Errata
to
ASME B31.12-2019
Hydrogen Piping and Pipelines

Paragraph GR-3.9.2 was inadvertently omitted from ASME B31.12-2019, page 48. The corrected page follows this cover sheet.

THE AMERICAN SOCIETY OF MECHANICAL ENGINEERS
Two Park Avenue, New York, NY 10016-5990

February 2020
GR-3.9 FORMING OF PIPE COMPONENTS

Pipe may be bent and components may be formed by any hot or cold method that is suitable for the material, the intended service, and the severity of the bending or forming process. When selecting material for hydrogen service, consideration shall be given to the effects of cold working, which may promote lower resistance to HE, while hot working enhances resistance to HE. The finished surface shall be free of cracks and substantially free from buckling. Thickness after bending or forming shall be not less than that required by the engineering design.

GR-3.9.1 Bending Requirements

(a) Flattening. Flattening of a bend, the difference between maximum and minimum diameters at any cross section, shall not exceed 8% of nominal outside diameter for internal pressure and 3% for external pressure. Removal of metal shall not be used to achieve these requirements.

(b) Bending Temperature

(1) Cold bending of ferritic materials shall be done at a temperature below the transformation range.

(2) Hot bending shall be done at a temperature above the transformation range and in any case within a temperature range consistent with the material and the intended service.

(c) Corrugated and Other Bends. Dimensions and configuration shall conform to a design qualified in accordance with para. IP-3.8.2 or para. PL-3.7, as applicable.

(d) Hot Bending and Forming. After hot bending and forming, heat treatment is required for P-Nos. 1, 3, 4, 5A, and 5B materials in all thicknesses. Durations and temperatures shall be in accordance with Table GR-3.6.1-1.

(e) Cold Bending and Forming. After cold bending and forming, heat treatment is required (for all thicknesses, and with temperature and duration as given in Table GR-3.6.1-1) when any of the following conditions exist:

(1) for P-Nos. 1 through 5A and 5B materials, where the maximum calculated fiber elongation after bending or forming exceeds 50% of specified basic minimum elongation (in the direction of severest forming) for the applicable specification, grade, and thickness. This requirement may be waived if it can be demonstrated that the selection of pipe and the choice of bending or forming process provide assurance that, in the finished condition, the most severely strained material retains at least 10% elongation.

(2) for any material requiring impact testing, where the maximum calculated fiber elongation after bending or forming will exceed 5%.

(3) when specified in the engineering design.

GR-3.9.2 Post-Heat Treatment

Post-heat treatment, when required for pipe components after bending or forming, shall be performed in accordance with para. GR-3.6, including Table GR-3.6.1-1.

GR-3.10 HARDNESS TESTING

Hardness testing shall be conducted for welding procedure qualification tests for those materials with acceptance criteria described in Table GR-3.10-1. Base metal for welding procedure qualification tests shall be made from the same base metal specification (same P-Number and Group Number), similar in chemistry, and in the same heat treatment condition as specified for the piping. The thickness of base metal coupons shall not be less than the piping.

(a) Method

(1) The hardness survey shall be performed on a transverse weld cross section that has been polished and etched to identify the weld metal, fusion line, and HAZ.

(2) The hardness test shall be carried out in accordance with ASTM E92 using a 10-kg load. Other hardness testing methods for welding procedure qualification may be used when permitted by the engineering design.

(3) Two Vickers hardness traverses of the weld joint should be made on a weld sample in the minimum PWHT condition. These hardness traverses should be performed at 1.5 mm (1/16 in.) from the internal and external surfaces as shown in Figure GR-3.10-1. The HAZ readings should include locations as close as possible [approximately 0.2 mm (0.008 in.)] to the weld fusion line. Each traverse includes 10 hardness readings for a total of 20 hardness readings per weld sample.

(b) Acceptance Criteria

(1) Hardness measurements shall not exceed the limits of Table GR-3.10-1 after the required PWHT. Other hardness testing limits may be used if specified in the engineering design.

(2) The hardness data shall be reported on the PQR.

Table GR-3.10-1 Hardness Testing Acceptance Criteria

<table>
<thead>
<tr>
<th>Base Metal P-No.</th>
<th>Base Metal Group</th>
<th>Vickers HV 10 Max. Hardness [Note (2)]</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Carbon steel</td>
<td>235</td>
</tr>
<tr>
<td>3</td>
<td>Alloy steels, Cr ≤ $\frac{1}{2}$%</td>
<td>235</td>
</tr>
<tr>
<td>4</td>
<td>Alloy steels, $\frac{1}{2}$% &lt; Cr ≤ 2%</td>
<td>235</td>
</tr>
<tr>
<td>5A, 5B</td>
<td>Alloy steels, 2$\frac{1}{2}$% &lt; Cr ≤ 10%</td>
<td>248</td>
</tr>
</tbody>
</table>

NOTE:

(1) P-Number from ASME BPVC, Section IX, QW/QB-422.

(2) When other hardness testing methods are used, the acceptance criteria shall be equivalent to these Vickers HV 10 values.