gas under pressure) should not be considered unless one of the following conditions exists:

- The piping system is so designed that it cannot be filled with a liquid.
- The piping system service cannot tolerate traces of liquid testing medium.

The testing medium should be non-flammable and non-toxic. The test pressure should not exceed the maximum allowable test pressure for any non-isolated component in the test section.

Leaks may be detected using mild soap solutions (strong detergent solutions should be avoided), or other non-deleterious leak detecting fluids applied to the joint. Bubbles indicate leakage. After leak testing, all soap solutions or leak detecting fluids should be rinsed off the system with clean water.

4.10 HIGH-PRESSURE PROCEDURE

For continuous pressure rated pipe systems, the pressure in the test section should be gradually increased to not more than one-half of the test pressure, then increased in small increments until the required test pressure is reached. Test pressure should be maintained for 10 to 60 minutes, then reduced to the design pressure rating, and maintained for such time as required to examine the system for leaks.

4.11 LOW-PRESSURE PROCEDURE

For components rated for low pressure service the specified rated test pressure should be maintained for 10 minutes to one hour, but not more than one hour. **Test pressure ratings must not be exceeded.** Leakage inspections may be performed during this time. If the test pressure remains steady (within 5 percent of the target value) for the one-hour test time, no leakage is indicated. Pressure testing of gravity-flow sewer lines should be conducted in accordance with ASTM F1417, Standard Test Method for Installation Acceptance of Plastic Gravity Sewer Lines Using Low-Pressure Air.

4.12 INITIAL SERVICE TESTING

An initial service test may be acceptable when other types of tests are not practical, where leak tightness can be demonstrated by normal service, or when initial service tests of other equipment are performed. An initial service test may apply to systems where isolation or temporary closures are impractical, or where checking out pumps and other equipment affords the opportunity to examine the system for leakage prior to full-scale operations.

4.13 TEST PROCEDURE

The piping system should be gradually brought up to normal operating pressure, and held at operating pressure for at least 10 minutes. During this time, joints and connections should be examined for visual evidence of leakage.

4.14 NON-TESTABLE SYSTEMS

Some systems may not be suitable for pressure testing. These systems may contain non-isolatable components, or temporary closures may not be practical. Such systems should be carefully inspected during and after installation. Inspections such as visual examination of joint appearance, mechanical checks of bolt or joint tightness, and other relevant examinations should be performed.

5.0 REPAIRS TO DAMAGED PIPE

Repair situations may arise if a polyethylene pipe has been damaged. Damage may occur during shipping and handling, during installation, or after installation. Damage may include scrapes or abrasions, breaks, punctures, kinks, or emergency squeeze-off. Permanent repair usually involves removing and replacing the damaged pipe or fitting. In some cases, temporary repairs may restore sufficient serviceability and allow time to schedule permanent repairs in the near future. IN ANY EVENT, ALL DAMAGED MATERIAL MAY BE REPLACED OR REPAIRED BY METHODS AUTHORIZED BY THE

ENGINEER.

5.1 DAMAGE ASSESSMENT

Damaged pipe or fittings should be inspected and evaluated. Pipe, fittings, fabrications or structures with excessive damage should not be installed. Damage that occurs after installation may require that the damaged pipe or component be removed and replaced.

WARNING: Scrapes or gouges in pressure pipe cannot be repaired by filling in with extrusion or hot air welding. The damaged section should be removed and replaced.

WARNING: Improperly made fusion joints cannot be repaired.

Improper butt fusions must be cut out and re-done from the beginning. Poorly joined socket or electrofusion fittings must be removed and replaced. Poorly joined saddle fittings must be removed by cutting out the main pipe section, or, if the main is undamaged, made unusable by cutting the branch outlet or chimney off the saddle fitting, and installing a new saddle fitting on a new section of main.

WARNING: Broken or damaged fittings cannot be repaired and, as such, should be removed and replaced.

WARNING: Kinked pipe must not be installed and cannot be repaired. It must be removed and replaced.

WARNING: Pipe damaged during an emergency squeeze-off cannot be repaired. Squeeze-off damaged pipe must be removed and replaced.

Safety and Field Precautions:

1. **WARNING:** Treat electrical tools as potential sources of ignition and follow standard safety procedures for working in explosive atmospheres.

2. **WARNING:** Only properly trained and qualified personnel should make fusions.

3. **WARNING:** Wear suitable gloves and eye protection.
4. **WARNING:** Temperature of fusion tools should be checked to be sure that they conform to the recommended operating temperature range.

5. **WARNING:** When breaking down bulk packs, take care to stand clear of pipe while strapping is being cut. Coiled HDPE pipe may contain energy as in a spring. Both the straps and the pipe may spring outward when the strap is cut and could cause severe injury. All safety precautions and proper equipment is required.

6. **WARNING:** Before cutting coiled pipe, restrain both sides of cut. Pipe is under tension. Unrestrained pipe can spring back forcibly while being cut and could cause personal injury.

7. **WARNING:** Understand and follow all equipment manufacturer's recommendations and guidelines.

8. **WARNING:** Properly made heat fusion joints do not leak. An improperly made joint that leaks when pressurized may precede a catastrophic event that may result in violent or dangerous pipe movement, a sudden release of the system's pressurized contents, and the potential for personal injury. All faulty joints must be cut out and replaced using approved fusion procedures, after the system has been safely depressurized. Stay clear of leaking, faulty joints until the system has been fully depressurized.

5.2 HEATING TOOL MAINTENANCE

Clean heater adaptors carefully before and after each fusion. Remove any residual polyethylene using a clean non-synthetic cloth. Never use metal objects to clean heater adaptors because they can damage the surface.

The heating tool temperature recommendations shown in this bulletin represent the temperature on the surface of the heater adaptors that actually contact the pipe or fitting. This temperature should be monitored daily to ensure compliance with recommendations.

The operator can usually expect the tool thermometer to indicate a higher temperature than specified in order to achieve the correct surface temperature. In addition, the operator will normally encounter variations in heater adaptor temperature due to different adaptor configurations. In these cases, the adaptor having the lower temperature should be set at the recommended temperature.

6.0 FUSION PROCEDURES

6.1 SOCKET FUSION

WARNING: Understand and follow all equipment manufacturers' recommendations and guidelines.

Equipment:

1. Pipe or tubing cutter
2. Cold ring
3. Depth gauge
4. Chamfering tool
5. Heating tool
6. Female and male heater adaptors
7. Fitting puller
8. Clean non-synthetic cloth

Procedures:

1. Cut the pipe squarely with a pipe or tubing cutter.
2. Chamfer pipe using a chamfering tool.
3. Clean the end of the pipe with a clean, non-synthetic cloth.
4. Install the depth gauge and cold ring. Remove depth gauge once cold ring is secured. Ensure pipe is sufficiently round once cold ring is installed.
5. Place a fitting puller on couplings, caps and reducers on 2-inch IPS through 4-inch IPS.
6. Check the heater adaptor faces for proper joining temperature 500 degrees F (± 10 degrees F).
7. Place the fitting on the tool and then the tool on the pipe. Push the tool, pipe and fitting together with even pressure.
8. When the fitting is against the tool and the tool against the cold ring, begin the heating cycle shown in Table 3.
9. When you have heated for the proper cycle time, remove the fitting from the tool with a quick snap action. Then remove the tool from the pipe in the same way.
10. Quickly inspect the melt pattern on the pipe and fitting. If an incomplete pattern is obtained, repeat steps 1-9 using a longer heating cycle and new fitting.
11. Within 3 seconds, carefully line up and push the fitting onto the pipe until it bottoms against the cold ring on the pipe. Do not twist or rotate the fitting.
12. Hold the joint firmly together without movement for the recommended holding time shown in table below. After an additional 3 minutes, release the cold ring and fitting puller.
13. Inspect the entire circumference of the fused joint to be sure there are no open gaps in the pipe to fitting juncture, and that the melt is pressed against the coupling all the way around. If a gap is found or the joint is not aligned properly, cut it out and repeat the procedure. See Figure A for a properly made socket fusion joint. Only accept joints that meet these requirements. Never allow a questionable joint to be installed.
14. Wait an additional 10 minutes prior to pressure testing or burial.

SOCKET FUSION TIME CYCLES		
PIPE SIZE	**HEATING TIME** (sec)	**HOLDING TIME** (sec)
¾" IPS	12	30
1" IPS	15	40
1¼" IPS	18	40
1½" IPS	20	40
2" IPS	24	40
3" IPS	28	50
4" IPS	32	50

Table 3

Figure A

Correctly Made Socket Fusion Joint

Cold Weather Considerations (Below 55°F):

- Carefully remove (by light tapping or scraping) the ice and frost from the fusion areas and the areas to be clamped. Otherwise, ice will melt when exposed to the heating tool and spot chill the polyethylene. This could cause incomplete fusion.
- If possible, store fittings at room temperature (such as in truck cab) prior to use. This will reduce fitting contraction and make placing fitting on heater adaptor easier.

- Cold weather also causes pipe contraction that can result in a loose or slipping cold ring. For best results, clamp one cold ring in its normal position behind the depth gauge. Place shim material (i.e., a piece of paper or rag) around the inside diameter of a second cold ring and clamp this cold ring directly behind the first cold ring to prevent slippage.
- Shield the heating tool and fusion area from the wind, snow and freezing rain.
- Ensure heater adaptor faces maintain a temperature of 500 degrees F (±10 degrees F).
- The length of cycle necessary to obtain a complete melt pattern will depend not only on the outdoor temperature, but also on wind conditions, pipe contraction and operator technique. The maximum heating cycle times shown in Table 4 should be used as a starting point for determining the exact heating cycle time for the particular installation conditions.

Determining the exact heating cycle time can be accomplished by making a test melt pattern on a piece of cold scrap pipe. If the initial melt pattern is incomplete, try a 5-second longer cycle on another cold piece of scrap pipe. Continue this process until a complete melt pattern is obtained. Avoid cycles in excess of that required to achieve a good melt pattern.

Once the optimum heating cycle is established, begin fusion by placing the female adaptor on the pipe. Start counting the heating cycle once the pipe is completely seated. The socket fitting should then be pushed on the male adaptor. There should be no problem with melt development in the fitting since the fit will be snug.

Work quickly once pipe and fitting have been removed from the heating tool so that melt heat loss is minimized. But still take time (2-3 seconds) to inspect both melt patterns.

WARNING: Understand and follow all equipment manufacturer's recommendations and guidelines.

6.2 BUTT FUSION: REFERENCE PPI'S TR-33 GENERIC BUTT FUSION PROCEDURE FOR FIELD JOINING OF PE PIPE

The most widely used method for joining individual lengths of large diameter polyethylene pipe is by heat fusion of the pipe butt ends, as illustrated in Figure B. This technique, which precludes the need for specially modified pipe ends or couplings, produces a permanent, economical and flow-efficient connection. Field-site butt fusions may be made readily by trained operators using specially developed butt fusion machines that secure and precisely align the pipe ends for the fusion process.

Heater Surface temperature	400-450 degrees F (204-232 degrees C)
Interfacial Pressure	60-90 psi (4.14-6.21 bar)

The six steps involved in making a butt fusion joint are:

1. Securely fasten the components to be joined
2. Face the pipe ends
3. Align the pipe profile
4. Melt the pipe interfaces
5. Join the two profiles together
6. Hold under pressure

Figure B

Correctly Made Butt Fusion Joint

6.2.1 SECURE

Each component that is to be fused must be held in position so that it will not move unless it is moved by the clamping device.

6.2.2 FACE

The pipe ends must be faced to establish clean, parallel mating surfaces. Most, if not all, equipment manufacturers have incorporated the rotating planer block design in their facers to accomplish this goal. Facing is continued until a minimal distance exists between the fixed and movable jaws of the machine and the facer is locked firmly and squarely between the jaws. This operation provides for a perfectly square face, perpendicular to the pipe centerline on each pipe end and with no detectable gap.

6.2.3 ALIGN

The pipe profiles must be rounded and aligned with each other to minimize mismatch (high-low) of the pipe walls. This can be accomplished by adjusting the clamping jaws until the outside diameters of the pipe ends match. The jaws must not be loosened or the pipe may slip during fusion. The minimal distance requirement between fixed and moveable jaws mentioned above allows the pipe to be rounded as close as possible to the joint area. The closer to the joint area that the pipe can be clamped, the better control the operator has in properly aligning the pipe.

6.2.4 MELT

Heating tools that simultaneously heat both pipe ends are used to accomplish this operation. These heating tools are normally furnished with thermometers to measure internal heater temperature so the operator can monitor the temperature before each joint is made. However, the thermometer can be used only as a general indicator because there is some heat loss from internal to external surfaces, depending on factors such as ambient temperatures and wind conditions. A pyrometer or other surface-temperature-measuring device should be used periodically to insure proper temperature of the heating tool face. Additionally, heating tools are usually equipped with suspension and alignment guides that center them on the pipe ends. The heater faces that come into contact with the pipe should be clean, oil-free and coated with a nonstick coating as recommended by the manufacturer to prevent molten plastic from sticking to the heater surfaces. Remaining molten plastic can interfere with fusion quality and must be removed according to the tool manufacturer's instructions.

Plug in the heater and bring the surface temperatures up to the temperature range (400-450 degrees F) (204-232 degrees C). Install the heater in the butt fusion machine and bring the pipe ends into full contact with the heater. To ensure that full and proper contact is made between the pipe ends and the heater, the initial contact should be under moderate pressure. After holding the pressure very briefly, it should be released without breaking contact. Continue to hold the components in place, without force, while a bead of molten polyethylene develops between the heater and the pipe ends. When the proper bead size (see Table 4) is formed against the heater surfaces, the heater should be removed.

BEAD SIZE FOR PIPE SIZES	
PIPE SIZE	**SUGGESTED BEAD SIZE**
1¼" and smaller	1⁄32" – 1⁄16"
1¼" – 3"	1⁄16"
3" – 8"	1⁄8" – 3⁄16"
8" – 12"	3⁄16" – ¼"
12" – 24"	¼" – 7⁄16"
24" – 36"	7⁄16"
36" – 63"	9⁄16"

Table 4

6.2.5 JOINING

After the pipe ends have been heated for the proper time, the heater tool is removed and the molten pipe ends are brought together with sufficient force to form a double rollback bead against the pipe wall. The fusion force is determined by multiplying the interfacial pressure, 60-90 psi (4.14-6.21 bar),

by the pipe area.
For manually operated fusion machines, a torque wrench may be used to accurately apply the proper force. For manual machines without force reading capability of a torque wrench, the correct fusion joining force is the force required to roll the melt beads over to the pipe surface during joining. For hydraulically operated fusion machines, the fusion force can be divided by the total effective piston area of the carriage cylinders to give a hydraulic gauge reading in psi. The gauge reading is theoretical; the internal and external drag need to be added to this figure to obtain the actual fusion pressure required by the machine.

6.2.6 HOLD

The molten joint must be held immobile under pressure until cooled adequately to develop strength. The designs of the machines vary from a lever-arm-assist to manual or automatic locking devices that assist the operator to accomplish this step. The proper cooling time is until the joint is cool to the touch. Allowing proper times under pressure for cooling prior to removal from the clamps of the machine is important in achieving joint integrity. Do not apply water, wet cloths or similar items to shorten cool time. The pulling, installation or rough handling of the pipe should be avoided for an additional 30 minutes.

6.2.7 VISUAL INSPECTION

Visually inspect and compare the joint against a properly made joint. Visually, the width of butt fusion beads should be approximately two to two and one-half times the bead height above the pipe and the beads should be rounded and uniformly sized all around the pipe circumference. The v-groove between the beads should not be deeper than half the bead height above the pipe surface. When butt fusing to molded fittings, the fitting-side bead may display shape irregularities such as minor indentations, deflections and non-uniform bead rollover from molded part cooling and knit lines. In such cases, visual evaluation is based mainly on the size and shape of the pipe-side bead. Visually unacceptable joints should be cut out and re-fused using the correct procedure.

Visually mitered (angled, off-set) joints should be cut out and re-fused. Coiled pipe is available in sizes through 6-inch IPS. Coiling may leave a curvature in some pipe sizes that must be addressed in the preparation of the butt fusion process. There are several methods to address this situation:

Straighten and re-round coiled pipe before the butt fusion process. ASTM D2513 requires field re-rounding of coiled pipe larger than 3-inch IPS.

If there is still curvature present, if possible, install the pipe ends in the machine in an “S” configuration with print lines approximately 180 degrees apart in order to help gain proper alignment and help produce a straight joint.

If curvature is still present, another option is to install a straight piece of pipe between the two coiled pipes.

Every effort should be made to make the joint perpendicular to the axis of the pipe.

WARNING: Understand and follow all equipment manufacturer’s recommendations and guidelines.

6.2.8 SADDLE FUSION JOINING PROCEDURE OF POLYETHYLENE (PE) PIPE MAINS 1.25-INCH IPS AND LARGER

This procedure is for use only in conjunction with PPI’s Technical Report TR-41, which more fully explains the background, scope and purposes of the PPI generic saddle fusion procedure, resuting in Figure C. This procedure has not been qualified for use with any particular piping product or any combination of piping products and must be qualified for use in accordance with DOT 49 CFR Part 192.283 prior to its use in field joining of PE gas pipe.

Figure C

Standard Saddle/Sidewall Fusion Joint

This procedure can be used for HDPE pipe and fittings that have a grade designation (in accordance with ASTM D3350) of PE 3408/3608/4710. The pipe and fitting nominal melt index range would be .07-.20 g/10 min. This procedure is intended only as a guide because heating times can vary under different ambient conditions. Please refer to table below for saddle fusion parameters.

GENERIC SADDLE FUSION PARAMETERS	
Heater Adapter Surface Temperature	500°±10°F
Initial Interfacial Pressure	60±6 psi
Heat Soak Interfacial Pressure	0 psi
Fusion Interfacial Pressure	30±3 psi
Total Heating Time on Main – 1¼-inch IPS Pressure Main	15 seconds max.
Total Heating Time on Main – 2-inch IPS Pressure Main	25-35 seconds max.
Total Heating Time on non-pressure 1¼" IPS, 2-inch IPS mains, and on pressure or non-pressure 3-inch IPS and larger mains.	Look for a 1⁄16-inch bead around the fitting base.

Table 5

Note: *Look in the lower right hand corner of the fitting label for the forces required for that fitting (Initial Heat Force / Heat Soak Force / Fusion Force) (example 180/0/90)*

6.2.9 DEFINITIONS

Initial Heat (Bead-up)—The heating step used to develop an initial melt bead on the main pipe.

Initial Heat Force (Bead-up force)—The force (pounds) applied to establish an initial melt pattern on the main pipe. The Initial Heat Force is determined by multiplying the fitting base area (square inches) by the initial interfacial pressure (pounds per square inch).

Heat Soak Force—The force (pounds) applied after an initial melt pattern is established on the main pipe. The Heat Soak Force is the minimum force (essentially 0 pounds) that ensures that the fitting, heater and main stay in contact with each other.

Fusion Force—The force (pounds) applied to establish the fusion bond between the fitting and the pipe. The Fusion Force is determined by multiplying the fitting base area (square inches) by the fusion interfacial pressure (pounds per square inch).

Total Heat Time—A time that starts when the heater is placed on the main pipe and initial heat force is applied and ends when the heater is removed.

Cool Time—The time required to cool the joint to approximately 120 degrees F (49 degrees C). The fusion force must be maintained for 5 minutes on 1 ¼-inch IPS or 10 minutes for all other main sizes, after which the saddle fusion equipment can be removed. The joint must be allowed to cool undisturbed for an additional 30 minutes before tapping the main or joining to the branch outlet.

Interfacial Area for rectangular base fittings—The major width times the major length of the saddle base, without taking into account the curvature of the base or sides, minus the area of the hole in the center of the base.

Interfacial Area for round base fittings—The radius of the saddle base squared times π (3.1416), without taking into account the curvature of the base or sides, minus the area of the hole in the center of the base.

Fitting Label—The initial heat force, heat soak force and the fusion force will be listed in the lower right-hand corner of the fitting label for all saddle fusion fittings. This will eliminate the need to calculate the fusion forces in the field. (example: 180/0/90)

6.2.10 PREPARATION

This procedure requires the use of a saddle fusion tool. This tool must be capable of holding and supporting the main, rounding the main for good alignment between the pipe and fitting, holding the fitting, and applying and indicating the proper force during the fusion process.

1. Install the saddle fusion tool on the main according to the manufacturer's instructions. The tool should be centered over a clean, dry location where the fitting will be fused. Secure the tool to the main. A main bolster or support is recommended under the pipe on 6-inch IPS and smaller main pipe sizes.
2. Abrade the main, where the fitting will be joined, with a 50- to 60-grit utility cloth until a thin layer of the pipe surface is removed. The abraded area must be larger than the area covered by the fitting base. After abrading, brush residue away with a clean, dry cloth.
3. Abrade the fusion surface of the fitting with 50- to 60-grit utility cloth; remove all dust and residue. Insert the fitting in the saddle fusion tool loosely. Using the saddle fusion tool, move the fitting base against the main pipe and apply about 100-pound force to seat the fitting. Secure the fitting in the saddle fusion tool.

6.2.11 HEATING

1. The heater must be fitted with the correct heater adapters. The temperature of the heater adapter fusion surfaces must be 490 to 510 degrees F.
2. Place the heating tool on the main centered beneath the fitting base. Immediately move the fitting against the heater faces, apply the initial heat force (see fitting label), and start the heat time. Apply the initial heat force until melt is first observed on the crown of the pipe main (initial heat is the term used to describe the initial heating (bead-up) step to develop a melt bead on the main pipe and usually is 3 to 5 seconds) and then reduce the force to the heat soak force (Bead-up force) (see fitting label). Maintain the heat soak force until the total heat time is complete.
3. At the end of the Total Heat Time, remove the fitting from the heater and the heater from the main with a quick snapping action. Quickly check for an even melt pattern on the pipe main and fitting heated surfaces (no unheated areas).
4. Total Heat Time ends:

a. When the Total Heating Time expires for a pressurized 1¼-inch IPS or 2-inch IPS main, or

b. When a melt bead of about 1/16-inch is visible all around the fitting base for a 1¼-inch IPS or 2-inch IPS non-pressurized main, or a larger pressurized or non-pressurized main.

6.2.12 FUSION AND COOLING

1. Whether or not the melt patterns are satisfactory, press the fitting onto the main pipe very quickly (within 3 seconds) after removing the heater and apply the Fusion Force (see the fitting label). Maintain the Fusion Force on the assembly for 5 minutes on 1¼-inch IPS and for 10 minutes on all larger sizes, after which the saddle fusion equipment may be removed. (Fusion force adjustment may be required during cool time, but never reduce the fusion force during cooling.)
2. Cool the assembly for an additional 30 minutes before rough handling or tapping the main. (If step 7 melt patterns were not satisfactory or if the fusion bead is unacceptable, cut off the saddle fitting above the base to prevent use, relocate to a new section of main, and make a new saddle fusion using a new fitting.)

These procedures are based on tests conducted under controlled ambient temperature conditions. Environmental conditions on a job site could affect heating and cooling times. Regardless of job site conditions or ambient temperature, the prescribed heating tool temperature is required. Do not increase or decrease the heating tool temperature.

6.3 HEAT FUSION QUALIFICATION

Approved joining methods are heat fusion, electrofusion, flanging, transition fittings and approved mechanical fittings. Persons performing heat fusion shall be qualified in accordance with the manufacturer's recommended fusion joining procedures. Electrofusion and mechanical joints shall be made in accordance with the fitting manufacturer's instructions, according to Table 6.

ASTM TEST METHOD		
TEST	**ASTM NO.**	**REQUIREMENT**
Short term rupture strength (hoop stress)	D1599	Ductile Failure
Test for tensile properties of plastics	D638	> 25%
Time to failure under constant internal pressure (1600) psi hoop Stress	D1598	1000 hours
Knock-off resistance of saddle fusions	F905	No joint failure

Table 6

Procedures for Heat Qualification

1. Prepare fusion joint as described previously in the "Fusion Procedures" section of this manual. Allow joint to cool one hour.
2. Compare the outside appearance of joint with photograph illustrating the correct procedure.
3. Section the joint axially into at least three straps (1-inch wide) to expose the bond area. Leave approximately 8-inch of pipe on both sides of the joint.
4. Inspect the fusion to verify:

SOCKET FUSION	BUTT FUSION	SIDEWALL FUSION
• complete melt development • no gaps or voids • external melt pressed against coupling • bond length • alignment	• complete and uniform melt beads • melt bead rolled back to pipe • proper alignment • complete facing • visually mitered (angled, off-set) joints should be cut out and re-fused.	• complete pipe melt pattern • complete melt development around base of fitting • fitting placement in pipe melt pattern • properly prepared pipe surface

5. Using the sectioned joint from step 3, perform the bend test as shown in Figures D, E and F. Hold the ends of the strap in the bent position and inspect the fusion area. If there are any gaps or voids evident, the joint should be rejected. The sectioned joint must be free of gaps or voids. An alternative method is to examine the joint by ultrasonic inspection and find no flaws that would cause failure.
6. If the joint is not representative of the photographs shown in this guide, determine the incorrect procedure step taken and make another joint.

Figure D

Correctly Made Socket Fusion Joint

Figure E

Correctly Made Butt Fusion Joint

Figure F

Correctly Made Saddle Fusion Joint

7.0 SQUEEZE-OFF

WARNING: Understand and follow all equipment manufacturer's recommendations and guidelines.

PE gas pipe manufactured to ASTM D2513 is suitable for squeeze-off; however, squeeze-off practices are not limited to gas applications. Squeeze-off is applicable to PE 3408/3608/4710 pressure pipe. JM Eagle™ Municipal & Industrial Water or Sewer Pipe is suitable to proper squeeze-off procedures.

Effective flow control is a basic requirement in piping systems. This is accomplished with the JM Eagle™ Municipal & Industrial Water or Sewer Pipe in two ways. The primary method of flow control should be those installed system valves that are available. Secondly, squeeze-off using suitable equipment can be used to control flow or isolate a section of pipe. Also, squeeze-off is frequently used to control flow for emergency repairs or during certain pipeline or branch extension operations. Squeeze-off is applicable to sizes up to 16 inches and up to 100-psig internal pressures. Currently, there is no demonstrated experience with larger sizes or higher pressures.

This section describes equipment and explains proper procedures and precautions for effectively and safely squeezing off JM Eagle™ Municipal & Industrial Water or Sewer Pipe for flow control. The pressure rating of the pipe is retained if the recommended procedures and equipment are used.

7.1 TOOLS

Squeeze units suitable for use on JM Eagle™ Municipal & Industrial Water or Sewer Pipe consist of steel bars and a mechanical or hydraulic means of forcing the bars together. These units are designed to squeeze JM Eagle™ Municipal & Industrial Water or Sewer Pipe until the inside surfaces meet. This adequately controls flow although a leak tight seal is not always obtained. A positive locking mechanism should be available.

CAUTION: To assure flow control, yet prevent damage to the pipe, tools have mechanical stops to limit the minimum gap between the squeeze bars. Recommended minimum gaps between the squeeze bars for JM Eagle™ Municipal & Industrial Water or Sewer Pipe are based on the formula:

min.gap = (2)(max wall thickness)(0.7)

In addition to observing the minimum gap distances between bars, the bars themselves should be rounded to prevent pipe damage.

The user also may want to consult the "Standard Guide for Squeeze-Off of Polyolefin Gas Pressure Pipe and Tubing," Designation F1041, issued by the ASTM.

7.2 PRECAUTIONS FOR SQUEEZE-OFF

- Certain precautions should be taken to prevent damage to the squeeze tools or to JM Eagle™ Municipal & Industrial Water or Sewer Pipe during squeeze-off in recognition of the large forces required for flow control, particularly in large main sizes. Damage to the pipe from improper squeeze-off procedures may cause eventual failure.
- Make certain the pipe is centered and squared in the squeeze tool. It is important that the pipe be free to spread as it flattens. Failure to do so may prevent flow control or result in damage to the pipe or the tool.
- Locate the squeeze point at least three pipe diameters away from the nearest fitting or butt-fused joint. Failure to do so may result in damage to the fittings or joints.
- Squeeze-off JM Eagle™ Municipal & Industrial Water or Sewer Pipe only once in the same place. It is possible for scale or other metal particles contained within the flow to become trapped at the squeeze point. A second squeeze in the immediate area of the first could force these particles to penetrate into or through the pipe wall.
- Always use a squeeze tool with gap stops to limit the amount of squeeze and use the proper gap stops for the pipe size being squeezed. Using smaller gap stops or otherwise over-squeezing the pipe may result in dam-

age to the pipe or tool.

- A leak tight flow control will not always be obtained through squeeze-off. If more complete flow control is required, a valve should be used or additional squeeze tools used in series to supplement each other.
- Close the squeeze tools until flow is controlled or until the gap stops make contact. Do not use extension levers or “cheater bars,” or otherwise abuse the tools in trying to effect a squeeze-off. Such abuse may overstress the tool and result in failure of the tool and release of the flow. Any damaged tool should be repaired or replaced before use for squeeze-off of JM Eagle™ Municipal & Industrial Water or Sewer Pipe.
- Squeeze JM Eagle™ Municipal & Industrial Water or Sewer Pipe slowly or use momentary pauses in the operation to allow for pipe relaxation and reduction in resistance to closure. This is particularly helpful in larger diameters or when the pipe becomes stiffer in cold weather.
- A release rate of 0.5 inches/minute or less is recommended by ASTM F1041 based on a GRI/Battelle Study, “Effect of Squeeze-Off Practices and Parameters on PE Gas Pipe Damage.”*

** Twelfth Plastic Fuel Gas Pipe Proceedings, pp. 228-242 (1991).*

NOTES:

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