Approval Date: April 4, 2012

Case 2725
Polymer Material for Heating Boiler Components
Section IV

Inquiry: May ASTM D4349-96 (2010), grades PPE410G30A40346 and PPE210G30A50553 polymers be used for the construction of boiler components in Section IV?

Reply: It is the opinion of the Committee that ASTM D4349-96 (2010), grades PPE410G30A40346 and PPE210G30A50553 polymers may be used for the construction of Section IV boiler components, provided the following requirements are met.

1 GENERAL REQUIREMENTS

(a) The polymer materials shall be in compliance with ASTM D4349-96 (2010) and shall be limited to the polymers with a classification designation of PPE410G30A40346 and PPE210G30A50553.

(b) The polymer materials shall be certified by the materials manufacturer, and a report of test results shall be furnished to the boiler manufacturer for each lot1 of material.

(c) The material shall not be used for heat transfer purposes and shall not be exposed to direct flame. The material may be exposed to the products of combustion, but the maximum flue gas temperature shall not exceed 212°F (100°C).

(d) The boiler shall be limited to hot water heating service.

(e) The maximum heat input shall be limited to 256,000 Btu/hr (75 kW).

(f) The maximum allowable working pressure shall not exceed 50 psi (345 kPa).

(g) The maximum material design and water temperature shall not exceed 210°F (99°C).

(h) The maximum water temperature shall be stamped on the ASME nameplate and documented on the Manufacturer’s Data Report.

(i) The maximum water volume of the polymer parts shall not exceed 1.85 gal (7 L).

(j) The polymer material shall not be repaired.

(k) The polymer parts shall have a permanently attached label or marking stating, “Repair of the polymer parts is prohibited.”

(l) The polymer parts shall be permanently marked in a manner to provide traceability to the material manufacturer’s report of test results and to the injection molding machine.

(m) The injection molding process shall be controlled by a written procedure in which all of the following process variables shall be considered essential:
   - melting temperature
   - nozzle
   - front
   - middle
   - rear
   - mold temperature
   - drying time (average)
   - drying time (maximum)
   - moisture content (% maximum)
   - back pressure
   - screw speed
   - ratio of shot size to cylinder size
   - weight of finished molded part

(n) A change of any of the essential variables in (m) shall require requalification of the written procedure per the test procedure specified in section 2.

(o) The Authorized Inspector (AI) shall monitor the injection molding process to ensure compliance with the written procedure. The AI shall verify that the manufacturer has performed all steps in sections 1, 2, and 3.

(p) Material used for qualification testing shall not be used on Code stamped boilers.

(q) The use of regrind material is prohibited.

(r) This Case number shall be shown on the Manufacturer’s Data Report.

(s) The Manufacturer’s quality control system shall address use of polymers for injection molded parts.

(t) Joining to other parts shall be only by mechanical methods. Fusion bonding is not allowed.

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1 The term “lot” is a continuous production run of finished polymer material in pellet or granular form that has been assigned a unique identification number and issued a certificate of compliance by the polymer manufacturer.
(u) After using mold release agents, the first five parts shall be scrapped.
(v) Adding colorant to the polymer is prohibited.
w) The polymer shall not have line of sight to the flame to prevent degradation as a result of UV radiation.
x) All finished products (boiler) using these polymer parts shall be subject to a hydrostatic test per HG-510.
y) All other requirements of Section IV shall apply.
z) The production of the polymer parts may be subcontracted, but the production of these parts shall be witnessed by a representative of the boiler Manufacturer (Stamp Holder) and the boiler Manufacturer’s AI. The design qualification of the polymer parts per section 2 of this Case shall remain the responsibility of the boiler Manufacturer.

2 DESIGN QUALIFICATION

The qualification of the polymer part design shall be by testing of one or more full-size prototype parts by the following test sequence:
(a) The weight of the prototype parts shall be measured to an accuracy of 1.25%.
(b) The weight of the part shall be within the range specified in the injection molding procedure.
(c) The part shall be examined for conformance with dimensions and tolerances shown on the design drawings.
(d) Water Cycling Pressure Test. Pressure shall be raised from atmospheric pressure to MAWP and back 100,000 times at maximum design temperature.
(e) Water Cycling Temperature Test. The water temperature shall be raised from 59°F (15°C) to the maximum design temperature and back 100,000 times at the MAWP.
(f) After successful completion of the cyclic tests specified in (d) and (e), the same prototype parts shall then be subjected to a design qualification pressure test. This pressure test shall be conducted using water at the maximum design temperature. The test pressure applied shall be a minimum of 6 times the MAWP of the part and shall be raised from zero to this pressure in no less than 1 min and held for 5 min. Test to failure is not required. If the prototype part exhibits any leakage, cracking, or bursts during the application of pressure, or during the required hold time, the prototype shall be considered to have failed and requalification shall be required.

\[ P = \frac{B}{6} \]

where
\[ B = \text{bursting test pressure, psi (kPa)} \]
\[ P = \text{design pressure, psi (kPa)} \]
\[ = \text{MAWP, psi (kPa)} \]

(g) The AI shall verify the cyclic pressure and temperature tests and shall witness and accept the design pressure test.
(h) The specified weight of each part shall be reported in the proof test report.
(i) Classification and acceptance level of imperfections shall be according to Table 1.

3 PRODUCTION OF POLYMER PARTS

3.1 GENERAL REQUIREMENTS

(a) Production of polymer parts may begin when the injection molding parameters [see 1(m)] are stable and within tolerance as defined in the injection molding procedure. The parameters shall be recorded at the beginning of production. Further, the injection molding machine shall be monitored during production, and the parameters [see 1(m)] shall be recorded once per hour minimum for review by the AI.
(b) The first ten parts produced are to be used for startup purposes only. These ten parts shall not be considered part of the production batch and shall be scrapped. The following parts shall be monitored as defined in 3.2.
(c) Each production part shall be weighed by a scale calibrated to an accuracy of \( \frac{1}{10} \) of the tolerance range, and the weight of parts shall not be less than 98.75% of the weight of the prototype unit.

3.2 INSPECTION OF PRODUCTS

There are two acceptable methods for inspection of the products: a 100% inspection as described in (a) or statistical methods described in (b). For the statistical methods, there are two alternatives described: Statistical Process Control (SPC) [see (b)(1)] or two sample T-test method [see (b)(2)].

(a) Inspection at 100%

(1) Each polymer part shall be examined internally and externally for imperfections. Classification and acceptance level of imperfections shall be according to Table 1.

(2) The first ten parts in a production batch \(^2\) shall be examined for conformance per the design drawings. Any dimension outside the specified limit shall be cause for rejection.

(3) Every tenth part after the first ten parts in a production batch shall be examined for conformance with dimensions and tolerances shown on the design drawings. Any dimension outside the specification limits shall be cause for rejection of that part and the previous parts in the production batch. The previously rejected parts in the production batch shall be thoroughly examined, and shall meet all requirements of this Code Case, or shall be scrapped. The injection molding process shall be requalified before production is resumed.

\(^2\) The term “production batch” is a continuous production run of molded parts from each individual injection molding machine.
(4) At least one part per 1,000 parts shall be subjected to the requirements identified in 2(b) through 2(i). The parts to be used for these tests shall be selected at random by the Authorized Inspector. If the part(s) fail any of these tests, the complete batch shall be scrapped, including the remainder of the parts. The production process shall be requalified per section 2.

(b) Inspection by Statistical Control Methods

(1) Statistical Process Control (SPC)


(-b) The Manufacturer shall comply with ASTM E2587-07e1, Standard Practice for Use of Control Charts in Statistical Process Control, and demonstrate the following items:

(-1) critical variables defined on design drawings of the part; as a minimum the outer dimensions of length, height, and width
(-2) part weight
(-3) visual inspection of the part according to Table 1

(-c) The Manufacturer shall comply with the following:

(-1) minimum $CP$ value of 1.67
(-2) minimum $Cpk$ value of 1.33
(-d) If the $CP$ and/or $Cpk$ values go below the minimum values stated in (-c), then each part in the production batch shall be thoroughly examined, and shall meet all requirements of this Code Case, or shall be scrapped. The injection molding process shall be requalified before production is resumed.

(2) The Two Sample T-Test Method

(-a) The Manufacturer shall establish a control sample such that all parts within the sample are acceptable. The control sample shall be 100 parts, minimum.

(-b) The T-test shall be based on critical variables such as the outer dimensions of length, height, and width. As a minimum, the weight of the polymer part shall be used for the T-test.

(-c) The T-test shall be performed:

(-1) at the beginning and end of each production batch
(-2) at initial production for each lot of polymer material
(-3) each production sample shall consist of a minimum sample size of 20 production parts.
(-4) each production sample shall be compared to the control sample.
(-5) the calculated $t$ value shall be less than or equal to the tabulated $t$ value at $p = 0.01$
(-6) if the calculated $t$ value is greater than the tabulated $t$ value, then each part in the production batch shall be thoroughly examined, and shall meet all requirements of this Case, or shall be scrapped. The injection molding process shall be requalified before production is resumed.

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2 The term “production batch” is a continuous production run of molded parts from each individual injection molding machine.

1 The term “lot” is a continuous production run of finished polymer material in pellet or granular form that has been assigned a unique identification number and issued a certificate of compliance by the polymer manufacturer.
### Table 1
Visual Acceptance Criteria

<table>
<thead>
<tr>
<th>Defect</th>
<th>Definition</th>
<th>Maximum Size</th>
</tr>
</thead>
<tbody>
<tr>
<td>Black spots, brown streaks</td>
<td>Dark spots or streaks</td>
<td>None permitted</td>
</tr>
<tr>
<td>Blister</td>
<td>Hollows on or in the parts</td>
<td>Pressure side: none permitted;</td>
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<tr>
<td></td>
<td></td>
<td>Nonpressure side:</td>
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<td></td>
<td></td>
<td>maximum diameter, ( \frac{1}{16} ) in. (1.5 mm);</td>
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<tr>
<td></td>
<td></td>
<td>maximum density 1 per 1 ft(^2) (1 per 0.1 m(^2));</td>
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<tr>
<td></td>
<td></td>
<td>none less than 2 in. (50 mm) apart</td>
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<tr>
<td>Bubbles</td>
<td>Air entrapped in the parts</td>
<td>Maximum diameter: ( \frac{1}{16} ) in. (1.5 mm);</td>
</tr>
<tr>
<td></td>
<td></td>
<td>maximum density: 4 per 1 in(^2) (4 per 650 mm(^2));</td>
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<tr>
<td></td>
<td></td>
<td>maximum diameter: ( \frac{1}{16} ) in. (1.5 mm);</td>
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<tr>
<td></td>
<td></td>
<td>maximum density 10 per 1 in(^2) (10 per 650 mm(^2))</td>
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<tr>
<td>Burn marks, dieseleng</td>
<td>Charred or dark plastic caused by trapped gas</td>
<td>None permitted</td>
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<tr>
<td>Cracking, crazing</td>
<td>Any visible</td>
<td>None permitted</td>
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<tr>
<td>Delamination</td>
<td>Single surface layers flake off parts</td>
<td>None permitted</td>
</tr>
<tr>
<td>Discoloration</td>
<td>Similar to burns marks but generally not as dark or severe</td>
<td>Acceptable</td>
</tr>
<tr>
<td>Flow, halo, blush marks</td>
<td>Marks seen on the part due to flow of molten plastic across the molding surface</td>
<td>Acceptable</td>
</tr>
<tr>
<td>Gels</td>
<td>Bubbles or blisters on or in the part due to poor melt quality</td>
<td>None permitted</td>
</tr>
<tr>
<td>Jetting</td>
<td>Undeveloped frontal flow</td>
<td>None permitted</td>
</tr>
</tbody>
</table>