Section VIII

INSTALLATION OF PLASTIC MAINS & SERVICES

I. GENERAL

Since the beginning of large scale use in the mid-1960's, plastic pipe has become the major construction material for gas distribution use in the United States. As it happened with steel pipe, operating practices with plastic developed as a result of utility experiences and information that was available from the various gas associations and ASME codes. As the installation experience base broadened, and as new information on the behavior of thermoplastic materials has evolved, and with the advent of the Federal Pipeline Safety Standards, practices have become better defined.

Today, plastic pipe manufacturing and installation practices are very well outlined by the following sources of information:

- The OPS Regulations (ASTM D2513 and ASTM D2517 Incorporated)
- The Guide to Federal Regulations
- The AGA Plastic Pipe Manual for Gas Service
- Manufacturer's Recommendations

Each plastic piping manufacturer must manufacture the product in accordance with existing standards such as ASTM D2513 "Standard Specification for Thermoplastic Gas Pressure Pipe, Tubing, and Fittings", and ASTM D2517 "Standard Specification for Reinforced Epoxy Resin Gas Pressure Pipe and Fittings". Additionally, every manufacturer of plastic piping systems also provides its own usage recommendations. Most manufacturers provide printed materials outlining joining practices and general installation recommendations and some provide extensive training materials in addition to on-the-job technical assistance and training.

Because important differences exist among the various plastic materials currently acceptable for use, it is important for each Inspector to be familiar with the characteristics of the particular material chosen by his/her company. For this reason, the Inspector should be totally familiar with the manufacturer's joining and installation recommendations. Some Companies require their Inspectors to be qualified to join plastic as outlined in pipeline safety regulations, section §192.285. Others may choose to have Inspectors qualified only to inspect plastic joints, under section §192.287.

Over 95% of all plastic pipe currently being used for gas distribution in the US is polyethylene. For this reason, this section will deal generally with polyethylene plastic pipe.

All polyethylene pipe used in gas distribution has the strength to provide a high margin of safety when operated at design pressures. The toughness, flexibility, and light weight of plastic pipe provide installation conveniences and economies unsurpassed by metal piping gas distribution systems. However, polyethylene has, as does any piping system, certain design, material, and procedural limitations which can be exceeded to result in system failure. It is the inspector's responsibility to see that those system limitations are not exceeded during installation.

II. HANDLING & STORAGE OF PLASTIC PIPE

Since plastics are relatively soft, poor handling techniques may result in gouges, scratches, cuts, or punctures. Plastic pipe and tubing must be carefully inspected for cuts, gouges, deep scratches, and other imperfections before use. Defective pipe must be rejected or the damaged sections must be removed.

A. ACCEPTABLE PIPE CONDITION: Minor exterior scratches which result from normal handling of the pipe are acceptable. Most standards recommend maximum scratch depth of 10% of the nominal wall thickness of the pipe. Impact damage can occur particularly in cold weather and pipe should be inspected for evidence of such damage.

B. LOADING & UNLOADING: When unloading or loading, take care to not damage the pipe. Fork lift operators should be cautioned against damaging the pipe with the forks or tines of the lift truck. Coils of pipe are strapped or palletized for easy unloading or loading. When unloading or loading straight sticks of pipe, allow for some bending in the middle of the lift. Position fork lift tines as far apart as possible to reduce the amount of bending. This will enable operators to lift the load without raising the forks to excessive heights which risks dropping the load.

When breaking down bulk packs or mini-bundles, take care to keep clear of the pipe while strapping is being cut. It is recommended that pipe to be unloaded from a truck bed not be dropped to the ground. Rolling the pipe down inclined planks will keep damage to a minimum. Never drop the pipe onto hard pavements or rocky terrain from truck beds. This is particularly important when unloading pipe in cold weather conditions. At lower temperatures, the pipe is stiffer and more susceptible to damage from impact.

If silo packs are not to be trans-shipped and you will be using individual coils, it is advisable to cut the large steel bands which tie the silo pack to the pallet as soon as possible after unloading. If there is any deformation of pipe caused by the pallet strapping, this releasing of tension will allow any deformed areas to recover to normal shape.

Any sections of pipe which are severely damaged should be cut out before installation.

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

C. TRANSPORTING PLASTIC PIPE: During transport, the plastic pipe should be continuously supported in such a manner as to minimize movement between the pipe and its support. Do not allow the practice of carrying supplies or equipment on top of plastic pipe because of damage from sharp edges and other projections.

D. STRINGING: Reel trailers can be extremely helpful when stringing coiled pipe out 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 as soon as you arrive at the job site. This allows the coil set to relax, which will simplify handling and emplacement of the pipe. Larger sizes of coiled pipe (4" and up) require use of special straightening and rounding machines. When uncoiling pipe by hand, cut only those straps on the coil which are necessary to uncoil outer rolls. cut internal bands when you get to them as the coil is unrolled.

E. STRAIGHTENING: Whenever making socket or saddle fusion's on freshly uncoiled pipe, always make an effort to straighten the pipe in the area in which the fusion will be made.

F. 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. Sand bags, used tires, or short logs may be used to keep the pipe up and away from sharp rocks or hard pavement.

G. CUTTING: Plastic pipe and tubing should be cut with cutters designed for use with plastic. Many manufacturers provide cutters with special cutter wheels for use with plastic. These tools easily produce the square cut ends which are necessary to provide satisfactory fusion joints. Larger sizes of pipe can be cut easily with guillotine-type cutters. If carpenter or hack saws are used to cut the pipe, special care must be taken to ensure square cut ends and to clean the resultant saw dust from inside the pipe. Use a cold ring to aid in making a square cut when using a saw.

H. STORAGE OF PLASTIC PIPE: Plastic pipe and tubing should be stored so as to minimize the possibility of the material being damaged by crushing, piercing, or extended exposure to direct sunlight.

Plastics are affected by extended exposure to sunlight, though most plastic pipe manufacturers have incorporated UV stabilizers in their products to protect against such damage. The manufacturer should be consulted for his/her particular recommendations.

The maximum height to which plastic can be stacked depends on many factors such as material, size, wall thickness, and ambient temperatures. At no time should the loading cause the pipe section to be forced out of round. It is always prudent to obtain the manufacturer's recommendations for this purpose.

III. BENDING & EARTH LOADING

In addition to proper procedures for handling and joining plastic, close attention must be given to the installation of all plastic piping systems in the manner required to avoid failures from "external stress". Excessive bending in plastic piping systems, particularly at joints, must be avoided. Poor pipe laying and backfilling procedures can result in bending stresses which exceed the material strength and increase the potential for failure. There are some guidelines which can minimize the chance of damaging the pipe by bending.

A. MINIMUM BENDING RADIUS: While **plastic pipe can be bent temporarily for installation convenience**, most manufacturers provide permanent minimum bending radius limits (such as 20 times pipe diameter) which should not be exceeded. Bending should be particularly avoided in the area of joints or fittings (limit to not less than 90 to 125 times the pipe diameter).

B. BURIAL STRESSES:

1. Pipe should be laid true to line and grade and backfilled carefully to prevent differential settlement, and thus excessive bending.

2. Protective sleeves and proper backfilling and compaction techniques for service branches and transition fittings combine to alleviate shearing stresses.

3. Ring deflection damage of plastic pipe caused by earth loading is not generally a problem in the size ranges generally used in gas distribution today. In the case of direct buried large diameter thin wall pipes, however, manufacturers should be consulted for backfilling recommendations.

4. ASTM D2774, "Standard Recommended Practice for Underground Installation of Thermoplastic Pressure Piping", provides good general installation and backfilling recommendations.

IV. DIRECT BURIAL OF PLASTIC PIPE BY OPEN TRENCHING

A. TRENCHING: For direct burial of plastic 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 must be padded with sand or other fine grained fill materials. The trench should be wide enough to allow fusion in the ditch if required, snaking of the pipe along the bottom of the trench if needed, and filling and compaction of sidefills for larger diameter pipes. Minimum trench widths can be utilized in most instances by joining the pipe before lowering it into the trench.

Minimum burial depth is regulated by Federal, state, and local codes. Generally, sufficient cover must be maintained to provide reasonable protection against anticipated external stress loads. Service lines must have a minimum cover of 12 inches in private property and 18 inches in streets and roads, while mains in Class 1 Locations must be installed at a minimum depth of 30 inches in normal soil and 24 inches in consolidated rock.

B. PIPE PLACEMENT IN TRENCHES: Plastic pipe can be joined either above grade or in the ditches as the situation dictates. Though most joining can be accomplished above ground, joining which 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 plastic pipe into the ditch. The pipe should be laid so that there are no bends in a radius less than minimum manufacturers recommendations. Align all pipe and fitting joints true to line and grade.

Plastic pipe must be buried far enough away from steam lines, hot water lines, power lines, and other sources of heat to avoid temperatures in excess of 100^{o} F, or other temperatures as required by Federal Standards.

Because plastic pipe contracts as it cools, (1" per 100' for each 10° F of temperature change) it is desirable in warm weather to snake the pipe in the bottom of the trench. This provides for "slack" in the pipe to be taken up as the pipe cools and contracts as it lies in the ditch prior to backfilling.

C. BACKFILLING & COMPACTION: Backfilling and compaction of emplaced plastic pipe must be accomplished so as to avoid induced bending, shear and tensile 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, back-filling, and compaction procedures will avoid such induced stresses and mechanical damage.

1. Plastic mains and services should be continuously supported beneath their entire lengths by firm backfill material. Blocking should not be used to intermittently support pipe or tubing across excavated sections.

2. Relatively compactible and clean fill material should be used to initially bed newly emplaced mains and services with particular attention to filling voids beneath transitions and service connections. Sidefill compaction should be utilized when trenches are wide enough and to develop lateral passive soil forces when backfilling large diameter thin wall pipes. The first layer of fill material around and about 4 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 or mechanical tamper. Successive layers should be spread evenly and in relatively uniform layers to fill the trench completely without voids around or beneath rocks or lumps of earth. Large rocks, frozen earth, and decomposable debris such as wood should not be included in the backfill.

3. Heavy rollers and large mechanical tampers such as hydra-hammers 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.

D. VALVE INSTALLATION Each valve installed in plastic pipe must be designed so as to protect the plastic material against excessive torsional or shearing loads when the valve or shut-off is operated, and from any other secondary stresses that might be exerted through the valve or its enclosure. (49 CFR 192.193)

The Guide material published for Gas Piping Systems suggests several methods which can be used to prevent excessive stresses in plastic pipe at metallic valve installations. Among these are:

1. Use low torque valves.

2. Anchor the valve to resist turning and rotation.

3. When using metal valves, make the transition from metal to plastic at some distance from the valve. The transition should be well supported in undisturbed or well compacted soil.

4. Use a metallic pipe sleeve rigidly connected to the valve and encasing the plastic particularly for service tubing at curb valves.

5. Curb boxes or other enclosures should not be supported by the plastic pipe, or in any way impose secondary stresses on the plastic.

6. Use curb boxes designed for plastic valves. These feature a support base and a device to prevent valve body rotation.

E. TRACER WIRES: In order to locate plastic pipe an electrical conductor or tracer wire must be installed with direct buried plastic pipe. One danger which has become evident with tracer wires is that lightning can have sufficient energy to disintegrate the conductor and its coating. Damage can result to plastic pipe that is very close to or in direct contact with a conductor that becomes a path to ground for lightning. For this reason, OPS has issued a pipeline safety alert that recommends that tracer wires or metallic tapes, be placed 2" to 6" from buried mains or services.

V. INSERTION RENEWAL WITH PLASTIC PIPE

Particular care must be taken when inserting plastic pipe to avoid damage to the pipe both during installation and from shear forces caused by earth loading after the system is installed. The OPS Federal Safety Standards, Part 192.321 (f) states: "Plastic pipe that is being encased must be inserted into the casing pipe in a manner that will protect the plastic. The leading end of the plastic must be closed before insertion". The suggestions which follow should aid in meeting the requirements of the Federal regulation.

A. EARTH LOADING: To protect encased plastic mains and services against damage from bending and shear due to earth loads:

1. Any portion of exposed plastic piping which spans disturbed earth should be protected by adequate consolidation and compaction of backfill beneath and around the exposed section or by bridging between the casing ends.

2. The inserted pipe must be padded where it emerges form the casing to prevent it from bearing on the end of the casing.

3. When holes in the casing must be cut for installation of services, it is desirable to remove only the top part of the casing to ensure continuous support for the inserted plastic main.

4. The same care in backfilling and compaction around service connections that apply for direct burial applications also apply for insertion service connections.

B. THE INSERTION PROCEDURE: To protect plastic mains and services against damage during the insertion procedures:

1. Open a starter ditch of sufficient length to allow the pipe to be inserted without buckling or excessive bending. Required length is dependent upon casing depth, temperature and inserted pipe diameter.

2. Prepare the casing pipe to the extent necessary to prevent any sharp edges, projections, or abrasive materials form damaging the plastic pipe during or after insertion. This can often be accomplished with pigs or reamers. It is advisable to pull a test piece of the same sized plastic pipe through the casing for examination prior to the actual insertion.

3. The edge of the casing opening should be shielded to prevent shaving or gouging of pipe while being inserted. Nylon cable protectors, split rings of pipe, or old traffic cones cut to proper funnel size can be used for this purpose.

4. The OPS Regulation requires that the leading end of the plastic be closed before insertion. Fabricated nose cones of wood, metal or plastic end caps can be used for this purpose. A straight length on the lead end of coiled pipe will often aid insertion.

5. If plastic pipe is to be pulled through the casing pipe, the tensile loading should not exceed one half the tensile strength of the inserted pipe. "Weak links" fabricated from smaller sizes of plastic can be fabricated to protect the inserted pipe from damage due to excessive pulling stress. A suitable lubricant should be used where clearances are tight.

C. STRESS RELAXATION & THERMAL CONTRACTION: The decision whether to push or pull the inserted main through the casing must consider working space and equipment availability. If the inserted main is to be pulled, time must be allowed prior to final tie-in for the newly inserted pipe to relax and recover from any stretching which may have occurred. When inserted mains are pushed in, they tend to remain in a compressed state which may help to lessen the possibility of future pull-out from compression type fittings which may have been used to couple or tie-in the inserted main.

In any event, allow newly inserted mains or services time to contract while cooling to ground temperature prior to tie-in. Tie-in or coupling of inserted mains or service can be accomplished using standard heat fusion or compression type fittings.

When compression fittings are used to join inserted mains, precautions should be taken to ensure against pull-out due to thermal contraction of the plastic. Only pull-out resistance fittings are permitted. The plastic pipe should be anchored against movement relative to the casing and coupling.

D. SEAL ANNULAR SPACE: Though opinions differ, it is advisable to seal the annular space between the old carrier pipe and the newly inserted main or service. The sealing will help to localize any leaking gas and prevent backfill and ground water from washing into the casing. The foam or caulking materials used can also act as a suitable bearing surface between the inserted plastic and the old metallic pipe.

VI. INSTALLATION OF PLASTIC PIPE BY PLOWING

Another method which has been used successfully and has become quite common for installing plastic mains and services is the plow-in technique, especially for 3 inch and smaller pipe. This method is effective in locations which are generally free of surface obstructions and where the soil is relatively rock free. Two plowing methods are used: pull-in and plant-in.

A. PULL-IN: In the pull-in method, the pipe is pulled into and through the ground in an oversized borehole created by a mole on a plow blade. The plow blade is pulled by a winch or tractor and usually employs vibration to reduce the pulling force needed. The lengths which can be installed in a single pull by this method are limited by soil-to-pipe friction. It is good practice to install a "weak link" of less than half the pipe strength between the plow and the section being pulled to protect the pipe from over stressing.

B. PLANT-IN: The plant-in method uses a plow with a chute attachment through which the pipe is fed into the bottom of the trench behind the plow blade. The pipe can be fed into the chute from a coil carried on the plow or a reel trailer running beside the plow. The pipe can also be strung out ahead of the plow and fed overhead into the chute. The chute should be designed so that the pipe is not bent to a radius of less than recommended by the manufacturer. Avoid kinking of the pipe as it is fed overhead into the chute.

C. WATCH FOR DAMAGE: Both of these methods require particular caution to ensure that the pipe is not damaged during installation. When using the plant-in method, any sudden jump of the plow as when a rock is struck can damage the pipe. When pipe is pulled in, it is more subject to abrasion damage. Any suspected damage to the pipe should be investigated.

D. STRESS RELAXATION: Pipe which has been pulled or planted will contract as it cools and recovers from any stretching which occurred during installation. Sufficient overlap must be provided at locations where connections are to be made to allow for such shrinkage. All contraction should have occurred with 12 hours of plow-in.

VII. PRESSURE TESTING AND LEAK DETECTION

The OPS Minimum Federal Safety Standards require that:

- Each segment of a plastic pipeline must be tested in accordance with section 192.513
- The test procedure must insure discovery of all potentially hazardous leaks in the segment being tested
- The test pressure must be at least 150% of the maximum operating pressure or 50 psig, whichever is greater, but not more than three times the design pressure of the pipe

- The temperature of thermoplastic material must not be more than 100° F during the test

Pressure test duration is often dictated by state and local codes as well as utility standards. Generally, test duration should be determined by consideration of the volumetric content of the test section and instrumentation used to ensure discovery of all leaks. Air or inert gas are standard test mediums.

A. WHEN TO TEST: Pressure testing of plastic should not be initiated until it is certain that joints are sufficiently cooled (able to withstand rough handling). Some operators pressure test new installations prior to backfilling so that soap bubble checks of joints can be used to locate any leaks. In very hot, sunny conditions, the pipe may have to be back-filled at least partially to avoid exceeding temperature limits. If not back-filled, the test section should be tied down or secured at intervals to prevent whipping of the pipeline should sudden pressure release occur. This is particularly important when pressure testing sections of pipe on top of the ground prior to insertion.

B. CAPPING FOR TEST: When using expandable caps or compression coupling type test heads, adequate pull-out resistance of the mechanical connector must be demonstrated. Additional restraining methods such as anchoring, sandbagging, staking, strapping, or other means of restraint should be used for safety. Many utilities use transition fittings with welded on closure caps as test heads.

C. USE OF AIR COMPRESSORS ON PLASTIC: When using air compressors to pressure test sections of plastic, care should be taken to minimize contamination of the pipe with excessive amounts of oil or other agents. Oil has the effect of plasticizing on polyethylene which results in a small decrease in strength where concentrations of oil are absorbed by the plastic. Pneumatic tool oilers should be by-passed or traps or filters used on the discharge side of the compressor to minimize the amount of contamination present in the air. Also, the temperature of the air from the compressor must be low enough so that the test temperature does not exceed the maximum allowable 100° F for thermoplastic materials.

D. READING TEST RESULTS: When time-testing large-volume sections of plastic pipe, the operator should be aware of the creep characteristics of plastic pipe and the effects of temperature change. After initial pressurization, polyethylene pipe may continue to expand slightly causing a noticeable drop in gage reading which will then stabilize after a few minutes. A long term reading should be initiated at the stabilization point. Of course, the heating and cooling of the test medium as in an overnight test will also have an effect on pressure readings, which could mask or falsely indicate slow leaks. No specific guidelines can be given, as they would vary greatly depending on volume and temperature characteristics.

VIII. JOINING OF PLASTIC PIPE

Polyethylene pipe and fittings may be joined by hot plate heat fusion, electrofusion, or mechanical fittings. Plastics may be joined to metals by compression couplings, flanges, or other qualified types of proprietary transition fittings. The OPS Standards for the joining of plastic pipe materials are contained in Sections 192.273 (joints must be pullout resistance, follow written procedures and be inspected) and 192.281 (methods of joining: solvent cement, heat-fusion, adhesive and mechanical). Manufacturer's recommendations are intended to enable plastic pipe users to make plastic pipe joints which meet OPS regulations.

A. JOINT REQUIREMENTS: (192.273) "The pipeline must be designed and installed so that each joint will sustain the longitudinal pullout or thrust forces caused by contraction or expansion of the piping or by anticipated external or internal loading. Each joint must be made in accordance with written procedures that have been proven by test or experience to produce strong gastight joints. Each joint must be inspected to insure compliance with this subpart."

(192.281, General) "A plastic pipe joint that is joined by solvent cement, adhesive, or heat fusion may not be disturbed until it has properly set. Plastic pipe may not be joined by a threaded joint or miter joint."

1. HEAT FUSION JOINTS. [(192 281(c)]. Each heat-fusion joint on plastic pipe must comply with the following:

a. "A **butt** heat-fusion joint must be joined by a device that holds the heater element square to the ends of the piping, compresses the heated ends together, and holds the pipe in alignment while the plastic hardens".
b. "A **socket** heat-fusion joint must be joined by a device that heats the mating surfaces of the joint uniformly and simultaneously to essentially the same temperature".
c. "Heat may not be applied with a torch or other open flame".

Saddle joints, which are not specifically addressed in Part 192, are typically made using a sidewall fusion assist tool that holds the fitting in alignment with the pipe and applies correct pressure while heating and joining pipe and fitting.

2. MECHANICAL JOINTS (§192.281(e) "Each compression type mechanical joint on plastic pipe must comply with the following:

a. The gasket material in the coupling must be compatible with the plastic.
b. A rigid internal tubular stiffener, not a split tubular stiffener, must be used in conjunction with the coupling.

B. HOT PLATE HEAT-FUSION JOINING PROCEDURES:

1. Heat fusion joints are made by heating mating surfaces to their fusion temperature, usually with an electrically-heated aluminum plate (never open flame), and then bringing the surfaces into contact with one another. ASTM D2657 is a recommended practice for heat joining of thermoplastic pipe and fittings.

2. The fusion temperature required to produce a strong bond depends on the particular plastic being joined. Over-heating, damages the material, and insufficient heating does not adequately soften the material, resulting in unsatisfactory joints. Again, reference should be made to the pipe manufacturer for specific joining recommendations.

3. Supervised training of construction personnel is required prior to initial installation of plastics. Although the written instructions may be rather straightforward and simple, practice and attention to detail is required to prevent poor quality joints which may result from not fully understanding those joining procedures.

4. Handling equipment for larger sizes of pipe may be required in order to consistently produce a properly made joint. This equipment aids in alignment and supplies a more uniform force required for fusion or for insertion of the pipe into the full depth of a socket joint.

5. There are three types of hot plate heat-fusion joints used in the polyethylene piping systems currently available:

a. Socket Fusion - Consists of simultaneously heating the external surface of the pipe end and the internal surface of the socket with a male/female heating plate until the material reaches fusion temperature (determined by time), inspecting the melt pattern, inserting the pipe end into the socket, and holding joint in alignment while the joint cools. Inspect the joint after it has been made. If the fusion appears to contain voids or an excessive amount of melt was left on the tool, cut it out and make another fusion.
b. Butt Fusion - Consists of heating the square ends of the pipe ends by holding them against a flat heating plate until fusion temperature is reached (determined by time or width of melt bead), pressing the two ends together, and holding in alignment while the joint cools. In Butt Fusion, visual keys are used both during and after the making of the joint to fulfill inspection requirements. In all cases, the manufacturer of the pipe material you are using should be consulted for specific recommendations.

c. Saddle Fusion - Consists of simultaneously heating the side of the pipe and the underside of the saddle fitting with a contoured heating plate until the material reaches fusion temperature (determined by time or width of melt bead), inspecting the melt pattern, pressing the saddle onto the pipe and holding in alignment while the assembly cools. The fusion is finally inspected to assure that the fitting is properly positioned and that proper amount of melt was squeezed out around all edges of the fitting.

C. ELECTROFUSION HEAT-FUSION JOINING PROCEDURES:

1. These systems are typically designed to simplify joining of polyethylene pipe, tubing and fittings, especially when joining dissimilar polyethylenes while maintaining a single installation procedure throughout a specified ambient temperature range. Cleanliness is of extreme importance in electrofusion. Follow the manufacturer's instructions for all joints.

   a. Fittings must be kept in their original packaging until time of installation.
   b. Pipe surfaces must be scraped clean and kept free of any contact other than by the fitting.
   c. Unless otherwise indicated, the fitting must specifically match with the control box. Newer systems reaching the market are mixable with identification provided by means of bar coding.

2. Power source requirements for electrofusion must be strictly observed. The following must be verified before connecting to a fitting:

   a. Correct voltage and type of current (AC or DC)
   b. Correct power output.
   c. Correct current cycles (i.e.: 60 Hz nominal).
   d. Generator set on "manual" mode, not "auto-throttle.
   e. Extension cords of adequate wire size and not excessive length.

3. Pipe ends must be cut as squarely as possible to achieve uniform gap between ends to be joined in socket fitting.

4. Scraping of pipe/tubing must be thorough and correct distance from ends, but must not be done more than the maximum number of times recommended by manufacturer.

5. Alignment clamp must be properly placed to assure no movement can occur and pipe/fittings are perfectly aligned.

6. Verify that the fitting name displayed by the control box correctly identifies the fitting connected. DO NOT START A FUSION IF CONTROL BOX INCORRECTLY IDENTIFIES THE FITTING. A POOR JOINT WILL RESULT.

7. Do not permit the fitting or pipe do be disturbed for the specified minimum time

For each of the above methods, manufacturers have specific recommendations for temperature, visual keys, time cycles, tooling, joining pressures, etc. Familiarity with and adherence to these recommendations and utility standards is essential.

D. MECHANICAL JOINTS:

Mechanical joints should be designed to effectively sustain the forces caused by contraction of the piping or by external loading. If such provision is not made in the design of the joint, suitable restraint such as anchoring, bracing, or strapping must be provided in the installation. The tubular stiffener used with compression type joints should reinforce the end of the pipe and should extend at least to the end of the fitting. The stiffener should be free of rough or sharp edges and should not be a forced fit in the plastic pipe. Joints using elastomeric seals such as O-rings as pressure sealing devices only, may be used provided other suitable measures are used to prevent longitudinal pull-out or other mechanical failure.

E. TOOLING REQUIREMENTS:

Heat fusion joining equipment, including heating tools, butt fusion joiners, and saddle fusion assist tools, is available from several manufacturers. In a few cases, the pipe manufacturers themselves provide fusion joining equipment. In all cases, the pipe and fitting manufacturer should be consulted regarding tool usage.

1. Tool Maintenance: Heat fusion joining tools are designed for optimum performance provided they are properly maintained. Cleanliness and good repair are essential for consistently good joints.

2. Heating Tool Temperature: Heating tools have temperature indicating thermometers and are controlled by thermostatic switches. It is essential that the thermometers be checked periodically for accuracy so that any needed adjustments can be made to ensure that tools are heated to proper temperatures.

F. INSPECTOR'S RESPONSIBILITY: The Inspector must ensure that each joint is made by properly trained and qualified personnel in accordance with established written procedures which are shown to be satisfactory for the particular pipe and fittings system being joined. The fusion tools and equipment should be inspected regularly and frequently to assure they are clean, properly maintained and heating plate surface coating is intact. This includes ensuring that appropriate visual or non-destructive requirements have been met.

IX. PLASTIC PIPE INSTALLATION REFERENCE MATERIALS

This information summarizes generally accepted installation and use practices involving plastic pipe. All of this information has been previously discussed in the various code and guideline publications which were referred to throughout the text. Below is a summary list of those readily available references with which each user of plastic piping systems should be familiar.

- Title 49, Code of Federal Regulation, Part 192 "Transportation of Natural and Other Gas by Pipelines: Minimum Federal Safety Standards"
- Guide for Gas Transmission and Distribution Piping Systems
- A.G.A. Plastic Pipe Manual for Gas Service