Case N-755-2
Use of Polyethylene (PE) Class 3 Plastic Pipe
Section III, Division 1

Inquiry: Under what conditions may polyethylene (PE) pipe be used for the construction of Section III, Division 1, Class 3, buried piping systems?

Reply: It is the opinion of the Committee that buried PE piping systems may be constructed to the rules of Section III, Division 1, Class 3 provided the following requirements for PE piping are met.

(a) For the construction of a buried polyethylene piping system, only the following are permitted:
   (1) straight polyethylene pipe
   (2) three segment and five segment mitered elbows
   (3) polyethylene to metallic flanges
   (4) butt fusion joints
   (b) All metallic components that interface with the polyethylene material shall meet the requirements of Subsection ND, Class 3 construction.
   (c) This Case provides the requirements for the materials, design, procurement, fabrication, installation, examination, and testing of PE material.
   (d) All applicable requirements of Section III shall be met unless modified by this Case.
   (e) Use of this Case shall be identified on the N-5 Data Report.

The Committee’s function is to establish rules of safety, relating only to pressure integrity, governing the construction of boilers, pressure vessels, transport tanks and nuclear components, and in-service inspection for pressure integrity of nuclear components and transport tanks, and to interpret these rules when questions arise regarding their intent. This Code does not address other safety issues relating to the construction of boilers, pressure vessels, transport tanks and nuclear components, and the in-service inspection of nuclear components and transport tanks. The user of the Code should refer to other pertinent codes, standards, laws, regulations or other relevant documents.
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**FIGURES**

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\( M_E = \) resultant moment range due to the combined effects of seismic wave passage, seismic soil movement, and building seismic anchor motion effects, in.-lb (N-mm)

\( P = \) internal design gage pressure, plus pressure spikes due to transient events, psi (MPa)

\( P_o = \) design or Service Level A, B, C, or D pressure, psi (MPa)

\( P_D = \) piping system internal design gage pressure at the specified design temperature \( T_D \), both being specified in the piping Design Specification, not including the consideration of pressure spikes due to transients, psi (MPa)

\( P_E = \) vertical soil pressure due to earth loads, lb/ft\(^2\) (MPa)

\( P_{gw} = \) pressure due to ground water above the top of the pipe, lb/ft\(^2\) (MPa)

\( P_{hydro} = \) external hydrostatic pressure, equal to earth plus groundwater pressure plus surcharge load, psi (MPa)

\( P_L = \) vertical soil pressure due to surcharge loads, lb/ft\(^2\) (MPa)

\( R = \) buoyancy reduction factor

\( r_1' = \) radius of curvature at the beginning of a tapered transition joint, in. (mm)

\( r_2' = \) radius of curvature at the end of a tapered transition joint, in. (mm)

\( S = \) allowable stress, per Tables -3131-1(a) and -3131-1(b) or Table -3223-3, psi (MPa)

\( S_{comp} = \) allowable side wall compression stress per Tables -3220(a) and -3220(b), psi (MPa)

\( T = \) temperature, °F (°C)

\( T_D = \) design temperature, °F (°C)

\( T_{ground} = \) temperature of soil around pipe, °F (°C)

\( T_{water} = \) temperature of water running through pipe, °F (°C)

\( t = t_{fab \ min}, \) in. (mm)

\( t_{min} = \) minimum required wall thickness, in. (mm)

\( W_p = \) weight of empty pipe per unit length, lb/ft (kg/m)

\( W_w = \) weight of water displaced by pipe, per unit length, lb/ft (kg/m)

\( Z = \) section modulus of pipe cross section at the pipe section where the moment is calculated, in.\(^3\) (mm\(^3\))

\( \alpha = \) coefficient of thermal expansion of pipe, \( 1/\text{°F} \ (1/\text{°C}) \)

\( \Delta P = \) differential pressure due to negative internal pressure of pipe, psi (MPa)

\( \Delta T = T_{water} - T_{ground}, \) °F (°C)

\( \Delta T_{eq} = \) equivalent temperature rise, °F (°C)

\( (\varepsilon_a)_{\text{Earthquake}} = \) strain in the pipe from earthquake wave computer analysis

\( \varepsilon_{soil} = \) maximum soil strain due to seismic wave passage

\( \nu = \) Poisson’s ratio (0.35 for short duration loads to 0.45 for long duration loads)

\( \Omega = \) change in diameter as a percentage of the original diameter, commonly called the change in ring diameter

\( \Omega_{max} = \) maximum allowable change in diameter as a percentage of the original diameter, commonly called the change in ring diameter, per Table -3210-1

\( \rho_{dry} = \) density of dry soil, lb/ft\(^3\) (kg/m\(^3\))

\( \rho_{saturated} = \) density of saturated soil, lb/ft\(^3\) (kg/m\(^3\))

\( \sigma_E = \) tensile stress in the pipe due to an earthquake, psi (MPa)

\( \sigma_{sw} = \) circumferential compressive stress in the sidewalls of pipe, psi (MPa)

\( \sigma_r = \) tensile stress in the pipe, psi (MPa)

**-3120 Design Life**

(a) The Design Specification shall specify the design life of the system.

(b) The duration of load shall be specified for each load case, and the PE pipe physical and mechanical properties shall be based on the duration of load.

**-3130 Design and Service Loading**

Design loads shall be as defined in ND-3112.1 through ND-3112.3. Loads applied to buried PE pipe shall be defined in the Design Specification, and shall include, as a minimum, the following:

(a) Maximum internal design gage pressure \( P_D \), for pressure design in accordance with -3131 and -3132, and, if applicable, maximum negative internal gage pressure for evaluation in accordance with -3221.2.

(b) Maximum and minimum temperature \( T \), for the selection of allowable stress (Tables -3131-1(a) through -3131-1(d) and -3223-3) and design for temperature effects in accordance with -3300. The maximum Service Level A temperature shall be the design temperature, \( T_D \).

(c) The loads resulting from the maximum transient pressures.

(d) Vertical soil pressure \( P_E \), due to saturated soil, surcharge, buoyancy, and flotation, for the designs in accordance with -3200.

(e) Vertical pressure due to surcharge loads \( P_L \) for the design in accordance with -3200.
gasket material shall be selected to be consistent and compatible with the service requirements of the piping system. See Figure -4520-1 for a typical flange configuration.

-4530 Pipe Supports

All installed PE pipe supports shall meet the requirements of Subsection NF and the following:

(a) Piping shall be supported, guided, and anchored in such a manner as to prevent damage to the piping. Point loads and narrow areas of contact between piping and supports shall be avoided. Suitable padding shall be placed between piping and supports where damage to piping may occur.

(b) Valves and equipment that would transmit excessive loads to the piping shall be independently supported to prevent such loads.

-5000 EXAMINATION

-5100 GENERAL REQUIREMENTS

(a) Visual examinations shall be conducted in accordance with the examination method of Section V, Article 9.

(b) All personnel qualified to perform visual examinations required by this Case, excluding the hydrostatic pressure test, shall receive the same training as required for the fusion machine operator in Mandatory Appendix I. This training shall include the use of a fusion machine to make a fused joint. This joint is not required to be tested for qualification. This training shall be documented on a training record.

-5110 Procedures

-5111 Examination Procedures

All examinations performed under this Case shall be executed in accordance with detailed written procedures which have been proven by actual demonstration, to the satisfaction of the Authorized Nuclear Inspector. Written procedures, records of demonstration of procedure capability, and personnel qualification shall be made available to the Authorized Nuclear Inspector on request.

-5120 Time of Examination of Completed Fused Joints

Visual examination of all fused joints shall be conducted:

(a) upon the completion of cooling period

(b) after the review required by -4430 has been completed and accepted

(c) shall be completed before piping is placed in the burial trench

-5200 REQUIRED EXAMINATIONS

Visual examinations are required on the following material and components.

(a) During receipt inspection of the external surface for indentations.

(b) Fusion joints after the fusion process includes review and verification of fusion data for the joint, and external surfaces.

(c) All pipe fusion joints during the hydrostatic test.

-5210 General Requirements

The following visual examination and inspections shall be conducted:

(a) inspection of the general surface for indentations.

(b) fusion joints, including review and verification of fusion data for the joint.

(c) all fusion joints during the hydrostatic test [6100(c)]. Any fusion joint leakage shall cause rejection of the joint.

(1) The visual examination shall be conducted by examining the accessible external exposed surfaces of pressure retaining components for evidence of leakage.

(2) For components whose external surfaces are inaccessible for direct visual examination, only the examination of the surrounding area (including areas or surfaces located underneath the components) for evidence of leakage shall be required.

(3) Flange gasket leakage is excluded from this requirement.

-5300 ACCEPTANCE STANDARDS

-5310 General Requirements

Unacceptable joints shall be removed. Repair of unacceptable joints is not permitted.

-5320 Visual Examination Acceptance Criteria of External Surfaces

-5321 Thermal Fusion Butt Joints

Thermal fusion butt joints shall meet the following:

(a) Joints shall exhibit proper fusion bead configuration, see Nonmandatory Appendix C.

(b) There shall be no evidence of incomplete fusion.

(c) Joints shall not be visually angled or offset. The ovality offset shall be less than 10% \( r_{\text{lab min}} \) of the fused components.

(d) The cleavage between fusion beads shall not extend to or below the outside diameter pipe surface (see Figure-5321-1).

(1) The data acquisition record for the joint and compare it to the Fusion Procedure Specification (FPS) to ensure the proper parameters and procedures were followed in making the fused joint.

-5500 QUALIFICATION OF NONDESTRUCTIVE EXAMINATION PERSONNEL

-5510 General Requirements

Organizations performing Code required nondestructive examinations shall use personnel qualified in accordance with ND-5520 as applicable. When these services
**Figure 4520-1**

Transition Flange Arrangement

- Metallic flange
- Metallic backing ring
- PE flange adapter
- Fusion joint
- Metallic pipe
- PE piping
- Gasket (optional)

**Figure 5321-1**

Polyethylene Pipe Butt Fusion Joint O.D. Bead (Cross Section View)

- **(a) Visually Acceptable**
  (Uniform bead around pipe)

- **(b) Visually Acceptable**
  (Nonuniform bead around pipe)

- **(c) Visually Acceptable**
  (Nonuniform bead around pipe localized diameter mismatch less than 10% of the wall)

- **(d) Visually Unacceptable**
  (Nonuniform/uniform bead around pipe – V-Groove too deep at pipe-tangent)

Cleavage tip shall not meet or extend below pipe surface.

**ERRATA:**
Missing " - "
### Table -3221.2-1
**Ovality Correction Factor, \( f_o \)**

<table>
<thead>
<tr>
<th>Percent-Ovality</th>
<th>Ovality Correction Factor</th>
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<tr>
<td>1%</td>
<td>0.91</td>
</tr>
<tr>
<td>2%</td>
<td>0.84</td>
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<tr>
<td>3%</td>
<td>0.76</td>
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<tr>
<td>5%</td>
<td>0.64</td>
</tr>
<tr>
<td>6%</td>
<td>0.59</td>
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</table>

### Table -3223-1
**Stress Indices, \( B_1 \) and \( B_2 \)**

<table>
<thead>
<tr>
<th>DR 7</th>
<th>DR 9</th>
<th>DR 11</th>
<th>DR 13.5</th>
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<tr>
<td>( B_1 ) Straight and butt fused joint</td>
<td>0.5</td>
<td>0.5</td>
<td>0.5</td>
</tr>
<tr>
<td>( B_2 ) Straight and butt fused joint</td>
<td>1.0</td>
<td>1.0</td>
<td>1.0</td>
</tr>
<tr>
<td>( B_1 ) Miter [Note (1)]</td>
<td>0.69</td>
<td>0.69</td>
<td>0.69</td>
</tr>
<tr>
<td>( B_2 ) Miter [Note (1)]</td>
<td>1.38</td>
<td>1.64</td>
<td>1.91</td>
</tr>
</tbody>
</table>

**NOTE:**
1. Mitered elbows shall not exceed 22.5 deg (±3 deg) angle of change in direction at mitered joint.

### Table -3223-2
**Design and Service Level Longitudinal Stress Factors, \( K \)**

<table>
<thead>
<tr>
<th>Service Level</th>
<th>Design</th>
<th>A</th>
<th>B</th>
<th>C</th>
<th>D</th>
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<tr>
<td>( k )</td>
<td>1.0</td>
<td>1.0</td>
<td>1.1</td>
<td>1.33</td>
<td>1.33</td>
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### Table -3223-3
**Short Duration (< 5 min) Allowable Longitudinal Tensile Stress Values**

<table>
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<tr>
<th>Temp (°F)</th>
<th>Temp (°C)</th>
<th>( S ) (psi)</th>
<th>( S ) (MPa)</th>
</tr>
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<tr>
<td>( S \leq 70 )</td>
<td>( S \leq 21 )</td>
<td>1,200</td>
<td>8.3</td>
</tr>
<tr>
<td>100</td>
<td>38</td>
<td>940</td>
<td>6.5</td>
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<td>120</td>
<td>49</td>
<td>770</td>
<td>5.3</td>
</tr>
<tr>
<td>140</td>
<td>60</td>
<td>630</td>
<td>4.3</td>
</tr>
<tr>
<td>176</td>
<td>80</td>
<td>400</td>
<td>2.7</td>
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</table>

### Table -3311.2-1
**Stress Intensification Factor, \( i \)**

<table>
<thead>
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<th>Fitting or Joint</th>
<th>( i )</th>
</tr>
</thead>
<tbody>
<tr>
<td>Straight pipe</td>
<td>1.0</td>
</tr>
<tr>
<td>Butt fusion</td>
<td>1.0</td>
</tr>
<tr>
<td>Mitered elbows</td>
<td>2.2</td>
</tr>
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</table>
I-122 Data Acquisition Record Evaluation

I-122.1 Data Acquisition Device.
(a) The data acquisition device shall be capable of recording the following butt fusion essential variables on each joint:

1. Heater surface temperature immediately prior to insertion of the heater plate
2. Gauge pressure during the heat cycle
3. Gauge pressure during the fusion and cool cycle
4. Amount of time during the heat cycle
5. Amount of time to open the fusion machine, remove the heater, and bring the pipe ends together at fusion pressure
6. Amount of time during the fusion and cool cycle
(b) All job information related to the joints such as job number, joint number, employee number, time, date, fusion machine identification, pipe manufacturer, interfacial pressure, and pipe material shall be recorded.
(c) The data acquisition device must be capable of storing at least one day of butt fusion joint information and capable of downloading this information as a permanent record.

I-122.2 Data Acquisition Log Evaluation. The butt fusion joint record should be compared to the FPS to ensure that the proper butt fusion parameters and procedures were followed. If they were not, the joint shall be cut out and a new joint fused using the correct parameters and procedures per the FPS. An example of a data acquisition log review is provided in Nonmandatory Appendix B of this Case.

(a) Verify that all job related data was entered in the record.
(b) Verify that the recorded “Fuse” interfacial pressure was within the range of qualification.
(c) Verify that the heater surface temperature recorded was within the range of qualification.
(d) Verify that the drag pressure was recorded.
(e) The examiner shall calculate the fusion pressure for the fusion machine and add the drag pressure to confirm the machine’s hydraulic fusion gauge pressure. This fusion gauge pressure must be shown in the recorded pressure/time diagram at the initial heater contact and during the fusion/cool cycle.
(f) Verify that the fusion gauge pressure dropped quickly to a value less than or equal to the drag pressure at the beginning of the heat soak cycle.
(g) At the end of the heat soak cycle, review that the machine was opened, the heater removed and the pipe ends brought together at the fusion gauge pressure as quickly as possible (not to exceed allowance in procedure).
(h) Verify that the machine fusion gauge pressure was within the range of qualification for the pipe diameter being fused. Observe that the data recording device stopped logging at the end of the fusion/cool cycle.

I-130 TESTS

I-131 HIGH SPEED TENSILE IMPACT TEST

I-131.1 Significance and Use. This test method is designed to impart tensile impact energy to a butt fused plastic pipe joint.

I-131.2 Test Specimens.
(a) The test specimen shall conform to the dimensions shown in Figure I-131.2. Except as permitted in I-131.3(c), test specimens of butt fused pipe shall use the full wall thickness.
(b) Preparation. Test specimens shall be prepared by machining operations on butt fused sections of pipe and on the pipe itself. The machining operations shall result in a smooth surface on both sides of the reduced area with no notches or gouges.
(c) All surfaces of the specimen shall be free of visible flaws, scratches, or imperfections. Marks left by coarse machining operations shall be carefully removed with a fine file or abrasive, and the filed surfaces shall then be smoothed with abrasive paper (600 grit or finer). The finishing sanding strokes shall be made in a direction parallel to the longitudinal axis of the test specimen. In machining a specimen, undercuts that would exceed the dimensional tolerances shall be avoided.
(d) When marking the specimens, use a permanent marker of a color that will be easily read or etch the specimen number in the area outside the hole.

I-131.3 Number of Test Specimens. The following specifies the number of required test specimens:

(a) four test specimens shall be cut 90 deg apart from a pipe coupon made from pipe sizes larger than 4 in. (100 mm)
(b) two test specimens shall be cut 180 deg apart from a pipe coupon made from 2 in. to 4 in. pipe sizes (50 mm to 100 mm), inclusive
(c) for pipes with a wall thickness greater than 2.5 in. (62 mm), the test specimens shall be cut into equal thicknesses to fit the testing machine

I-131.4 Speed of Testing. The speed of testing shall be in accordance with Table I-131.4.

I-131.5 Conditioning.
(a) Conditioning. Condition the test specimens at 73.4°F ± 4°F [23°C ± 2°C] for not less than 1 hr prior to test.
system/quality assurance program, the operational control of procedure qualifications. In this situation, separate fusion procedure qualifications are not required, provided all other requirements of this Mandatory Appendix are met.

(d) The manufacturer or contractor shall certify that he has qualified each fusion procedure specification.

I-220 FUSION PROCEDURE SPECIFICATION (FPS)

I-221 Standard Fusion Procedure Specification

(a) The standard fusion procedure specification is based on standard industry practice and testing as reported in the Plastic Pipe Institute (PPI), report TR-33.

(b) When the FPS is limited to the following parameters, qualification testing is not required. If the manufacturer or contractor deviates from the conditions listed below, procedure qualification testing in I-223 shall be performed.

(1) The pipe is limited to the horizontal position ±45 deg (see Figure I-105).

(2) The pipe ends shall be faced to establish clean, parallel mating surfaces that are perpendicular to the pipe centerline on each pipe end. When the ends are brought together, there shall be no visible gap.

(3) The external surfaces of the pipe are aligned to within 10% of the pipe wall thickness.

(4) The drag pressure shall be measured and recorded. The fusion pressure shall be calculated so that an interfacial pressure of 60 psi to 90 psi (0.41 MPa to 0.62 MPa) is applied to the pipe ends.

(5) The heater plate surface temperature shall be 400°F to 450°F (204°C to 232°C) measured at four locations approximately 90 deg apart, on both sides immediately prior to insertion of the heater plate in the fusion machine.

(6) The heater plate shall be inserted into the gap between the pipe ends and fusion pressure shall be applied and maintained until an indication of melt is observed around the circumference of the pipe. The pressure shall be reduced to drag pressure and the fixture shall be locked in position so that no outside force is applied to the joint during the cool time.

(7) The ends shall be held in place until the bead size shown in Figure I-221(b)-1 and Table I-221(b)-1 is formed in the heat soak cycle between the heater faces and the pipe ends.

(8) After the proper bead size is formed, machine shall be opened and the heater removed. The pipe ends shall be brought together and the fusion pressure reapplied.

(9) The maximum time from removal of the heating plate until the pipe ends are pushed together shall not exceed the time given in Table I-221(b)-1 and Table I-221(b)-2.

(10) The fusion pressure shall be maintained until the joint has cooled, after which the pipe can be removed from the fusion machine. The cooling time under pressure shall be 30 in./sec to 90 in./sec (25.4 mm) of pipe diameter. When the wall thickness is greater than 2 in. (51 mm), a minimum of 90 in./sec (25.4 mm) of pipe diameter shall be used for the cooling time.

I-222 Essential Variables for Fusion Procedure Specifications (FPS)

Any change in the essential variables listed below and I-221, requires requalification of the FPS per I-223. The following are the essential variables:

(a) pipe material
(b) heater surface temperature range
(c) butt fusion interfacial pressure range
(d) melt bead width in heat soak cycle
(e) maximum heater removal time
(f) minimum cool time under fusion pressure

I-223 Testing Procedure to Qualify the FPS

(a) Use IPS 8 (DN 200) DR 11 pipe size as a minimum in qualification testing of butt fusion joints.

(b) Make the following butt fusion joints using the following combinations of heater temperature ranges and interfacial pressure ranges and the FPS:

<table>
<thead>
<tr>
<th>Heater Surface Temperature</th>
<th>Interfacial Pressure</th>
</tr>
</thead>
<tbody>
<tr>
<td>High</td>
<td>High</td>
</tr>
<tr>
<td>High</td>
<td>Low</td>
</tr>
<tr>
<td>Low</td>
<td>High</td>
</tr>
<tr>
<td>Low</td>
<td>Low</td>
</tr>
</tbody>
</table>

(c) Evaluate three joints of each combination using the high speed tensile impact tests per I-131. All joints must fail in a ductile mode.

(d) Evaluate two joints of each combination using the sustained pressure testing per I-132. All joints must pass this test.

I-230 MECHANICAL TESTS

I-231 General Requirements

Specifications (FPS)

Any change in the essential variables listed below and I-221, requires requalification of the FPS per I-223. The following are the essential variables:

(a) pipe material
(b) heater surface temperature range
(c) butt fusion interfacial pressure range
(d) melt bead width in heat soak cycle
(e) maximum heater removal time
(f) minimum cool time under fusion pressure

ERRATA:

Reference to Table I-221(b)-1 is erroneous and was not present in N-755-1 or added by N-755-2 ballot or N-755-2 errata. In N-755-1 as published, Table I-221(b)-1 is used in the testing procedure to qualify the FPS. Table I-221(b)-1 is not related to fusing parameters, another test coupon shall be considered as failed.

(b) When it can be determined that the cause of failure is not related to fusing parameters, another test coupon may be fused using identical fusing parameters.

(c) Alternatively, if adequate material of the original test coupon exists, additional test specimens may be removed as close as practicable to the original specimen location to replace the failed test specimens.
MANDATORY APPENDIX IV
POLYETHYLENE COMPOUND AND POLYETHYLENE MATERIAL

IV-100 POLYETHYLENE COMPOUND AND POLYETHYLENE MATERIAL REQUIREMENTS

IV-110 General Requirements

(a) Natural compound, pigment concentrate compound, polyethylene compound and polyethylene material shall be procured using the requirements of this Mandatory Appendix.

(b) Conformance with ASTM Standards referenced in Mandatory Appendix III and herein shall be limited as specified in this Mandatory Appendix. In the event of conflict between a referenced standard and this Mandatory Appendix, the requirements of this Mandatory Appendix shall prevail.

(c) Natural compound, pigment concentrate compound, polyethylene compound, and polyethylene material shall be marked in accordance with the marking requirements in this Mandatory Appendix and the applicable ASTM standard.

IV-120 REQUIREMENTS FOR POLYETHYLENE COMPOUND, NATURAL COMPOUND, PIGMENT CONCENTRATE COMPOUND, AND POLYETHYLENE SOURCE MATERIAL

IV-121 Requirements for Certification of Polyethylene Compound

(a) General

(1) To provide polyethylene material that is in accordance with the design requirements of this case, certification of polyethylene compound shall be in accordance with Mandatory Appendix IV and Table IV-121.

(2) The required value for each physical property shall be as specified in Table IV-121.

(3) The requirement standard for determining the required value for physical properties shall be as specified in Table IV-121.

(4) The test method for determination of the required value for the physical property shall be as specified in Table IV-121.

(b) Polyethylene compound used for the manufacture of polyethylene material shall meet the requirements of the polyethylene compound manufacturer and Table IV-121.

(c) Polyethylene compound shall be black except as provided in IV-131(b).

(d) Polyethylene compound is the combination of natural compound and pigment concentrate compound as follows:

(1) When polyethylene compound is combined by the Polyethylene Compound Manufacturer, polyethylene compound is the polyethylene source material.

(2) When polyethylene compound is combined by the Polyethylene Material Manufacturer, natural compound and pigment concentrate compound are the polyethylene source materials.

(3) When polyethylene compound is combined by the Polyethylene Material Manufacturer, the Natural Compound Manufacturer shall provide the Polyethylene Material Manufacturer with a formulation that specifies the weight ratio (proportions) of natural compound and pigment concentrate compound, and with processing equipment setting recommendations that produce polyethylene compound in accordance with Table IV-121.

(e) Polyethylene compound shall have an independent listing that is published in PPI TR-4, Table I.A.13. The independent listing shall identify the following:

(1) A standard grade hydrostatic design basis (HDB) rating of at least 1,600 psi (11.03 MPa) at 73°F (23°C).

(2) A standard grade HDB rating of at least 1,000 psi (6.90 MPa) at 140°F (60°C).

(3) A hydrostatic design stress (HDS) rating of at least 1,000 psi (6.90 MPa) for water at 73°F (23°C).

(4) Standard grade HDB ratings and HDS ratings shall be determined in accordance with PPI TR-3, Parts A, D, and F.

(5) The polyethylene compound shall have a material designation of PE4710 in accordance with PPI TR-4, Table I.A.13.

(6) The unique trade name or designation for the polyethylene compound.

(7) The Polyethylene Natural Compound Manufacturer.

(f) The Polyethylene Material Manufacturer of polyethylene pipe shall have a dependent listing for black polyethylene compound that is published in PPI TR-4, Table I.A.13. The dependent listing shall identify the following:

(1) A standard grade hydrostatic design basis (HDB) rating of at least 1,600 psi (11.03 MPa) at 73°F (23°C).

(2) A standard grade HDB rating of at least 1,000 psi (6.90 MPa) at 140°F (60°C).

(3) A hydrostatic design stress (HDS) rating of at least 1,000 psi (6.90 MPa) for water at 73°F (23°C).

(4) Standard grade HDB and HDS ratings shall be determined in accordance with PPI TR-3, Parts A, D and F.

(5) The Polyethylene Material Manufacturer shall assign a unique trade name or designation to the polyethylene compound that is published in PPI TR-4, Table I.A.13.
NONMANDATORY APPENDIX D
NONMANDATORY SEISMIC ANALYSIS METHOD

The buried pipe may be qualified by analysis for the effects of seismic wave passage, following the method provided in this Appendix.

Step 1. The strains from seismic wave passage, and seismically-induced permanent or temporary movements if any, shall be obtained by a plant-specific geotechnical civil investigation.

Step 2. The soil strains (see -3410) shall be converted into an equivalent temperature rise of the buried pipe, as follows:

\[ \Delta T_{eq} = \frac{\varepsilon_{soil}}{a} \]

Step 3. The pipe soil system shall be modeled as a piping system constrained by soil springs.

(a) The pipe model shall consider two cases: short-term modulus (< 10 hr, Tables -3210-3(a) and -3210-3(b)) for wave passage and long term modulus for permanent soil movement (permanent seismic anchor motion).

(b) The soil model shall have at least a bi-linear stiffness, and shall consider two cases: upper and lower bound of soil stiffness.

For guidance on modeling soil pipe interaction, refer to ASCE and ASCE 4, see Table D-1.

Table D-1

<table>
<thead>
<tr>
<th>Standard ID</th>
<th>Published Title</th>
<th>Referenced Edition</th>
</tr>
</thead>
<tbody>
<tr>
<td>American Society of Civil Engineers (ASCE)</td>
<td>Guidelines for the Seismic Design of Oil and Gas Pipeline Systems, 1984</td>
<td></td>
</tr>
<tr>
<td>ASCE</td>
<td>Seismic Analysis of Safety-Related Nuclear Structures and Commentary, or American Lifelines Alliance, Guidelines for the Design of Buried Steel Pipes Addenda</td>
<td>2001 with the 2005 Addenda</td>
</tr>
</tbody>
</table>

Step 4. The equivalent change of temperature \( \Delta T_{eq} \) shall be applied to the pipe soil model to obtain forces and moments throughout the system.

Step 5. The anticipated building seismic anchor movements, if any, shall be applied to the pipe soil model to obtain forces and moments throughout the system.

Step 6. The anticipated seismic movements, if any, shall be applied to the pipe soil model to obtain forces and moments throughout the system.

Step 7. The results of Steps 4, 5, and 6 shall be combined by SRSS, at each point along the piping system to obtain resultant forces and moments.

Step 8. The resultant forces and moments shall be evaluated as follows:

(a) The axial stresses in pipe, fittings, and fused joints shall comply with the requirements of -3410.

(b) Alternatively, the seismic induced strain shall be determined as follows:

\[ \varepsilon_{\text{Earthquake}} = \frac{\sqrt{\varepsilon_{E}^2 + \nu(PD/2t)^2}}{E} \]

This strain, \( \varepsilon_{\text{Earthquake}} \), shall be limited to the values listed in Table D-2, where \( k \) is defined in Table -3223-2.

Table D-2

<table>
<thead>
<tr>
<th>DR</th>
<th>Allowable Strain</th>
</tr>
</thead>
<tbody>
<tr>
<td>( DR \leq 13.5 )</td>
<td>( 0.025 \times k )</td>
</tr>
<tr>
<td>( 13.5 &lt; DR \leq 21 )</td>
<td>( 0.020 \times k )</td>
</tr>
<tr>
<td>( DR &gt; 21 )</td>
<td>( 0.017 \times k )</td>
</tr>
</tbody>
</table>