Comments must be submitted on the attached Public Review Comment Form

Draft 2015 Edition

Deleted items are designated by strikethrough. Additions are designated by double underline.
National Board of Boiler and Pressure Vessel Inspectors
National Board Inspection Code
Submission of Public Review Comment
2015 Draft Edition

Comments Must be Received No Later Than: October 13, 2014

Instructions: If unable to submit electronically, please print this form and fax or mail. Print or type clearly.

Date: ____________________________

Commenter Name: ____________________________________________

Commenter Address: ___________________________________________
_________________________________________________________________

Commenter Phone: ________________________________

Commenter Fax: _____________________________________________

Commenter Email: ____________________________________________

Section/Subsection Referenced: _________________________________

Comment/Recommendation: ____________________________________

Proposed Solution: □ New Text □ Revise Text □ Delete Text

_____________________________________________________________

_____________________________________________________________

_____________________________________________________________

_____________________________________________________________

_____________________________________________________________

Source: □ Own Experience/Idea □ Other Source/Article/Code/Standard

Submit Form To: Robin Hough, Secretary, NBIC Committee, The National Board of Boiler & Pressure Vessel Inspectors, 1055 Crupper Avenue, Columbus, OH 43229, fax 614-847-1828, email, rhough@nationalboard.org

NB Use Only

Commenter No. Issued: ____________________________ Project Committee Referred To:

Comment No. Issued: ____________________________
1.1 **SCOPE**

NBIC Part 1 provides requirements for the installation of power boilers, steam heating boilers, hot-water heating boilers, hot-water supply boilers, potable water heaters, pressure vessels and piping.

1.5 **CHANGE OF SERVICE**

See NBIC Part 2, Supplement 9 for requirements and guidelines to be followed when a change of service or service type is made to a pressure retaining item.

Whenever there is a change of service, the jurisdiction where the pressure retaining item is to be operated, shall be notified for acceptance, when applicable. Any specific jurisdictional requirements shall be met.

2.1 **SCOPE**

NBIC Part 1, Section 12 provides requirements for the installation of power boilers, as defined in NBIC Part 1, 2.2, Definitions. For installation of items that do not fall within the scope of NBIC Part 1, Section 1, refer to the applicable Sections of NBIC Part 1:

2.3.3 **CLEARANCES**

c) Boilers with a top-opening manhole shall have at least 84 in. (2135 mm) of unobstructed clearance above the manhole to the ceiling of the boiler equipment room.

2.4 **BOILER ROOM EQUIPMENT ROOM REQUIREMENTS**

2.4.1 **EXIT**

Two means of exit shall be provided for boiler room equipment rooms exceeding 500 sq. ft. (46.5 sq. m) floor area and containing one or more boilers having a combined fuel capacity of 1,000,000 Btu/hr (293 kW) or more. Each elevation shall be provided with at least two means of exit, each to be remotely located from the other. A platform at the top of a single boiler is not considered an elevation.

2.4.3 **DRAINS**

At least one floor drain shall be installed in the boiler room equipment room.

2.4.4 **WATER (Cleaning)**

A convenient water supply shall be provided for flushing out the boiler and its appurtenances, adding water to the boiler while it is not under pressure, and cleaning the boiler room equipment room floor.

2.5.1.3 **PUMPS**

a) Boiler feedwater pumps shall have discharge pressure in excess of the boiler rated pressure (MAWP) in-order to compensate for frictional losses, entrance losses, regulating valve losses, and normal static head, etc. Each source of
feedwater shall be capable of supplying feedwater to the boiler at a minimum pressure of 3% higher than the highest setting of any safety valve on the boiler plus the expected pressure drop across the boiler. The following table is a guideline for estimating feedwater pump differential:

Table 2.5.1.3

Guide for Feedwater Pump Differential

<table>
<thead>
<tr>
<th>Boiler Pressure (psig)</th>
<th>Boiler Feedwater Pump Discharge Pressure (psig)</th>
</tr>
</thead>
<tbody>
<tr>
<td>(1.38)</td>
<td>(1.72)</td>
</tr>
<tr>
<td>(2.76)</td>
<td>(3.28)</td>
</tr>
<tr>
<td>(5.52)</td>
<td>(6.38)</td>
</tr>
<tr>
<td>(8.27)</td>
<td>(9.31)</td>
</tr>
</tbody>
</table>

2.5.3 ELECTRICAL

A disconnecting means capable of being locked in the open position shall be installed at an accessible location at the boiler so that the boiler can be disconnected from all sources of potential. This disconnecting means shall be an integral part of the boiler or adjacent to it.

2.5.3.2 REMOTE EMERGENCY SHUTDOWN SWITCHES

a) A manually operated remote shutdown switch or circuit breaker shall be located just outside the equipment room boiler room door and marked for easy identification. Consideration should also be given to the type and location of the switch in order to safeguard against tampering.

b) For boiler rooms exceeding 500 sq. ft. (46.5 sq. m) floor area or containing one or more boilers having a combined fuel capacity of 1,000,000 Btu/hr (293kW) or more, additional manually operated remote emergency shutdown switches shall be located at suitably identified points of egress acceptable to the Jurisdiction.

c) Where a boiler is located indoors in a facility and not in a equipment room boiler room, a remote emergency shutdown switch shall be located within 50 feet of the boiler along the primary egress route from the boiler area.

2.5.4 VENTILATION AND COMBUSTION AIR

a) The equipment room shall have an adequate air supply to permit clean, safe combustion, minimize soot formation, and maintain a minimum of 19.5% oxygen in the air of the boiler room. The combustion and ventilation air should be supplied by either an unobstructed air opening or by power ventilation or fans.\(^1\)

b) Unobstructed air openings shall be sized on the basis of 1 sq. in. (650 sq. mm) free area per 2000 Btu/hr (586 W) maximum fuel input of the combined burners located in the equipment room, or as specified in the National Fire Protection Association (NFPA) standards for oil and gas burning installations for the particular job conditions. The equipment room air supply openings shall be kept clear at all times.

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\(^1\) Fans – When combustion air is supplied to the boiler by an independent duct, with or without the employment of power ventilators or fans, the duct shall be sized and installed in accordance with the manufacturer’s recommendations. However, ventilation for the equipment room must still be considered.
c) Power ventilators or fans shall be sized on the basis of 0.2 cfm (0.0057 cu meters per minute) for each 1000 Btu/hr (293 W) of maximum fuel input for the combined burners of all boilers located in the equipment room. Additional capacity may be required for any other fuel-burning equipment in the boiler room.

2.5.5 LIGHTING

The equipment room should be well lighted and it should have an emergency light source for use in case of power failure.

2.6.3.2 PRESSURE RATING

a) When the maximum allowable working pressure of the boiler is equal to or less than 100 psig (700 kPa), the drain pipe, valve, and fittings shall be rated for at least 100 psig (700 kPa) and 220°F (104°C).

b) When the maximum allowable working pressure of the boiler exceeds 100 psig (700 kPa), the drain pipe, valve, and fittings shall be rated for at least the maximum allowable working pressure and temperature of the boiler.

Drain piping from the drain connection, including the required valve(s) or the blanked flange connection, shall be designed for the temperature and pressure of the drain connection. The remaining piping shall be designed for the expected maximum temperature and pressure. Static head and possible choked flow conditions shall be considered. In no case shall the design pressure and temperature be less than 100 psig (690-700 kPa (gage)) and 220°F (105-104°C), respectively.

2.7.3 STEAM SUPPLY

f) Ample provision for an ample gravity drain shall be provided when a stop valve is so located that water or condensation may accumulate. The gravity drain(s) shall be located such that the entire steam supply system can be drained.

2.9.4 ECONOMIZERS

An economizer that may not be isolated from a boiler does not require a safety relief valve. Economizers that may be isolated from a boiler or other heat transfer device, allowing the economizer to become a fired pressure vessel, shall have a minimum of one safety relief valve. Discharge capacity, rated in lbs/hr (kg/hr), of the safety relief valve or valves shall be calculated from the maximum expected heat absorption rate in Btu/hr (Joules/hr) of the economizer, and will be determined from manufacturer data, divided by 1000. The safety relief valve shall be installed in a location recommended by the manufacturer, when no recommendation exists the location shall be as close as practical to the economizer outlet.

2.9.6 MOUNTING AND DISCHARGE REQUIREMENTS

h) All safety or safety relief valves shall be piped to a safe point of discharge so located or piped as to be carried clear from running boards or platforms. Ample provision for an ample gravity drain shall be made in the discharge pipe at or near each safety or safety relief valve, and where water or condensation may collect.
2.11 TABLES AND FIGURES

a) NBIC Part 1, Table 2.5.1.3 - Guide for Feedwater Pump Differential

3.1 SCOPE

The scope of NBIC Part 1, Section 3 shall apply to steam heating boilers, hot-water heating boilers, hot-water supply boilers, and potable water heaters, as defined in NBIC Part 1, 3.2, Definitions. For installation of items that do not fall within the scope of this Section, refer to the applicable sections:

NBIC Part 1, Section 2 – Power Boilers
NBIC Part 1, Section 4 – Pressure Vessels
NBIC Part 1, Section 5 – Piping

3.4 EQUIPMENT ROOM REQUIREMENTS

3.4.1 EXIT

Two means of exit shall be provided for equipment rooms exceeding 500 sq. ft. (46.5 sq. m) of floor area and containing one or more boilers having a combined fuel capacity of 1,000,000 Btu/hr (293 kW) or more (or equivalent electrical heat input). Each elevation shall be provided with at least two means of exit, each to be remotely located from the other. A platform at the top of a single boiler is not considered an elevation.

3.5.3.1 STEAM HEATING, HOT WATER HEATING, AND HOT WATER SUPPLY BOILERS

b) A manually operated remote shutdown switch or circuit breaker shall be located just outside the equipment room door and marked for easy identification. Consideration should also be given to the type and location of the switch to safeguard against tampering.

c) A disconnecting means capable of being locked in the open position shall be installed at an accessible location at the boiler so that the boiler can be disconnected from all sources of potential. This disconnecting means shall be an integral part of the boiler or adjacent to it.

d) If the equipment room door is on the building exterior, the switch shall be located just inside the door. If there is more than one door to the equipment room, there shall be a switch located at each door of egress.

3.5.3.2 POTABLE WATER HEATERS

a) All wiring for controls, heat generating apparatus, and other appurtenances necessary for the operation of the potable water heaters shall be installed in accordance with the provisions of national or international standards and comply with the applicable local electrical codes.

b) A manually operated remote shutdown switch or circuit breaker shall be located just outside the equipment room door and marked for easy identification. Consideration should also be given to the type and location of the switch to safeguard against tampering.
c) A disconnecting means capable of being locked in the open position shall be installed at an accessible location at the heater so that the heater can be disconnected from all sources of potential. This disconnecting means shall be an integral part of the heater or adjacent to it.

d) If the equipment room door is on the building exterior, the switch shall be located just inside the door. If there is more than one door to the equipment room, there shall be a switch located at each door of egress.

3.5.3.3 CONTROLS AND HEAT GENERATING APPARATUS

3.5.4 VENTILATION AND COMBUSTION AIR

a) The equipment room shall have an adequate air supply to permit clean, safe combustion, minimize soot formation, and maintain a minimum of 19.5% oxygen in the air of the boiler room. The combustion and ventilation air may be supplied by either an unobstructed air opening or by power ventilation or fans.2

b) Unobstructed air openings shall be sized on the basis of 1 sq. in. (645 sq mm) free area per 2000 Btu/hr (586 W) maximum fuel input of the combined burners located in the equipment room, or as specified in the National Fire Protection Association (NFPA) standards for oil and gas burning installations for the particular job conditions. The equipment room air supply openings shall be kept clear at all times.

c) Power ventilators or fans shall be sized on the basis of 0.2 cfm (.0057 cu meters per minute) for each 1,000 Btu/hr (293 W) of maximum fuel input for the combined burners of all boilers and/or water heaters located in the equipment room. Additional capacity may be required for any other fuel burning equipment in the equipment room.

3.6.3 DRAINS

Unobstructed floor drains, properly located in the equipment room, will facilitate proper cleaning of the equipment room. Floor drains that are used infrequently should have water poured into them periodically to prevent the entrance of sewer gasses and odors. If there is a possibility of freezing, an environmentally safe antifreeze mixture should be used in the drain traps. Drains receiving blowdown water should be connected to the sanitary sewer by way of an acceptable blowdown tank or separator or an air gap that will allow the blowdown water to cool to at least 140°F (60°C) and reduce the pressure to 5 psig (34 kPa) or less.

Table 3.7.7.1 Size of bottom blowoff piping, valve, and cocks

<table>
<thead>
<tr>
<th>Minimum Required Safety Valve Capacity, lbs. of steam/hr (Note 1)</th>
<th>Blowoff Piping, Valve, and Cock Sizes, in.(mm)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Up to 500 (up to 227 kg)</td>
<td>% (19)</td>
</tr>
<tr>
<td>501 to 1,250 (over 227 kg to 567 kg)</td>
<td>1 (25)</td>
</tr>
<tr>
<td>1,251 to 2,500 (227 kg to 1 134 kg)</td>
<td>1-1/4 (32)</td>
</tr>
<tr>
<td>2,501 to 6,000 (over 1 134 to 2 722 kg)</td>
<td>1-1/2 (38)</td>
</tr>
</tbody>
</table>

2 Fans – When combustion air is supplied to the boiler by an independent duct, with or without the employment of power ventilators or fans, the duct shall be sized and installed in accordance with the manufacturer’s recommendations. However, ventilation for the equipment room must still be considered.
### Table 3.7.9.1-a Expansion Tank Capacities for Gravity Hot-Water Systems

Based on two-pipe system with average operating water temperature 170°F (77°C), using cast-iron column radiation with heat emission rate 150 Btu/hr ft² (473 W/m²) equivalent direct radiation.

<table>
<thead>
<tr>
<th>Installed Equivalent Direct Radiation, ft² (m²) (Note)</th>
<th>No.</th>
<th>Tank Capacity, gallon (l)</th>
</tr>
</thead>
<tbody>
<tr>
<td>up to 350 (33)</td>
<td>1</td>
<td>18 (68)</td>
</tr>
<tr>
<td>up to 450 (42)</td>
<td>1</td>
<td>21 (79)</td>
</tr>
<tr>
<td>up to 650 (60)</td>
<td>1</td>
<td>24 (91)</td>
</tr>
<tr>
<td>up to 900 (84)</td>
<td>1</td>
<td>30 (114)</td>
</tr>
<tr>
<td>up to 1,100 (102)</td>
<td>1</td>
<td>35 (132)</td>
</tr>
<tr>
<td>up to 1,400 (130)</td>
<td>1</td>
<td>40 (151)</td>
</tr>
<tr>
<td>up to 1,600 (149)</td>
<td>2</td>
<td>60 (227)</td>
</tr>
<tr>
<td>up to 1,800 (167)</td>
<td>2</td>
<td>60 (227)</td>
</tr>
<tr>
<td>up to 2,000 (186)</td>
<td>2</td>
<td>70 (265)</td>
</tr>
<tr>
<td>up to 2,400 (223)</td>
<td>2</td>
<td>80 (303)</td>
</tr>
</tbody>
</table>

Note: For systems with more than 2,400 ft² (223 m²) of installed equivalent direct water radiation, the required capacity of the cushion tank shall be increased on the basis of 1 gallon (3.79 l) tank capacity/33 ft² (3.1 m²) of additional equivalent direct radiation.

### Table 3.7.9.1-b Expansion Tank Capacities for Forced Hot-Water Systems

(Based on average operating water temperature 195°F [91°C], fill pressure 12 psig [83 kPa], and maximum operating pressure 29 psig [200 kPa])

<table>
<thead>
<tr>
<th>System Volume, gallon (l)</th>
<th>Pressurized Diaphragm Type</th>
<th>Nonpressurized Type</th>
</tr>
</thead>
<tbody>
<tr>
<td>100 (379)</td>
<td>9 (34)</td>
<td>18 (68)</td>
</tr>
<tr>
<td>200 (757)</td>
<td>17 (64)</td>
<td>30 (114)</td>
</tr>
<tr>
<td>300 (1136)</td>
<td>25 (95)</td>
<td>45 (170)</td>
</tr>
<tr>
<td>400 (1514)</td>
<td>33 (125)</td>
<td>60 (227)</td>
</tr>
<tr>
<td>500 (1893)</td>
<td>42 (159)</td>
<td>75 (284)</td>
</tr>
<tr>
<td>1,000 (3785)</td>
<td>83 (314)</td>
<td>150 (568)</td>
</tr>
<tr>
<td>2,000 (7571)</td>
<td>165 (625)</td>
<td>300 (1 136)</td>
</tr>
</tbody>
</table>

Note: System volume includes volume of water in boiler, radiation, and piping, not including the expansion tank. Expansion tank capacities are based on an acceptance factor of 0.4027 for pre pressurized types and 0.222 for nonpressurized types.

For other cases or metric calculations see Chapter 12 of the 1996 HVAC Systems and Equipment Volume of the ASHRAE Handbook.
Table 3.7.9.2 Expansion Tank Capacities for a Potable Water Heater (Note)

<table>
<thead>
<tr>
<th>System Volume</th>
<th>Prepressurized Diaphragm Type</th>
<th>Nonpressurized Type</th>
</tr>
</thead>
<tbody>
<tr>
<td>50 (189)</td>
<td>1 (4)</td>
<td>3 (11)</td>
</tr>
<tr>
<td>100 (379)</td>
<td>2 (8)</td>
<td>6 (23)</td>
</tr>
<tr>
<td>200 (757)</td>
<td>3 (11)</td>
<td>12 (45)</td>
</tr>
<tr>
<td>300 (1140)</td>
<td>4 (15)</td>
<td>18 (68)</td>
</tr>
<tr>
<td>400 (1514)</td>
<td>5 (19)</td>
<td>24 (91)</td>
</tr>
<tr>
<td>500 (1893)</td>
<td>6 (23)</td>
<td>30 (114)</td>
</tr>
<tr>
<td>1,000 (3785)</td>
<td>12 (45)</td>
<td>60 (227)</td>
</tr>
<tr>
<td>2,000 (7571)</td>
<td>24 (91)</td>
<td>120 (454)</td>
</tr>
</tbody>
</table>

Note: Capacities in this table are given as a guide to reduce or eliminate relief valve weeping under conditions of partial water system demands or occasional water draw during recovery.

System volume includes water heater capacity plus all piping capacity for a recirculation system or potable water heater capacity only for a non-recirculation system.

The capacities are based upon a water temperature rise from 40°F to 180°F (4°C to 82°C), 60 psig (414 kPa) fill pressure, maximum operating pressure of 125 psig (862 kPa) 20% water recovery, and an acceptance factor of 0.465 for pre-pressurized types, and 0.09156 for non-pressurized types. For other cases or metric calculations see Chapter 12 of the 1996 HVAC Systems and Equipment Volume of the ASHRAE Handbook.
Table 3.9.2 – Maximum Pounds of steam per hour per square foot of Heating Surface
lb steam/hr ft² (kg steam/hr m²)

<table>
<thead>
<tr>
<th>Boiler Heating Surface</th>
<th>Firetube Boiler</th>
<th>Watertube Boiler</th>
</tr>
</thead>
<tbody>
<tr>
<td>lb steam/hr ft² (kg steam/hr m²)</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

4.1 SCOPE

NBIC Part 1, Section 4 provides requirements for the installation of pressure vessels. as defined in NBIC Part 1, Section 9 Definitions. For installation of items that do not fall within the scope of this Section, refer to the applicable Section:

NBIC Part 1, Section 2 – Power Boilers
NBIC Part 1, Section 5 – Piping

4.5.4 CAPACITY

f) The owner shall make information regarding the basis of pressure relief device selection, including required capacity, available to the Jurisdiction.

Section 4 – Pressure Vessels

Section 5 – Piping

5.1 SCOPE

NBIC Part 1, Section 5 provides requirements for the installation of piping. for installation of items that do not fall within the scope of this Section, refer to the applicable Sections:

NBIC Part 1, Section 2 – Power Boilers
S3.4 GAS DETECTION SYSTEMS

Rooms or areas where carbon dioxide storage vessel(s) are located indoors or in enclosed or below grade outdoor locations shall be provided with a gas detection and alarm system for general area monitoring that is capable of detecting and notifying building occupants of a CO₂ gas release. Alarms will be designed to activate a low level pre-alarm at 5,000 ppm 1.5% concentration of CO₂ and a full high alarm at 30,000 ppm 3% concentration of CO₂ which is the NIOSH & ACGIH 15 minute Short Term Exposure Limit for CO₂. These systems are not designed for employee personal exposure monitoring. Gas detection systems shall be installed and tested in accordance with manufactures installation instructions and the following requirements:

### Table S2.5 Pipe Data

<table>
<thead>
<tr>
<th>Nominal Pipe Size, Unitless (US Customary)</th>
<th>Nominal Pipe Size, Unitless (SI Metric)</th>
<th>Average Outside Diameter (D)</th>
<th>Average Outside Diameter (D)</th>
<th>Nominal Wall Thickness Standard Weight Pipe (t)</th>
<th>Nominal Wall Thickness Standard Weight Pipe (t)</th>
<th>Approximate Internal Area (Note 1)</th>
<th>Approximate Internal Area (Note 1)</th>
</tr>
</thead>
<tbody>
<tr>
<td>NPS 3/8</td>
<td>DN 10</td>
<td>0.675</td>
<td>17.1</td>
<td>0.091</td>
<td>2.31</td>
<td>0.191</td>
<td>122</td>
</tr>
<tr>
<td>NPS 1/2</td>
<td>DN 15</td>
<td>0.840</td>
<td>21.3</td>
<td>0.109</td>
<td>2.77</td>
<td>0.304</td>
<td>195</td>
</tr>
<tr>
<td>NPS 3/4</td>
<td>DN 20</td>
<td>1.050</td>
<td>26.7</td>
<td>0.113</td>
<td>2.87</td>
<td>0.533</td>
<td>345</td>
</tr>
<tr>
<td>NPS 1</td>
<td>DN 25</td>
<td>1.315</td>
<td>33.4</td>
<td>0.133</td>
<td>3.38</td>
<td>0.864</td>
<td>557</td>
</tr>
<tr>
<td>NPS 1-1/4</td>
<td>DN 32</td>
<td>1.660</td>
<td>42.2</td>
<td>0.140</td>
<td>3.56</td>
<td>1.496</td>
<td>967</td>
</tr>
<tr>
<td>NPS 1-1/2</td>
<td>DN 40</td>
<td>1.900</td>
<td>48.3</td>
<td>0.145</td>
<td>3.68</td>
<td>2.036</td>
<td>1,316</td>
</tr>
<tr>
<td>NPS 2</td>
<td>DN 50</td>
<td>2.375</td>
<td>60.3</td>
<td>0.154</td>
<td>3.91</td>
<td>3.356</td>
<td>2,163</td>
</tr>
<tr>
<td>NPS 2-1/2</td>
<td>DN 65</td>
<td>2.875</td>
<td>73.0</td>
<td>0.203</td>
<td>5.16</td>
<td>4.788</td>
<td>3,086</td>
</tr>
<tr>
<td>NPS 3</td>
<td>DN 80</td>
<td>3.500</td>
<td>88.9</td>
<td>0.216</td>
<td>5.49</td>
<td>7.393</td>
<td>4,769</td>
</tr>
<tr>
<td>NPS 3-1/2</td>
<td>DN 90</td>
<td>4.000</td>
<td>101.6</td>
<td>0.226</td>
<td>5.74</td>
<td>9.887</td>
<td>6,379</td>
</tr>
<tr>
<td>NPS 4</td>
<td>DN 100</td>
<td>4.500</td>
<td>114.3</td>
<td>0.237</td>
<td>6.02</td>
<td>12.73</td>
<td>8,213</td>
</tr>
<tr>
<td>NPS 5</td>
<td>DN 125</td>
<td>5.563</td>
<td>141.3</td>
<td>0.258</td>
<td>6.55</td>
<td>20.00</td>
<td>12,908</td>
</tr>
<tr>
<td>NPS 6</td>
<td>DN 150</td>
<td>6.625</td>
<td>168.3</td>
<td>0.280</td>
<td>7.11</td>
<td>28.89</td>
<td>18,646</td>
</tr>
<tr>
<td>NPS 8</td>
<td>DN 200</td>
<td>8.625</td>
<td>219.1</td>
<td>0.332</td>
<td>8.18</td>
<td>49.78</td>
<td>32,283</td>
</tr>
<tr>
<td>NPS 10</td>
<td>DN 250</td>
<td>10.750</td>
<td>273.0</td>
<td>0.365</td>
<td>9.27</td>
<td>78.85</td>
<td>50,854</td>
</tr>
<tr>
<td>NPS 12</td>
<td>DN 300</td>
<td>12.750</td>
<td>323.8</td>
<td>0.375</td>
<td>9.53</td>
<td>113.1</td>
<td>72,937</td>
</tr>
</tbody>
</table>

Note 1: In applying these rules, the area of the pipe is always based upon standard weight pipe and the inlet size of the pressure-reducing valve.

Where: \( D = \) outside diameter of the pipe and \( t = \) nominal wall of the pipe

\[
\text{Area} = \pi \cdot \left(\frac{D - 2 \cdot t}{2}\right)^2
\]
S3.5 SIGNAGE

Warning signs shall be posted at the entrance to the building, room, enclosure, or enclosed area where the container is located. The warning sign shall be at least 8 in (200mm) wide and 6 in. (150mm) high. The wording shall be concise and easy to read and the upper portion of the sign must be orange as shown in figure NBIC Part 1, S3.5. The size of the lettering must be as large as possible for the intended viewing distance and in accordance with jurisdictional requirements. When no jurisdictional requirements exist, the minimum letter height shall be in accordance with NEMA American National Standard for Environmental and Facility Safety Signs (ANSI Z535.2). The warning signs shall state the following as shown in Figure S3.5:

Additional instructional signage shall be posted outside of the area where the container is located and such signage shall contain at minimum the following information:

a) Carbon Dioxide Monitors for general area monitoring (not employee personal exposure monitoring) are provided in this area. These monitors are set to alarm at 15,000 ppm (1.5% concentration) for the low level alarm and at 30,000 ppm (3% concentration) for high level alarm.

b) Low Level Alarm (15,000 ppm) – Provide appropriate cross ventilation to the area. Personnel may enter area for short periods of time (not to exceed 15 minutes at a time) in order to identify and repair potential leaks.

c) High Level Alarm (30,000 ppm) – Personnel should evacuate the area and nobody should enter the affected area without proper self-contained breathing apparatus until the area is adequately ventilated and the concentration of CO₂ is reduced below the high alarm limit.

S3.6 VALVES, PIPING, TUBING, AND FITTINGS

d) Safety Relief/Vent Lines – Safety relief/vent lines shall be as short and straight as possible with a continuous routing to an unenclosed area outside the building and installed in accordance with the manufacturer’s instructions. The vent line(s) shall be a continuous run from the vessel PRD vent piping safety relief valve to the outside vent line discharge fitting, without any splices. Mechanical joints in metallic piping and tubing shall be visible and inspectable. Any splices in plastic or polymeric tubing shall be done within three feet of the vessel and must be visible and inspectable. These lines shall be free of physical defects such as cracking or kinking and all connections shall be securely fastened to the LCDSV and the fill box. All safety relief/vent lines shall be protected by metallic protection to prevent penetration by nail, projectile, or other foreign object when routed through a wall, floor, or ceiling. The minimum size and length of the lines shall be in accordance with NBIC Part 1, Tables S3.6-a and S3.6-b. Fittings or other connections may result in a localized reduction in diameter have been factored into the lengths given by the NBIC Part 1, Tables S3.6-a and S3.6-b. Note: Due to the design of the LCDSV the discharge line may be smaller in diameter than the relief valve outlet size but shall not be smaller than that shown in NBIC Part 1, Tables S3.6-a and S3.6-b.NB14-0408.
SUPPLEMENT 4
INSTALLATION OF BIOMASS (WOOD/SOLID FUEL) FIRED BOILERS

S4.1 SCOPE

This supplement provides requirements for the installation of Biomass (Wood/Solid Fuel) Fired Boilers as defined in NBIC Part 1, Section 9.

S4.2 PURPOSE

a) The purpose of these rules is to establish minimum requirements, for the installation of Biomass Boilers.

b) It should be recognized that many of the requirements included in these rules must be considered in the design of the boiler by the manufacturer. However, the owner-user is responsible for ensuring that the installation complies with all the applicable requirements contained herein. Further the installer is responsible for complying with the applicable sections when performing work on the behalf of the owner user.

c) This supplement provides requirements for the installation and control of boilers which use biomass as a major fuel component and will address the differences that occur when solid fuels, such as Biomass, are being used. Thus the primary thrust of this section will be directed toward the control of the fuel handling and distribution systems.

d) Fuels will vary widely depending upon source, moisture content, particle size and distribution, however once the fuel has been established, the owner-user should adhere to the original specification, as closely as possible in order to minimize handling, combustion and emissions problems.

e) Additionally the emissions control equipment is designed around the initial fuel specification. Any changes in fuel fired will impact on the performance of the various elements of the emissions control system.

f) Biomass boilers and boiler rooms require additional considerations than traditionally fueled boilers that may include

1) Transportation of the fuel from a storage facility to a metering device within the boiler room

2) Transportation of the metered fuel to the boiler, for distribution to a combustion system whether it be a grate upon which the combustion takes place, a bubbling fluidized bed, circulating fluidized bed or suspension burner.

3) In grate based combustion systems combustion air is typically divided into an underfire air system and an overfire air system, each of which must be closely controlled in order to produce clean, efficient combustion.

4) Induced draft fans to overcome the pressure drop of the emissions control equipment

5) A fly ash or carbons recycle system, to return unburned carbon to the combustion zone.

6) An ash removal system, to move ash from the boiler and emissions control equipment to suitable cooling and storage area.

S4.3 DETERMINATION OF ALLOWABLE OPERATING PARAMETERS

The allowable operating parameters of the combustion side shall be installed in accordance with jurisdictional and environments requirements, manufacturer’s recommendations, and/or industrial standards, as applicable.
S4.4 GENERAL REQUIREMENTS

a) Power Boilers utilizing biomass as the primary fuel source shall meet the requirements of NBIC Part 1, Section 2 and this Supplement.

b) Steam Heating, Hot Water Heating, and Hot Water Supply Boilers utilizing biomass as the primary fuel source shall meet the requirements of NBIC Part 1, Section 3 and this Supplement.

S4.5 FUEL SYSTEM REQUIREMENTS AND CONTROLS

a) Fuel Transport Systems shall address preserving fuel particle size distribution, fire prevention, and the suppression of fires or explosions. In a single installation various types of fuel transportation systems may co-exist, the most common systems are:

1) Conveyor systems - In these systems fuel is dropped onto a moving belt, bucket elevator, drag link conveyor or a screw or auger mechanism. Speed of the conveyor may be varied to meet fuel demand.

2) Lean phase pneumatic systems - In these systems fuel is dropped into a moving airstream, mixes with the air, and travels through a pipe at a velocity of approximately 5000 ft/min. (1525 m/min) Air pressures are in the region of 25 inches (635 mm) water column.

3) Dense phase pneumatic systems – An intermittent or batch feed system, in which fuel is dropped through a valve (dome valve) into a pressure vessel. When the vessel is filled, the valve is closed, air at a pressure between 30 to 100 psig (207 to 690 kPa) is admitted and the fuel leaves the vessel in the form of a “slug”. The sequence then repeats. (Note that these systems are also used for ash handling.)

b) Fuel Transport Solid Fuel Metering Systems vary depending upon the fuel used and the particle size distribution, these metering systems include but are not limited to:

1) Variable speed augers

   a) Variable speed, helically flighted, augers can be located in the bottom of a fuel metering bin. Alternatively they could be a part of a retort type stoker. The auger dimensions, flighting, and speed range are selected on the basis of fuel being burned, its size range, heating value and required boiler turndown range. The metered fuel typically is then dropped into the throat of a venturi, (or in some cases a plain pipe) though which the fuel transport air flows to carry the fuel into the boiler combustion zone, for distribution on a grate, upon which the burning of the fuel takes place.

2) Variable speed air-lock valves

   a) This valve is basically a rotating slotted cylinder, operating within an outer cylinder, suitably sealed to prevent leakage. Rotational speed and slot dimensions can be varied to accommodate changes in fuel flow rate. The fuel passing through the valve, typically, is deposited onto a moving grate type stoker.

3) Variable stroke rams

   a) This is another device that can be located on the bottom of a metering bin, is typically used on smaller units and is essentially a batch feed mechanism. The stroke of the ram is adjusted to set fuel flow rate.
S4.6 COMBUSTION REQUIREMENTS

a) Overfire Air/Underfire Air Distribution

When solid fuels are burned on a grate, rather than in fluidized bed units or in suspension, it is normal practice to introduce some of the combustion air under the grate, or bed, and the remainder over the bed. In many cases fuel transport air becomes a part of the over-the-bed combustion air. The proportioning of the overfire to underfire airflow rates is dependent upon several factors, such as fuel particle size, fuel density, burn rate and volatiles. In general the objective is to get as complete a burn on the grate as possible, without creating large quantities of particulate emissions, and then using the overfire air to complete burning of the volatile and small particulate matter, leaving the fuel bed.

Loss of combustion air from either the underfire or overfire source shall cause shutoff of the fuel supply and a lockout condition. The control system shall be capable of maintaining the correct relationship between underfire air and overfire air, over the complete firing range of the boiler, while promoting complete burning with minimum particulate emissions.

b) Programming Controls

Programming controls may be relay based, or on more current units, PLC based. Interactive graphics displays may also be incorporated into the system. Access to PLC based controls and interactive graphic displays shall be limited to qualified individuals and password protected. PLC functions shall be confined to the normal boiler operating logic, covering startup, interlocks, and normal shutdown sequences. PLC logic shall not interfere with, or over-ride safety controls, which cause boiler safety shutdown when activated. The PLC logic shall comply with the requirements of NFPA-85.

c) Pre-firing Checks/interlocks

In addition to the Safety Controls defined in NBIC Part 2, Sections S4.5, S4.6 a), and S4.6b), prove that the following air handling fans are operating properly shall be required.

1) Induced draft fans
2) Fuel transport fans
3) Underfire air and Overfire air fans, and
4) Carbon, or flyash, re-injection fans.

In cases where variable speed drives are used on fans, the combustion system manufacturer’s instructions shall be followed in terms of the allowable upper and lower limits of the power supply frequency (Hz).

d) Pre-purging

Pre-purging the boiler and its venting system shall be required. Unless defined otherwise by the manufacturer of the fuel burning equipment, the pre-purge may be achieved by operating the induced draft fan prior to starting the remaining fans in the installation.

Purge air volume shall be set during commissioning by the combustion system manufacturer, or the manufacturer’s representative, in accordance with applicable Codes or Standards and shall not be capable of being reset by operating
personnel.

e) Ignition Systems

Solid fuel ignition systems and/or methods can vary from the placement of manually ignited, oil soaked rags on the fuel bed, to gas or oil fired pilot burners or lances but in all cases shall be in accordance the manufactures recommendations.

f) Firing Rate Control and Fuel/Air Ratio Control

The control system shall be capable of maintaining the desired air to fuel ratio over the entire firing range of the boiler, while promoting clean, stable combustion.

g) Re-injection Systems

In installations where fly ash is re-injected from a multi-cyclone collector into the combustion zone for carbon re-burn; precautions should be taken to ensure that plugging of the reinjection pipe work does not occur. Consideration should be given to installing cleanouts in the pipe work.

h) Shutdown and Post Purge

Unless the boiler manufacturer’s instructions state otherwise, the fuel supply shall be terminated at shutdown, and the overfire air should remain on until the fuel bed is burned out, and the residue cooled.

SUPPLEMENT 5
INSTALLATION OF THERMAL FLUID HEATERS

S5.1 SCOPE

This Supplement describes guidelines for the installation of a thermal fluid heater. A thermal fluid heater system consists of the heater, expansion tank, circulating pump, safe catchment with the proper piping and controls to heat jacketed kettles, presses, reactors, ovens, exchangers, etc. The scope does not include thermal fluid vaporizers.

S5.2 DEFINITION

Thermal fluid: a fluid (other than water) that is chemically stable over a large temperature range and is specifically designed for use as a heat transfer medium.

Thermal fluid heater: a closed loop liquid phase heater (flooded pressure vessel) in which the heat transfer media is heated but no vaporization takes place within the vessel. Depending on the fluid selection and operating parameters, systems may be open or closed to the atmosphere. Closed systems may be pressurized with an inert gas blanket.

Thermal fluid vaporizer: a heater in which the thermal fluid is vaporized within the pressure vessel.

S5.3 GENERAL REQUIREMENTS

S5.3.1 SUPPORTS, FOUNDATIONS, AND SETTINGS

Each thermal fluid heater and its associated piping must be safely supported. Design of supports, foundations, and settings shall consider vibration (including seismic where necessary), movement (including thermal movement), and loadings.
(including the weight of the fluid in the system) in accordance with jurisdictional requirements, manufacturer’s recommendations, and/or other industry standards, as applicable.

S5.3.2 STRUCTURAL STEEL

a) If the thermal fluid heater is supported by structural steel work, the steel supporting members shall be so located or insulated that the heat from the furnace will not affect their strength.

b) Structural steel shall be installed in accordance with jurisdictional requirements, manufacturer’s recommendations, and/or other industry standards, as applicable.

S5.3.3 SETTINGS

The thermal fluid heater shall be installed on a flat, level, non-combustible surface preferably of concrete to protect against any fire hazard. A 4” containment curb or 2” seal welded drip lip around the thermal fluid heater equipment skid shall be provided.

S5.3.4 CLEARANCES

a) Thermal fluid heater installations shall allow for normal operation, maintenance, and inspections. There shall be at least 18 in. (457 mm) of clearance on each side of the thermal fluid heater to enable access for maintenance and/or inspection activities. Thermal fluid heaters operated in battery shall not be installed closer than 18 in. (457 mm) from each other. The front or rear of any thermal fluid heater shall not be located nearer than 36 in. (915 mm) from any wall or structure.

b) Vertical heaters shall have at least 60 in. (915 mm) clearance from the top of the heater or as recommended by the heater manufacturer.

c) Heaters with a bottom opening used for inspection or maintenance shall have at least 18 in. (350 mm) of unobstructed clearance.

d) NOTE: Alternative clearances in accordance with the manufacturer’s recommendation are subject to acceptance by the Jurisdiction.

S5.4 THERMAL FLUID HEATER ROOM REQUIREMENTS

S5.4.1 EXIT

Two means of exit shall be provided for thermal fluid heater rooms exceeding 500 sq. ft. (46.5 sq. m) floor area and containing one or more thermal fluid heaters having a combined fuel capacity of 1,000,000 Btu/hr (293 kW) or more. Each elevation shall be provided with at least two means of exit, each to be remotely located from the other. A platform at the top of a single thermal fluid heater is not considered an elevation.

S5.4.2 LADDERS AND RUNWAYS

a) All walkways, runways and platforms shall be:

1) Of metal construction:
2) Provided between or over the top of heaters that are more than 8 ft. (2.4 m) above the operating floor to afford accessibility for normal operation, maintenance, and inspection;

3) Constructed of safety treads, standard grating, or similar material and have a minimum width of 30 in. (760 mm);

4) Of bolted, welded, or riveted construction;

5) Equipped with handrails 42 in. (1070 mm) high with an intermediate rail and 4 in. (100 mm) toe-board.

b) Stairways that serve as a means of access to walkways, runways, or platforms shall not exceed an angle of 45 degrees from the horizontal and be equipped with handrails 42 in. (1070 mm) high with an intermediate rail.

c) Ladders that serve as a means of access to walkways, runways, or platforms shall:

1) Be of metal construction and not less than 18 in. (460 mm) wide;

2) Have rungs that extend through the side members and are permanently secured;

3) Have a clearance of not less than 30 in. (760 mm) from the front of rungs to the nearest permanent object on the climbing side of the ladder;

4) Have a clearance of not less than 6-1/2 in. (165 mm) from the back of rungs to the nearest permanent object;

5) Have a clearance width of at least 15 in. (380 mm) from the center of the ladder on either side across the front of the ladder.

d) There shall be at least two permanently installed means of exit from walkways, runways, or platforms that exceed 6 ft. (1.8m) in length.

S5.5 SYSTEM REQUIREMENTS

S5.5.1 THERMAL LIQUIDS (HEAT TRANSFER FLUIDS)

It is extremely important that the proper heat transfer fluid be selected by competent personnel knowledgeable of the system. Heat transfer fluids should meet the following basic requirements:

a) Resist deterioration at the temperatures involved, to assure long useful life and a clean system.

b) Possess good heat transfer characteristics.

c) Have low vapor pressures at operating temperatures to permit operation at moderate pressures. Note: processes requiring thermal fluid temperatures higher than 650°F will require the use of specialty fluids with high vapor pressures (e.g. 150 psi). These fluids also tend to have special environmental, safety and health considerations.

d) Have low viscosities to decrease pumping losses (due to pipe friction) and the power required for circulation.

e) Be suitable for outside temperatures involved to prevent freeze up unless a means of heat trace has been implemented.

f) Meet environmental regulations.
The heat transfer fluid must be kept clean and in proper condition. Tests of the fluid shall be conducted per the fluid manufacturer’s recommendations by approved laboratories. Any heat transfer fluid that is added must be clean and of the proper specification.

**S5.5.2 EXPANSION**

The expansion tank shall have sufficient volume to handle the required expansion of the total system thermal liquid at the required operating temperature.

The expansion tank should be sized so that when the thermal liquid in the system is cold, the tank will be one quarter full or as recommended by the manufacturer. When the system is up to operating temperature, the level of fluid in the expansion tank shall not exceed the manufacturer’s recommendation. A high expansion tank liquid level alarm may be used for indication of high liquid level in the expansion tank(s). An expansion tank low level switch (or similar device) shall be used to ensure the appropriate minimum level of fluid in the tank per the manufacturer’s recommendation. Tripping of this switch should shut down the pump and burner. The activation of this switch should activate an audible alarm and/or light. All expansion tank vents and drains shall be piped to a safe catchment or per the manufacturer’s recommendations.

If the expansion tank is to be pressurized with an inert gas, pressure relief shall be provided in accordance with the code of construction used for the expansion vessel. When a safety relief valve is used, it shall be piped to a safe catchment.

**S5.5.3 CONNECTION**

The circulating pump shall be piped to the thermal fluid heater per the manufacturer’s recommendations. The expansion tank should be installed at an elevation above all piping when possible. If the tank is not at the highest elevation, an inert gas blanket shall be used to pressurize the system to overcome the weight of the fluid above the tank.

a) **Vented** – The expansion tank shall accommodate the NPSH requirements of the circulating pump to provide a Net Positive Suction Head (NPSH) for the circulating pump. For nonpressurized tanks, a vent connection (open to the atmosphere) is part of the design and should be piped to a safe catchment with no valve in the piping.

b) **Pressurized** – The expansion tank may be pressurized with nitrogen or other inert gas as recommended by the fluid manufacturer and provisions made to provide a continuous recommended pressure. The pressure may be adjusted to meet the Net Positive Suction Head requirement of the circulating pump. Compressed air is not recommended as it oxidizes the thermal fluid. Carbon Dioxide is not recommended as it dissolves into the fluid and can create cavitation or other problems in the system.

**S5.5.4 CIRCULATING PUMP**

It is essential that the pump selection be made by competent personnel that are knowledgeable to the requirements of the specific system. Special attention to hot and cold alignment requirements and pump cooling requirements must be considered. The circulating pump must:

a) Provide the required fluid flow across the heater tube surface.

b) Handle the Total System Head.

c) Be specifically designed to handle the thermal fluid at the high temperatures as well as the viscosity requirements of cold start conditions. The pump should be rated for the maximum operating temperature of the fluid. A strainer should
be located in each pump suction piping. Globe valves or other throttling valves should be considered in the pump discharge piping to throttle the pump if necessary to prevent it from running out on its curve. Dual pumps are often installed to provide 100% redundancy in the case of a pump failure. A flexible connection in and out of each pump is recommended.

**S5.5.5 PIPING AND VALVES**

Carbon Steel Pipe such as SA-53 or SA-106 is preferred for the entire piping system. Seamless pipe should be used for thermal fluid piping. Copper, copper alloys, brass, bronze, aluminum or cast iron should not be used as they are incompatible with most thermal fluids. All joints and connections Nominal Pipe Size (NPS) 1” (25 mm) and over (within the flow circuit) should be welded or flanged. Full penetration welds shall be used in the piping. All flange gaskets shall be suitable for the operating temperature, pressure and fluid used. Special attention shall be given to the expansion of the piping due to the high temperatures involved. Valves shall be of steel material compatible for the thermal fluid and temperatures and shall be flanged or weld type manufactured from cast or forged steel or ductile iron. Valve internals and gland seals shall be made from materials suitable for use with high temperature fluids and compatible with the specific fluid utilized in the system. When 2-way valves are utilized in the piping system, a back pressure regulating valve or automatic bypass valve shall be incorporated to ensure the proper flow through the heater at all times regardless of control valve position. If 3-way valves are used, balancing valves should be included.

Design of piping supports should be in accordance with jurisdictional requirements, manufacturer’s recommendations and/or other industry standards as applicable. Thermal insulation used on the pipes and equipment should be selected for the intended purpose and for compatibility with the fluid. Where there is the potential for fluid system leaks (flanged joints etc.), the thermal insulation selected should be non-absorbent. Laminated foam glass or cellular glass (nonabsorbent, closed cell) insulation are examples of suitable insulation.

**S5.5.6 FUEL**

Fuel systems, whether firing on oil, gas or other substances, shall be installed in accordance with jurisdictional and environmental requirements, manufacturer’s recommendations, and/or other industry standards, as applicable.

**S5.5.7 ELECTRICAL**

a) All wiring for controls, heat generating apparatus, and other appurtenances necessary for the operation of the thermal fluid heater(s) should be installed in accordance with the provisions of national or international standards and comply with the applicable local electrical codes.

b) A manually operated remote shutdown switch or circuit breaker shall be located just outside the equipment room door and marked for easy identification. Consideration should also be given to the type and location of the switch to safeguard against tampering.

c) A disconnecting means capable of being locked in the open position shall be installed at an accessible location at the heater so that the heater can be disconnected from all sources of potential. This disconnecting means shall be an integral part of the heater or adjacent to it.

d) If the equipment room door is on the building exterior, the shutdown switch shall be located just inside the door. If there is more than one door to the equipment room, there shall be a shutdown switch located at each door of egress.
For atmospheric-gas burners, and oil burners where a fan is on a common shaft with the oil pump, the complete burner and controls should be shut off. For power burners with detached auxiliaries, only the fuel input supply to the firebox need be shut off.

e) Controls for Heat Generating Apparatus

1) Oil and gas-fired and electrically heated thermal fluid heaters shall be equipped with suitable primary (flame safeguard) safety controls, safety limit switches and controls, and burners or electric elements by a nationally or internationally recognized standard.

2) The symbol of the certifying organization that has investigated such equipment as having complied with a nationally recognized standard shall be affixed to the equipment and shall be considered as evidence that the unit was manufactured in accordance with that standard. Thermal fluid heater shall have:

a. Expansion tank low level switch- liquid level switch (or similar device) interlocked with the circulating pump operation to confirm minimum level in the expansion tank when the system is cold. This interlock prevents pump cavitation. The function of this device shall prevent burner and pump operation if the liquid level is not adequate.

b. Thermal fluid temperature operation control. This temperature actuated control shall shut down the fuel supply when the system reaches a preset operation temperature. This requirement does not preclude the use of additional operation control devices when required.

c. High temperature limit safety switch located on the thermal fluid heater outlet. This limit shall prevent the fluid temperature from exceeding the maximum allowable temperature of the specific fluid. The high temperature limit safety switch set point should be set no higher than the maximum temperature specified by the fluid manufacturer, heater designer or downstream process limits, whichever is lowest. Functioning of this control shall cause a safety shutdown and lockout. The manual rest may be incorporated in the temperature limit control. Where a reset device is separate from the temperature limit control, a means shall be provided to indicate actuation of the temperature sensing element. Each limit and operating control shall have its own sensing element and operating switch.

d. Primary flame safety control for each main burner assembly. This control shall deenergize the main fuel shut off valve and shut off pilot fuel upon loss of flame at the point of supervision. The function of this control shall cause a safety shutdown and lockout.

e. Power burners and mechanical draft atmospheric burners shall provide for the preignition purging of the combustion chamber and flue passes. The purge shall provide no fewer than four air changes or greater as specified by the manufacturer.

f. Proof of flow interlock- thermal fluid heaters require a minimum flow rate to ensure proper velocities and film temperatures through the heater. A low flow condition can cause overheating, degradation of the fluid or heater coil or tube failure. Activation of this interlock shall cause a safety shutdown of the burner and pump. One or more interlocks shall be provided to prove minimum flow through the heater at all operating conditions.

3) In accordance with jurisdictional and environmental requirements, manufacturer’s recommendations, and/or other industry standards, as applicable, Thermal fluid heaters may also have:
a. A high stack temperature switch interlock – in the event of a high stack temperature (indication of improper combustion or cracked coil) this device shall shut off the burner and circulating pump and cause a lockout condition.

b. An inert gas smothering system (steam or CO2) – this system is used to quench combustion in the event of a cracked heater coil or tube. The gas smothering system should be installed per local codes and requirements. A typical system may include two stack limit switches, an alarm and valve to allow inert gas to enter the combustion chamber. One stack limit is set at a value above the typical stack temperature for the equipment (1000 deg. F) and the second is set at 100 deg. F above the first. If the limit is tripped, the pump and burner will shut down. If the second limit is tripped, the inert gas shall enter the combustion chamber to quench the flame.

c. A high inlet pressure switch – this normally closed switch senses pressure at the heater inlet and its setpoint is determined based on the system design pressure when the system is cold. Activation of this switch indicates a restriction in flow and should shutdown the burner and pump and cause a lockout condition.

d. A low inlet pressure switch – this normally open switch senses pressure at the heater inlet and its setpoint is determined based on system pressure when the system is operating at temperature. Activation of this switch indicates a restriction in flow and should shutdown the burner and pump and cause a lockout condition.

e. A high outlet pressure switch – this normally closed switch senses pressure at the heater outlet and its setpoint is determined based on system pressures when the system is at operating temperature. Activation of this switch indicates a restriction in flow and should shutdown the burner and pump and cause a lockout condition. Note: the setpoint of this switch should be lower than the safety relief valve setting.

4) These devices shall be installed in accordance with jurisdictional and environmental requirements, manufacturer’s recommendations, and/or industry standards, as applicable.

5.5.8 VENTILATION AND COMBUSTION AIR

a) The equipment room shall have an adequate air supply to permit clean, safe combustion, minimize soot formation, and maintain a minimum of 19.5% oxygen in the air of the equipment room and sufficient to maintain ambient temperatures as recommended by the heater manufacturer. The combustion and ventilation air should be supplied by either an unobstructed air opening or by power ventilation or fans.3

b) Unobstructed air openings shall be sized on the basis of 1 sq. in. (650 sq. mm) free area per 2000 Btu/hr (586 W) maximum fuel input of the combined burners located in the equipment room, or as specified in the National Fire Protection Association (NFPA) standards for oil and gas burning installations for the particular job conditions. The heater equipment room air supply openings shall be kept clear at all times.

c) Power ventilators or fans shall be sized on the basis of 0.2 cfm (0.0057 cu meters per minute) for each 1000 Btu/hr (293 W) of maximum fuel input for the combined burners of all thermal fluid heaters located in the equipment room. Additional capacity may be required for any other fuel burning equipment in the equipment room. Pressure in the room should be consistently neutral.

3 Fans – When combustion air is supplied to the boiler by an independent duct, with or without the employment of power ventilators or fans, the duct shall be sized and installed in accordance with the manufacturer’s recommendations. However, ventilation for the equipment room must still be considered.
d) When power ventilators or fans are used to supply combustion air they shall be installed with interlock devices so that
the burners will not operate without an adequate number of ventilators/fans in operation.

e) The size of openings specified in (b) may be reduced when special engineered air supply systems approved by the
Jurisdiction are used.

f) Care should be taken to ensure that thermal fluid lines are not routed across combustion air openings, where freezing
may occur in cold climates.

S5.5.9 LIGHTING

The equipment room should be well lighted and it should have an emergency light source for use in case of power failure.

S5.5.10 EMERGENCY VALVES AND CONTROLS

All emergency shut-off valves and controls shall be accessible from a floor, platform, walkway, or runway. Accessibility shall
mean within a 6 ft. (1.8 m) elevation of the standing space and not more than 12 in. (305 mm) horizontally from the
standing space edge.

S5.6 DISCHARGE REQUIREMENTS

S5.6.1 CHIMNEY OR STACK

Chimneys or stacks shall be installed in accordance with jurisdictional and environmental requirements, manufacturer’s
recommendations, and/or industry standards, as applicable.

S5.6.2 DRAINS

A suitable low point drain fitted with a stop valve shall be provided in the heater or connecting piping to allow the heat
transfer media to be drained out of the pressure vessel and/or piping when necessary. The valve may either be locked in the
closed position or a blank flange can be installed downstream of the valve. The valve should never be opened when there is
temperature on the system.

S5.6.3 AIR VENT

A manual air vent valve should be installed on the high point of the system piping. This valve is typically used when filling or
draining the system. The valve should never be opened when there is temperature on the system or when a pressurized
system is utilized.

S5.7 OVERPRESSURE PROTECTION

S5.7.1 GENERAL

Thermal fluid heaters shall be provided with overpressure protection in accordance with the code of construction.

S5.7.2 PRESSURE RELIEF DEVICES

Thermal fluid heaters shall be equipped with one or more pressure relief devices unless the option for overpressure
protection by system design is utilized (when permitted by the original code of construction). When pressure relief devices
are used, the following shall apply:

a) Pressure relief valve(s) shall be of a totally enclosed type and shall not have a lifting lever.

b) Rupture disks may be installed upstream or downstream of the pressure relief valve(s) in accordance with the original code of construction.

c) Pressure relief valves and rupture disks shall be in accordance with the code of construction and designed for liquid, vapor, or combination service as required for the specific installation, service fluids, and overpressure conditions.

d) The inlet connection to the valve shall be not less than NPS ½ (DN 15).

S5.7.3 LOCATION

a) Pressure relief devices shall be connected to the heater in accordance with the original code of construction.

S5.7.4 CAPACITY

a) The pressure relief device(s) shall have sufficient capacity to prevent the pressure vessel from exceeding the maximum pressure specified in the vessel code of construction.

S5.7.5 SET PRESSURE

a) When a single relief device is used, the set pressure marked on the device shall not exceed the maximum allowable working pressure.

b) When more than one pressure relief device is provided to obtain the required capacity, only one pressure relief device set pressure needs to be set at or below the maximum allowable working pressure. The set pressure of the additional relief devices shall be such that the pressure cannot exceed the maximum pressure permitted by the code of construction.

S5.7.6 INSTALLATION

a) When a discharge pipe is used, the cross-sectional area shall not be less than the full area of the valve outlet. The size of the discharge lines shall be such that any pressure that may exist or develop will not reduce the relieving capacity or adversely affect the operation of the attached pressure vessel relief devices. Discharge piping shall be as short and straight as possible and arranged to avoid undue stress on the pressure relief device.

b) The cross-sectional area of the piping between the heater and the relief device shall be sized either to avoid restricting the flow to the pressure relief devices or made at least equal to the inlet area of the pressure relief devices connected to it.

c) When two or more required pressure relief devices are placed on one connection, the inlet cross-sectional area of this connection shall be sized either to avoid restricting the flow to the pressure relief devices or made at least equal to the combined inlet areas of the pressure relief devices connected to it.

d) Unless permitted by the code of construction, there shall be no intervening stop valve between the vessel and its pressure relief device(s), or between the pressure relief device and the point of discharge.
e) Pressure relief device discharges shall be arranged such that they are not a hazard to personnel or other equipment and, when necessary, lead to a safe location, such as a catchment tank, for the disposal of fluids being relieved.

f) Discharge lines from pressure relief devices shall be designed to facilitate drainage or be fitted with low point or valve body drains to prevent liquid from collecting in the discharge side of a pressure relief device. Drain piping shall discharge to a safe location for the disposal of the fluids being relieved.

S5.8 TESTING AND ACCEPTANCE

S5.8.1 GENERAL

a) Care shall be exercised during installation to prevent loose weld material, welding rods, small tools, and miscellaneous scrap metal from getting into the thermal fluid system. Where possible, an inspection of the interior of the thermal fluid heater and its appurtenances shall be made for the presence of foreign debris prior to making the final closure.

b) Safe operation should be verified by a person familiar with heater system operations for all heaters and connected appurtenances and all pressure piping connecting them to the appurtenances and all piping.

c) In bolted connections, the bolts, studs, and nuts shall be marked as required by the original Code of Construction and be fully engaged (e.g., the end of the bolt or stud shall protrude through the nut).

d) Washers shall only be used when specified by the manufacturer of the part being installed.

S5.8.2 PRESSURE TEST

Prior to initial operation, the completed thermal fluid heater system, including pressure piping, pumps, stop valves, etc., shall be pressure tested in accordance with the manufactures recommendations. Hydrostatic testing of the system is not recommended due to possible contamination of the system. All pressure testing should be witnessed by an Inspector.

S5.8.3 NONDESTRUCTIVE EXAMINATION

Thermal fluid heater components and subcomponents shall be nondestructively examined as required by the governing Code of Construction.

S5.8.4 SYSTEM TESTING

Prior to final acceptance, an operational test shall be performed on the complete installation. The test data shall be recorded and the data made available to the jurisdictional authorities as evidence that the installation complies with the provisions of the governing code(s) of construction. This operational test may be used as the final acceptance of the unit.

S5.8.5 FINAL ACCEPTANCE

A thermal fluid heater may not be placed into service until its installation has been inspected and accepted by the appropriate jurisdictional authorities.

S5.8.6 INSTALLATION REPORT

a) Upon completion, inspection, and acceptance of the installation, the installer should complete and certify the Boiler Installation Report I-1. See 1.4.5.1.
b) The Boiler Installation Report I-1 should be submitted as follows:

1) One copy to the Owner; and

2) One copy to the Jurisdiction, if required.
1.6 CHANGE OF SERVICE

Supplement 9 provides requirements and guidelines to be followed when a change of service or service type is made to a pressure retaining item.

Whenever there is a change of service, the Jurisdiction where the pressure retaining item is to be operated, shall be notified for acceptance, when applicable. Any specific jurisdictional requirements shall be met.

2.2.10.6 h) On forced circulation boilers, the flow sensing device should be tested to verify that the burner will shut down the boiler on a loss of flow;

2.3.6.6 FOR TRANSPORT TANKS, THE COMPETENT AUTHORITY (DOT) SHALL BE CONSULTED FOR ANY REQUIREMENTS WHICH IT HAS ESTABLISHED SINCE THEY TAKE PRECEDENCE.

a) Transport tanks manufactured prior to the adoption of ASME Section XII by the Competent Authority (DOT) were constructed in accordance with the ASME Section VIII Division 1. Certain transport tanks manufactured to this Code were required to be stamped in accordance with Section VIII Division 1 if the design pressure of the transport tank was 241 kPa (35 psi) (depending on material being transported) and greater. If the design pressure was less than 241 kPa (35 psi) (depending on material being transported), the transport tank was manufactured in accordance with Section VIII, Division 1, but not required by the Competent Authority (DOT) to be stamped.

b) ASME stamped transport tanks are subject to the requirements of NBIC Part 2 for in-service inspection, unless exempted by the Competent Authority (DOT).

2.3.6.8 INSPECTION OF PRESSURE VESSELS FOR HUMAN OCCUPANCY (PVHO's)

a) 1) PVHOs must be constructed in accordance with ASME PVHO-1 and inspected in accordance with ASME PVHO-2. These codes adopt Section VIII and therefore the vessels should bear a "U" or "U2" ASME designator.

4.4.8.7

f) Widely scattered corrosion pits may be left in the pressure-retaining item in accordance with the following requirements:

1) Their depth is not more than one-half the required thickness of the pressure-retaining item wall (exclusive of corrosion allowance);

2) The total area of the pits does not exceed 7 sq. in. (4500 sq mm) within any 50 sq. inches (32000 sq.mm); and

3) The sum of their dimensions (depth and width) along any straight line within this 50 sq. in (3200 sq. mm) area does not exceed 2 in. (50 mm).

g) If metal loss is less than specified corrosion/erosion allowance......

h) Techniques............
5.2 REPLACEMENT OF STAMPING OR NAMEPLATE DURING INSERVICE INSPECTION

5.2.1 AUTHORIZATION

a) When the stamping on a pressure-retaining item becomes indistinct or the nameplate is lost, illegible, or detached, but traceability to the original pressure-retaining item is still possible, the Inspector shall instruct the owner or user to have the nameplate or stamped data replaced. All re-stamping shall be done in accordance with the original code of construction, except as modified herein. Requests for permission to re-stamp or replace nameplates shall be made to the Jurisdiction in which the nameplate or stamping is reapplied, installed. Application must be made on the Replacement of Stamped Data Form, NB-136 (see 5.3.2). Proof of traceability to the original nameplate or stamping and other such data, as is available shall be furnished with the request. Permission from the Jurisdiction is not required for the reattachment of nameplates that are partially attached. When traceability cannot be established, the Jurisdiction shall be contacted. The completed Form NB-136 (see NBIC Part 2, 5.3.2) shall be submitted to the National Board.

b) When there is no Jurisdiction, traceability shall be accepted and the replacement of the nameplate or stamped data shall be authorized and witnessed by a National Board Commissioned Inspector. The completed Form NB-136 (see NBIC Part 2, 5.3.2) shall be submitted to the National Board.

5.2.2 REPLACEMENT OF NAMEPLATE OR STAMPED DATA

a) The re-stamping or replacement of data shall be witnessed by a National Board Commissioned Inspector. and shall be identical to the original stamping.

b) The re-stamping or replacement of a code symbol stamp shall be performed only as permitted by the governing code of construction.

c) Replacement nameplates shall be clearly marked "replacement".

5.2.3 REPORTING

Form NB-136 shall be filed with the Jurisdiction by the owner or user (if required) or the and the National Board by the “R” certificate Holder bearing a facsimile of the owner or user together with a facsimile of the replacement stamping or nameplate, as applied, and shall also bear the signature of the “R” stamp holder that performed the replacement and the National Board Commissioned Inspector who authorized and witnessed the replacement.

5.3 NATIONAL BOARD INSPECTION FORMS

5.3.1 SCOPE

The following forms (5.3.2 – 5.3.7.1) may be used for documenting specific requirements as indicated on the top of each form.

Note: Jurisdictions may have adopted other forms and may not accept these forms.
PROPOSED CHANGES TO FORM NB-136

REPLACEMENT OF STAMPED DATA FORM, NB-136
in accordance with provisions of the National Board Inspection Code

Submitted to: ________________________________________________
(name of jurisdiction)

_________________________ _____________________________
(address) (name of owner, user, or certificate holder)

_________________________ _____________________________
(telephone no.) (telephone no.)

Submitted by: ________________________________________________

_________________________ _____________________________
(name of owner, user, or certificate holder) (name of jurisdiction)

_________________________ _____________________________
(address) (address)

_________________________ _____________________________
(telephone no.) (telephone no.)

1. Manufactured by ________________________________________________
(name and address)

2. Manufactured for ________________________________________________
(name and address)

3. Location of Installation ____________________________________________
(address)

4. Date Installed ___________________________________________________________________

5. Previously installed at ________________________________________________

6. Manufacturer’s Data Report Attached □ No □ Yes

7. Item registered with National Board □ No □ Yes, NB Number ______________________

8. Item identification

Year built _________________

Type ________________________

Dimensions _________________

Mfg. Serial no. ________________________

Jurisdiction no. _________________

MAWP _________________ psi

Safety relief valve set at _________________ psi

9. Complete the reverse side of this report with a true facsimile of the legible portion of the nameplate or:

10. If nameplate is lost or illegible, traceability documentation, verified by the Inspector, shall be attached to this report, identifying the object to the Manufacturer’s Data referenced on this form.

11. I request authorization to replace the stamped data and/or nameplate on the above described pressure-retaining item in accordance with the rules of the National Board Inspection Code (NBIC).

Owner or User’s Organization Name

“R” Certificate Holder’s Name: ____________________________ Number

Signature ____________________________ Date _________________

Title __________________________________________________________________________

Verification of Traceability ____________________________ NB Commission __________________________

(Name of inspector)

12. Authorization is granted to replace the stamped data or to replace the nameplate of the above described pressure-retaining item.

Signature ____________________________ Date _________________

(chief inspector or authorized representative)

Jurisdiction (if available) or NB Commission number
The following is a true facsimile of the legible portion of the item’s original nameplate (if available). Please print. Where possible, also attach a rubbing or picture of the nameplate.

I certify that to the best of my knowledge and belief, the statements in this report are correct, and that the replacement information, data, and identification numbers are correct and in accordance with provisions of the National Board Inspection code. Attached is a facsimile or rubbing of the stamping or nameplate.

Name of Owner or User
“R” Certificate Holder _______________________________ Number __________________________

Signature __________________________________________ Date ____________________________

Witnessed by _______________________________ Date ____________________________

Employer _______________________________ NB Commission __________________________

Signature (Authorized representative) __________________________________________ Date ______

Signature (Name of inspector) __________________________________________ Date ______ NB Commission ________

(Back)
S1.4.2.8.1 BULGED STAYED SHEETS

a) The maximum depth of the bulged section of the firebox sheet shall not exceed the firebox sheet thickness. The bulged section depth is defined as the protrusion of the firebox sheet beyond its original position. Where sheets are bulged more than ¼” within one staybolt pitch, the thickness of the plate shall be verified. If the thickness is less than required the sheet shall be replaced. If the thickness of the sheet is adequate for the pressure, it shall be ensured that there is complete thread engagement between the staybolts and the sheet in the bulged area. If any deficiency is found in the thread engagement that impedes the holding power of the staybolt to a level below what is required for the operating pressure, the defective area shall be repaired or replaced.

b) If the maximum depth of the bulge exceeds the firebox sheet thickness, the bulged section of the firebox sheet shall be replaced. All staybolts within and/or contacting the bulged firebox sheet section shall be replaced. The adjacent sections of the firebox sheet shall be inspected to determine the cause of the bulge such as scale or mud accumulation prior to completing the repair.

c) If the bulged firebox sheet will remain in service, the conditions that caused the bulge shall be identified and corrected prior to placing the boiler back into operation.

d) If the bulged firebox sheet will remain in service the bulged sheet section and the sheet sections adjacent to the bulge shall be inspected for cracking and thinning (wastage) by use of NDE in order to confirm their suitability for service prior to placing the boiler back into operation.

S2.6.2 ULTRASONIC THICKNESS TESTING

b) To calculate MAWP, ultrasonic thickness testing results in areas of generalized thinning (3 in. [76 mm] in diameter or greater) or where grooved thinning is noted (2 in. [50 mm] in length or greater) are to be used in determining minimum thickness in accordance with S2.10. The MAWP calculation in S2.10 shall be completed based on the thickness data gathered.

S2.6.3 EVALUATION OF CORROSION

S2.6.3.1 LINE AND CREVICE CORROSION

Line and crevice corrosion may be disregarded for MAWP calculations when:

a) The thickness of the remaining material is at least 75% of the required thickness per the MAWP calculations.

b) The total length does not exceed 2 inches (50 mm).

S2.6.3.2 WIDELY RANDOMLY SCATTERED PITS

Widely Randomly scattered corrosion pits may be disregarded for MAWP calculations when:

a) The depths of the pits are such that the remaining material shall not be less than 50% of the required thickness per the MAWP calculations.
b) The total area of pits, below the required thickness per the MAWP calculations, does not exceed 7 sq. in. (4500 sq. mm) within any 50 sq. in. (32000 sq. mm) area.

c) Total length of pits in an 8 inch (200 mm) straight line cannot exceed 2 inches (50 mm).

S2.6.3.3 LOCALLY THINNED AREAS

Locally thinned areas (LTA), 3 inch (75 mm) in diameter or less, may be disregarded for MAWP calculations when:

a) The average depth of the corrosion is such that remaining material shall not be less than 75% of the required thickness per the MAWP calculations.

b) The remaining thickness at the thinnest point shall not be less than 50% of the required thickness per the MAWP calculations.

c) The minimum distance between the boundaries of two locally thinned areas (MDLTA) must be greater than the average diameters of the two locally thinned areas (LTA) multiplied by 3.0. See Figure S2.6.3.3.

S2.6.3.4 GENERALIZED THINNED AREAS

a) For corroded areas exceeding the specifications in S2.6.3.1, S2.6.3.2, and S2.6.3.3, the remaining thickness may be averaged over an area not exceeding the UT-grid size specified in S2.6.2 c) or S2.6.2 d).

1) The least measured remaining thickness within the grid indicated at S2.6.2 c) or S2.6.2 d) as applicable shall not be less than 50% of the required thickness per the calculation for MAWP.

2) The average remaining thickness recognized from the grid indicated in S2.6.2 c) or S2.6.2 d) as applicable shall not be less than 75% of the required thickness per the calculation for MAWP.

b) When general corrosion exceeds the limits of S2.6.3.4 a), the conditions shall be presented and reviewed with the Inspector, and when required, the Jurisdiction for resolution. Note: The guidance presented at S2.6.3.1, S2.6.3.2, S2.6.3.3, and S2.6.3.4 is to be used to evaluate areas of thinning due to corrosion. Areas where plates have been formed to make corners whereby the radii may have thinned due to the forming process shall not be considered in calculating MAWP.
S2.8.1

8) The safety valve(s) shall be connected so as to stand in an upright position with the spindle vertical.

9) The discharge from the safety valve(s) shall be arranged so that there is no danger of scalding either the operator(s) or individuals who may be in the vicinity of the boiler. If the valve(s) is a top discharge design, no discharge piping is required. If a side discharge design valve(s) is used, an elbow should be attached to the outlet to assure a vertical discharge. The elbow must be located as close to the valve(s) as possible to minimize reaction moment stress.

10) Provision for ample gravity drain shall be made in the discharge pipe at or near each safety valve, and where water can collect.

11) If the boiler is equipped with a canopy, the elbow may be other than 90 degrees to direct the discharge out from under the canopy, while still directing the discharge to a safe location. The elbow must be located as close to the valve(s) as possible to minimize reaction moment stress.

12) If the boiler is equipped with a canopy, the discharge may be piped through the canopy. When the discharge piping is piped through a canopy, the elbow must be located as close to the valve as possible to minimize reaction moment stress. The discharge piping may be a larger pipe than the discharge size of the valve. Discharge piping shall be completely supported separate from the valve and elbow so no extra loading is transmitted to the safety valve(s).

S2.10.4 STAYED SURFACES

The maximum allowable working pressure for Stayed flat plates and those parts which, by these rules, require staying as flat plates with stays or staybolts of uniform diameter, uniformly spaced, shall be calculated using the following formula or Table S2.10.4, and S2.10.4.1.
When pitches of stays or staybolts of uniform diameter are symmetrical and form a rectangle, the equation may be replaced with the following equation:

\[ P = \frac{t^2 \times S \times C}{p^2} \]

See definitions of nomenclature in S2.10.6.

**S2.10.4.1 STAYBOLTS**

**S = 7,500 psi (51.7 MPa)**

**S2.10.4.2 BULGING**

Stayed surfaces shall be examined, and any deformations shall be measured and recorded. Deformations may be caused from freezing, localized overheating, broken staybolts, or extended use (cyclic activity). Deformations may be described as bulging, bagging, or pillow/mattress-effects. The bulged section depth is defined as the protrusion of the sheet beyond its original position.

a) Changes in deformations between inspections shall be noted and shall require additional evaluation to determine fitness for service.

b) The probable cause of the deformation shall be determined and, where possible, resolved. For example, overheating due to scale build-up requires removal of scale.

c) The amount of the bulging shall be measured:

1) If the depth of the bulge does not exceed 50% of plate thickness, then no further activity is required.

2) If the depth of the bulge is between 50% and 100% plate thickness, and thread engagement is not affected, then additional NDE is required.

3) Note: If ultrasonic thickness testing (S2.6.2.c) is performed, then it is performed on a tight (1-inch) grid to determine any thinning throughout the deformation. Any generalized thinning (S2.6.2.b) shall be used in the calculation of MAWP. If the depth of the bulge exceeds the thickness of the plate, then repair is required.

d) The location of the deformations shall be examined. If the point of tangency of the curve in a bulge is within ‘t’ of the edge of the staybolt head, then determination of thread engagement shall be made. (‘t’ is defined in S2.10.6, and is the thickness of the plate.) Removal of one or more staybolts may be required to make this determination. Refer to Figure S2.10.4.2.d.

1) Cracks, deformations, and/or missing portions of the threaded staybolt head may indicate a deformation of the plate at the staybolt.

**Figure S2.10.4.2.d Point of Tangency of the Curve in a Bulge Within ‘t’ of the Edge of the Staybolt Head**
e) The following guidelines apply where repair is required.

1) Plate may only be repaired using a flush patch, in accordance with Supplement 2 of NBIC Part 3.

2) Where a deformation is to be repaired, all portions of that deformity shall be repaired. For example, for contiguous bulging where only some bulges exceed allowable deformation, the entire bulged area shall be repaired. Unrelated bulges separated by non-deformed plate shall be independently evaluated.
S2.10.6 NOMENCLATURE

\[ p = \text{maximum pitch measured between straight lines passing through the centers of the staybolts in the different rows, which lines may be horizontal, vertical, or inclined, inches or mm} \]

\[ l = \text{the pitch of stays in one row, passing through the centers of the staybolts, which line may be horizontal, vertical, or inclined, inches or mm} \]

\[ w = \text{the distance between two rows of staybolts, inches or mm} \]

\[ h = \text{the hypotenuse of a square or rectangle, defined as either} \sqrt{2p^2} \text{ or} \sqrt{l^2 + w^2} \text{, inches or mm} \]

\[ d = \text{minimum diameter of corroded staybolt, inches or mm} \]

Table S6.13.1-a

Inservice Minimum Thickness for Steel and Steel Alloys

<table>
<thead>
<tr>
<th>Minimum manufactured thickness (US “Manufacturers’ Standard Gage for Steel Sheets” or in.)</th>
<th>Nominal decimal equivalent, mm (in.)</th>
<th>Inservice minimum reference, mm (in.)</th>
</tr>
</thead>
<tbody>
<tr>
<td>19 gage</td>
<td>1.06 (0.0418)</td>
<td>0.97 (0.038)</td>
</tr>
<tr>
<td>18 gage</td>
<td>1.21 (0.0478)</td>
<td>1.09 (0.043)</td>
</tr>
<tr>
<td>17 gage</td>
<td>1.37 (0.0538)</td>
<td>1.22 (0.048)</td>
</tr>
<tr>
<td>16 gage</td>
<td>1.52 (0.0598)</td>
<td>1.37 (0.054)</td>
</tr>
<tr>
<td>15 gage</td>
<td>1.71 (0.0673)</td>
<td>1.55 (0.061)</td>
</tr>
<tr>
<td>14 gage</td>
<td>1.90 (0.0747)</td>
<td>1.70 (0.067)</td>
</tr>
<tr>
<td>13 gage</td>
<td>2.28 (0.0897)</td>
<td>2.06 (0.081)</td>
</tr>
<tr>
<td>12 gage</td>
<td>2.66 (0.1046)</td>
<td>2.39 (0.094)</td>
</tr>
<tr>
<td>11 gage</td>
<td>3.04 (0.1196)</td>
<td>2.74 (0.108)</td>
</tr>
<tr>
<td>10 gage</td>
<td>3.42 (0.1346)</td>
<td>3.07 (0.121)</td>
</tr>
<tr>
<td>9 gage</td>
<td>3.80 (0.1495)</td>
<td>3.43 (0.135)</td>
</tr>
<tr>
<td>8 gage</td>
<td>4.18 (0.1644)</td>
<td>3.76 (0.148)</td>
</tr>
<tr>
<td>7 gage</td>
<td>4.55 (0.1793)</td>
<td>4.09 (0.161)</td>
</tr>
<tr>
<td>3/16 in.</td>
<td>4.76 (0.1875)</td>
<td>4.29 (0.169)</td>
</tr>
<tr>
<td>1/4 in.</td>
<td>6.35 (0.2500)</td>
<td>5.72 (0.225)</td>
</tr>
<tr>
<td>5/16 in.</td>
<td>7.94 (0.3125)</td>
<td>7.14 (0.281)</td>
</tr>
<tr>
<td>3/8 in.</td>
<td>9.53 (0.3750)</td>
<td>8.59 (0.338)</td>
</tr>
</tbody>
</table>

Table S6.13.11.2-a

Minimum Thickness for Heads

<table>
<thead>
<tr>
<th>Materials</th>
<th>Volume capacity in liters per mm of length (gallons per in. of length)</th>
<th>Over 14 to 23 (0.21 to 0.36)</th>
<th>Over 23 (0.36)</th>
</tr>
</thead>
<tbody>
<tr>
<td>14 (0.21) or less</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>MS</td>
<td>HSLA SS</td>
<td>AL</td>
<td>MS</td>
</tr>
<tr>
<td>Thickness, mm (in.)</td>
<td>2.54 (0.100)</td>
<td>2.54 (0.100)</td>
<td>4.06 (0.160)</td>
</tr>
</tbody>
</table>
S7.10 REQUIREMENTS FOR CHANGE OF SERVICE FROM ABOVEGROUND TO UNDERGROUND SERVICE

ASME LPG storage vessels may be altered from aboveground (AG) service to underground (UG) service subject to the following conditions.

a) Vessels that have been previously used in anhydrous ammonia service are not permitted to be converted to LPG service.

b) The outside surface of the vessel shall be cleaned to bare metal for an external inspection of the vessel under the guidelines of this Supplement. Prior to placing underground, the outside surface of the vessel shall be prepared consistent with the paint manufactures specification and coated with a coating suitable for UG service. Any touch-up coating shall the same coating material. All corrosion shall be repaired in accordance with the NBIC.

c) Verify that here is no internal corrosion due to valves having been removed while the container was out of service.

d) Any unused connections located on the vessel shall be closed by seal welding around a forged plug or moved using a flush patch. If a flush patch is used the material shall be the same material thickness and material grade as the original code of construction.

e) All connections on top of the vessel, except for the liquid withdrawal opening, shall be replaced with a riser pipe with multi-valve suitable for UG LPG service. The valve shall be enclosed in a protective housing and placed underground in accordance with jurisdictional requirements.

f) The liquid withdrawal opening shall be located within the protective housing.

g) The liquid level tube in the multivalve shall be the length required according to jurisdictional requirements.

h) The NBIC nameplate shall be made of stainless steel and continuous welded to the vessel wall. The nameplate shall also have the information from the original nameplate. This shall include the manufacturer’s name, container serial number, National Board number, if registered with the National Board, MAWP, year built, head and shell thickness be stamped for “UG service”, the “liquid level tube length= inches” and the National Board “R” stamp. The original manufacturer’s nameplate shall remain attached to the vessel. See Part 2-5.2, Part 3-5.7 for additional stamping requirements.

i) The support legs and lifting lugs may remain in place and shall be welded around the entire periphery to prevent crevices that create a potential area for corrosion. Unused attachments shall be removed and welds ground flush.

j) A connection shall be added for the attachment of an anode for cathodic protection.

k) All welding shall be performed by a qualified “R” stamp holder using a qualified welding procedure.

SUPPLEMENT 9

REQUIREMENTS FOR CHANGE OF SERVICE


**S9.1 SCOPE:**

This Supplement provides requirements and guidelines to be followed when a change of service or service type is made to a pressure retaining item.

Whenever there is a change of service, the Jurisdiction where the pressure retaining item is to be operated shall be notified for acceptance. Any specific jurisdictional requirements shall be met.

**S9.2 CLASSIFICATION OF SERVICE CHANGES**

**S9.2.1 SERVICE CONTENTS**

A change in service contents is considered to be any modification to the commodity or contents that the pressure retaining item was originally intended to contain when the pressure retaining item was constructed.

For example, a change:

a) From LP gas service to Air receiver service.
b) From lethal to non lethal service.

**S9.2.2 SERVICE TYPE OR CHANGE OF USAGE**

A change in service type is considered to be a change of how the pressure retaining item is being used.

For example, a change:

a) From above ground service to underground service for LP gas tanks.
b) From mobile or transport use to stationary use

**S9.3 FACTORS TO CONSIDER**

Before a change of service is to be made, the owner or user shall consider and evaluate the effects of the new operating conditions or environment on the existing condition and suitability for service of the pressure retaining item. Various factors will have an impact on the reliability of the pressure retaining item in its new service environment. Changes can be successfully adopted providing there is an understanding of the effect on the pressure retaining item. However, there are some cases where changes are detrimental to the existing pressure retaining item. The owner or user should seek technical guidance of experienced personnel in appropriate areas affected by the change of service (e.g. design, metallurgy, or operations of the pressure retaining item).

The following is a listing of criteria that should be evaluated as appropriate. The criteria is not limited to that listed herein. Other factors may be considered as necessary:

a) **Design Consideration:**

   1) Thickness of existing vessel material
   2) Vessel or system flow rate or pressure
   3) Weight of vessel with new contents
   4) Existing or additional loads imposed on nozzles and highly stressed areas
5) Change in pressure or temperature, and cycling

6) Compliance to product or industry standards, such as ANSI K61, API 579, or NFPA 58

b) Material Consideration:

1) Chemical and mechanical properties of existing material or any new material to be added or replaced to assure it has the required strength and toughness to withstand the pressure and temperature effects of the new environment.

2) Effects of erosion or corrosion

3) Time dependent effects on service life - creep or fatigue, or both effects combined.

c) Environment

1) Physical condition of the pressure retaining item

2) Overpressure protection needs

3) Regulatory environment – Verification of compliance to new or existing jurisdictional rules or regulations.

4) Vessel cleanliness – When changing lading fluids or contents consideration should be given to cleaning or decontaminating the vessel as appropriate.

d) Operational History

1) A review of current and past operational logs or records should be made to assure that no conditions existed where any further use would render the pressure retaining item hazardous or otherwise unsafe.

2) Records to be obtained and reviewed would include Data Reports, Repair and Alteration Forms, Inspection reports, etc.

e) Repairs and Alterations Made:

1) A review of any repairs, alterations, reratings, or reconfigurations that have been performed on the pressure retaining item, so as to assure that they will not have a detrimental impact on the intended use.

f) Proposed rework

1) Any physical work to be performed to restore the material to the existing or intended state or to meet any requirements for the new operating conditions.

2) Repairs and alterations shall be performed in accordance with NBIC, Part 3.

3) The effects of heat applied as a result of welding or heat treatment on the material or shaped parts.

4) The method and extent of any physical or non destructive examination should be considered.

5) Any physical testing or pressure testing to be performed to determine or verify leak tightness or structural integrity of the pressure retaining item.
6) The pressure retaining item shall meet the Code requirements for the new environment at the time of change.

g) Documentation

1) Review existing records that are required to satisfy customer, user, or legal requirements.

2) Review the need for any marking, stamping, or labeling required for the intended service.

3) Review the need for developing or revising an inspection plan to ensure safe operation. Refer to NBIC Part 2, Section 1.5.2.1 Inspection Plan.

S9.4 EXAMPLES FOR CHANGE OF SERVICE

The following is a typical list of examples of what constitutes a change in service and some factors to consider. Note: This list is not all inclusive. There may be other service changes not mentioned.

The listing of “Factors to Consider” is also not all inclusive. There may be other elements that can influence the safe and reliable operation of the pressure retaining item.

The owner shall check with the Jurisdiction where the pressure retaining item is to operate in the new environment, and review local building codes, laws, and regulations for additional requirements or prohibitions against a change of service.

<table>
<thead>
<tr>
<th>Change</th>
<th>Some Factors to Consider</th>
</tr>
</thead>
<tbody>
<tr>
<td>LP gas to ammonia</td>
<td>• PWHT of vessel during construction</td>
</tr>
<tr>
<td>Change</td>
<td>Some Factors to Consider</td>
</tr>
<tr>
<td>--------</td>
<td>-------------------------</td>
</tr>
</tbody>
</table>
| Ammonia to LP gas | - NFPA-58, should be consulted i.e. restriction on maximum volume  
- Wet-fluorescent magnetic particle testing (WFMT) on all internal surfaces  
- Internal access of vessel is necessary, may need to install manhole  
- Also see, NBIC Part 2, 2.3.6.4 |
| LP gas service: from above ground to underground | - Requires alterations (additional nozzles)  
- Corrosion protection  
- See NFPA 58 |
| LP gas to air receiver | - Assurance of vessel cleanliness, i.e. removal of mercaptan  
- Appropriateness and number of inspection and drain openings  
- Corrosion allowance |
| Boiler service: steam to hot water | - Nozzles may require modification for water inlet and outlet  
- Change of Pressure Relief Device |
| Boiler service: high pressure to low pressure | - Controls required by the LP boiler code  
- Safety valve change  
- Need for larger openings for steam outlets and safety relief valves |
| Sulfur dioxide service, sweet to sour gas service | - Concern over hydrogen cracking |
| Inert to oxidizing or reducing atmosphere | - Inspection for damage mechanisms that may be present from previous service life that is detrimental to the vessel in the new environment  
- Cleanliness of hydrocarbons |
| Lethal service to non-lethal | - Design conditions and suitability for service |
S9.5 DOCUMENTATION OF CHANGE OF SERVICE

Any records, forms, or reports required documenting the change of service event that may be required by contract or the Jurisdiction where the pressure retaining item operates shall be completed. Such documentation should be retained by the owner or user for future reference or use as needed.

SUPPLEMENT 10
INSPECTION OF LIQUID CARBON DIOXIDE STORAGE VESSELS

S10.1 SCOPE

This supplement provides requirements for the inspection of Liquid Carbon Dioxide Storage Vessels (LCDSVs), fill boxes, fill lines and pressure relief discharge/vent circuits used for carbonated beverage systems, swimming pool pH control systems and other fill in place systems storing liquid CO₂.

S10.2 GENERAL REQUIREMENTS (ENCLOSED AND UNENCLOSED AREAS)

The Inspector shall verify that LCDSVs:

a) are not located within 10 feet (3050 mm) of elevators, unprotected platform ledges or other areas where falling would result in dropping distances exceeding half the container height;

b) are installed with sufficient clearance for filling, operation, maintenance, inspection and replacement;

c) are not installed on roofs;

d) are safely supported;

e) are not located within 36 in. (915 mm) of electrical panels; and

f) located outdoors in areas in the vicinity of vehicular traffic are guarded to prevent accidental impact by vehicles.

S10.3 ENCLOSED AREA LCDSV INSTALLATIONS

The Inspector shall verify that:

a) Permanent LCDSV installations with remote fill connections:
1) Are equipped with a gas detection system installed in accordance with NBIC Part 2, S10.5

2) Have signage posted in accordance with NBIC Part 2, S10.6

3) Are equipped with fill boxes; fill lines and safety relief/vent valve circuits installed in accordance with NBIC Part 2, S10.4.

b) Portable LCDSV installations with no permanent remote fill connection:

Warning: LCDSVs shall not be filled indoors or in enclosed areas under any circumstances. Tanks must always be moved to the outside to an unenclosed, free airflow area for filling.

1) Are equipped with a gas detection system installed in accordance with NBIC Part 2, S10.5;

2) Have signage posted in accordance with NBIC Part 2, S10.6.

3) Have a safety relief/vent valve circuit connected at all times except when the tank is being removed for filling. Connections may be fitted with quick disconnect fittings meeting the requirements of NBIC Part 2, S10.4.

4) Are provided with a pathway that provides a smooth rolling surface to the outdoor, unenclosed fill area. There shall not be any stairs or other than minimal inclines in the pathway.

S10.4 FILL BOX LOCATION /SAFETY RELIEF/VENT VALVE CIRCUIT TERMINATION

The Inspector shall verify that fill boxes and/or vent valve terminations are installed above grade, outdoors in an unenclosed, free airflow area, and that the fill connection is located so not to impede means of egress or the operation of sidewalk cellar entrance doors, including during the delivery process and that they are:

a) At least three (3) feet (915 mm) from any door or operable windows;*

b) At least three (3) feet (915 mm) above grade;*

c) Not located within ten (10) feet (3050 mm) from side to side at the same level or below, from any air intakes;*

d) Not located within ten (10) feet (3050 mm) from stair wells that go below grade.*

* Note: Many systems installed prior to 1/1/2014 do not meet the above requirements and the local Jurisdiction should be consulted for guidance.

S10.5 GAS DETECTION SYSTEMS

Rooms or areas where carbon dioxide storage vessel(s) are located indoors or in enclosed or below grade outdoor locations shall be provided with a gas detection and alarm system for general area monitoring that is capable of detecting and notifying building occupants of a CO₂ gas release. Alarms will be designed to activate a low level pre-alarm at 1.5% concentration of CO₂ and a full high alarm at 3% concentration of CO₂ which is the NIOSH & ACGIH 15 minute Short Term Exposure Limit for CO₂. These systems are not designed for employee personal exposure monitoring. Gas detection systems shall be installed and tested in accordance with manufactures installation instructions and the following requirements:
a) The Inspector shall verify that the gas detection system and audible alarm is operational and tested in accordance with manufacturer’s guidelines.

b) The Inspector shall verify that audible alarms are placed at the entrance(s) to the room or area where the carbon dioxide storage vessel and/or fill box is located to notify anyone who might try to enter the area of a potential problem.

S10.6 SIGNAGE

The Inspector shall verify that warning signs are posted at the entrance to the building, room, enclosure, or enclosed area where the container is located. The warning sign shall be at least 8 in (200mm) wide and 6 in. (150mm) high. The wording shall be concise and easy to read and the upper portion of the sign must be orange as shown in figure NBIC Part 2, Figure S10.6. The size of the lettering must be as large as possible for the intended viewing distance and in accordance with jurisdictional requirements. When no jurisdictional requirements exist, the minimum letter height shall be in accordance with NEMA American National Standard for Environmental and Facility Safety Signs (ANSI Z535.2). The warning signs shall be as shown in figure S10.6.

![Warning Sign](image)

**Figure S10.6**

Additional instructional signage shall be posted outside of the area where the container is located and such signage shall contain at minimum the following information:

a) Carbon dioxide monitors for general area monitoring (not employee personal exposure monitoring) are provided in this area. These monitors are set to alarm at 5,000 ppm (1.5% concentration) for the low level alarm and at 30,000 ppm (3% concentration) for high level alarm.
b) Low Level Alarm (5,000 ppm) – Provide appropriate cross ventilation to the area. Personnel may enter area for short periods of time (not to exceed 15 minutes at a time) in order to identify and repair potential leaks.

c) High Level Alarm (30,000 ppm) – Personnel should evacuate the area and nobody should enter the affected area without proper self-contained breathing apparatus until the area is adequately ventilated and the concentration of CO\textsubscript{2} is reduced below the high alarm limit.

S10.7 VALVES, PIPING, TUBING AND FITTINGS

a) Materials – The Inspector shall verify that the materials selected for valves, piping, tubing, hoses and fittings used in the LCDSV system meet following requirements:

1) Components shall be rated for the operational temperatures and pressures encountered in the applicable circuit of the system.

2) All valves and fittings used on the LCDSV shall be rated for the maximum allowable working pressure (MAWP) stamped on the tank.

3) All piping, hoses and tubing used in the LCDSV system shall be rated for the working pressure of the applicable circuit in the system and have a burst pressure rating of at least four times the MAWP of the piping, hose or tubing.

b) Relief Valves – The Inspector shall verify that each LCDSV shall have at least one ASME/NB stamped & certified relief valve with a pressure setting at or below the MAWP of the tank. The relief valve shall be suitable for the temperatures and flows experienced during relief valve operation. The minimum relief valve capacity shall be designated by the manufacturer. Additional relief valves that do not require ASME stamps may be added per Compressed Gas Association pamphlet, CGA S-1.3 Pressure Relief Device Standards Part 3, Stationary Storage Containers for Compressed Gases, recommendations. Discharge lines from the relief valves shall be sized in accordance with NBIC Part 2, Tables S10-a and S10-b.

Note: Due to the design of the LCDSV the discharge line may be smaller in diameter than the relief valve outlet size.

Caution: Company’s and or individuals filling or refilling LCDSV’s shall be responsible for utilizing fill equipment that is acceptable to the manufacturer to prevent over pressurization of the vessel.

c) Isolation Valves – The Inspector shall verify that each LCDSV shall have an isolation valve installed on the fill line and tank discharge, or gas supply line in accordance with the following requirements:

1) Isolation valves shall be located on the tank or at an accessible point as near to the storage tank a possible.

2) All valves shall be designed or marked to indicate clearly whether they are open or closed.

3) All valves shall be capable of being locked or tagged in the closed position for servicing.

4) Gas supply and liquid CO\textsubscript{2} fill valves shall be clearly marked for easy identification.

d) Safety Relief/Vent Lines – The Inspector, where possible, shall verify the integrity of the pressure relief/vent line from the pressure relief valve to outside vent line discharge fitting. All connections shall be securely fastened to the LCDSV. The minimum size and length of the lines shall be in accordance with NBIC Part 2, Tables S2 10-a and S2 10-b.
Fittings or other connections may result in a localized reduction in diameter have been factored into the lengths given by the NBIC Part 2, Tables S2 10-a and S2 10-b.

**Table S10-a Minimum LCDSV System Pressure Relief/Vent Line Requirements (Metallic)**

<table>
<thead>
<tr>
<th>Tank Size (Pounds)</th>
<th>Fire Flow Rate Requirements (Pounds per Minute)</th>
<th>Maximum Length of 3/8 inch ID Nominal Metallic Tube Allowed</th>
<th>Maximum Length of 1/2 inch ID Nominal Metallic Tube Allowed</th>
</tr>
</thead>
<tbody>
<tr>
<td>Less than 500</td>
<td>2.60 maximum</td>
<td>80 feet</td>
<td>100 feet</td>
</tr>
<tr>
<td>500-750</td>
<td>3.85 maximum</td>
<td>55 feet</td>
<td>100 feet</td>
</tr>
<tr>
<td>Over 750-1000</td>
<td>5.51 maximum</td>
<td>18 feet</td>
<td>100 feet</td>
</tr>
</tbody>
</table>

**Table S10-b Minimum LCDSV System Pressure Relief/Vent Line Requirements (Plastic/Polymer)**

<table>
<thead>
<tr>
<th>Tank Size (Pounds)</th>
<th>Fire Flow Rate Requirements (Pounds per Minute)</th>
<th>Maximum Length of 3/8 inch ID Plastic/Polymer Materials Tube Allowed</th>
<th>Maximum Length of ½ inch ID Plastic/Polymer Materials Tube Allowed</th>
</tr>
</thead>
<tbody>
<tr>
<td>Less than 500</td>
<td>2.60 maximum</td>
<td>100 feet</td>
<td>100 feet</td>
</tr>
<tr>
<td>500-750</td>
<td>3.85 maximum</td>
<td>100 feet</td>
<td>100 feet</td>
</tr>
<tr>
<td>Over 750-1000</td>
<td>5.51 maximum</td>
<td>N/A see ½ inch</td>
<td>100 feet</td>
</tr>
</tbody>
</table>

**Table S10-a Metric Minimum LCDSV System Pressure Relief/Vent Line Requirements (Metallic)**

<table>
<thead>
<tr>
<th>Tank Size (Kilograms)</th>
<th>Fire Flow Rate Requirements (Kilograms per Minute)</th>
<th>Maximum Length of 10mm ID Nominal Metallic Tube Allowed</th>
<th>Maximum Length of 13mm ID Nominal Metallic Tube Allowed</th>
</tr>
</thead>
<tbody>
<tr>
<td>Less than 227</td>
<td>1.8 maximum</td>
<td>24 m</td>
<td>30.5 m</td>
</tr>
<tr>
<td>227-340</td>
<td>1.75 maximum</td>
<td>17 m</td>
<td>30.5 m</td>
</tr>
<tr>
<td>340-454</td>
<td>2.50 maximum</td>
<td>5.5 m</td>
<td>30.5 m</td>
</tr>
</tbody>
</table>
Table S10-b Metric Minimum LCDSV System Pressure Relief/Vent Line Requirements (Plastic/Polymer)

<table>
<thead>
<tr>
<th>Tank size (kg)</th>
<th>Fire Flow Rate (kg per Minute)</th>
<th>Maximum Length of 10 mm ID Nominal Metallic Tube Allowed</th>
<th>Maximum Length of 10 mm ID Plastic/Polymer Materials Tube Allowed</th>
</tr>
</thead>
<tbody>
<tr>
<td>Less than 227</td>
<td>1.18 maximum</td>
<td>30.5 m</td>
<td>30.5 m</td>
</tr>
<tr>
<td>227-340</td>
<td>1.75 maximum</td>
<td>30.5 m</td>
<td>30.5 m</td>
</tr>
<tr>
<td>Over 340-454</td>
<td>2.5 maximum</td>
<td>N/A see 13 mm</td>
<td>30.5 m</td>
</tr>
</tbody>
</table>

Note: Due to the design of the LCDSV the discharge line may be smaller in diameter than the pressure relief valve outlet size but shall not be smaller than that shown in tables NBIC Part 2, S10-a and S10-b.

SUPPLEMENT 11
INSPECTION OF STATIONARY HIGH PRESSURE (3000-15000 psi) (21-103 MPa) COMPOSITE PRESSURE VESSELS

S11.1 SCOPE

This Supplement provides specific guidelines for inspection of high pressure composite pressure vessels, hereafter referred to as vessels. This supplement is applicable to pressure vessels with a design pressure that exceeds 3000 psi (21 MPa) but not greater than 15000 psi (103 MPa), and is applicable to the following four types of pressure vessels:

a) Metallic vessel with a hoop Fiber Reinforced Plastic (FRP) wrap over the straight shell cylindrical part of the vessel (both load sharing).

b) Fully wrapped FRP vessel with a non-load sharing metallic liner.

c) Fully wrapped FRP vessel with a non-load sharing non-metallic liner.

d) Fully wrapped FRP vessel with a load sharing metallic liner.

This Supplement is intended for inspection of ASME Section X, Class III vessels and ASME Section VIII, Division 3 Composite Reinforced Pressure Vessels (CRPVs). However, it may be used for inspection of similar vessels manufactured to other construction codes with approval of the Jurisdiction in which the vessels are installed.

S11.2 GENERAL

a) High pressure composite vessels are used for the storage of fluids at pressures up to 15000 psi (103 MPa). Composite vessels consist of the FRP laminate with load sharing or non-load sharing metallic shells/liners, or nonmetallic liners. The FRP laminate with load sharing metallic liners form the pressure retaining system. The FRP laminate is the pressure retaining material for composite vessels with non-load sharing metallic and nonmetallic liners. The purpose of the non-load sharing metallic and the nonmetallic liners is to minimize the permeation of fluids through the vessel wall.

b) Fluids stored in vessels are considered to be non corrosive to the materials used for vessel construction. The laminate is susceptible to damage from:

1) External chemical attack
2) External mechanical damage (i.e. abrasion, impact, cuts, dents, etc.)

3) Structural damage (i.e. over pressurization, distortion, bulging, etc.)

4) Environmental degradation (i.e. ultraviolet [if there is no pigmented coating or protective layer], ice, etc.)

5) Fire or excessive heat

S11.3 INSPECTOR QUALIFICATIONS

a) The Inspector referenced in this supplement shall be a National Board Commissioned Inspector.

b) The Inspector shall be familiar with vessel construction and qualified by training and experience to conduct such inspections. The Inspector should have a thorough understanding of all required inspections, tests, test apparatus, inspection procedures, and inspection techniques and equipment applicable to the types of vessels to be inspected. The Inspector should have basic knowledge of the vessel material types and properties. Refer to NBIC Part 2 S4.2 and S4.5.

S11.4 INSPECTION FREQUENCY

a) Initial Inspection

   The vessel shall be given an external visual examination by the Inspector or the Jurisdiction having authority where the vessel is installed and during the initial filling operation. The examination shall check for any damage during installation prior to initial filling and for any leaks or damage during and at the conclusion of filling.

b) Subsequent Filling Inspections

   Before each refilling of the vessel, the manager of the facility shall visually examine the vessel exterior for damage or leaks. Refilling operations shall be suspended if any damage or leaks are detected and the vessel shall be emptied and subsequently inspected by the Inspector to determine if the vessel shall remain in service.

c) Periodic Inspection

   Within 30 days of the anniversary of the initial operation of the vessel during each year of its service life, the vessel shall be externally inspected by the Inspector or the Jurisdiction having authority where the vessel is installed. Internal inspections shall only be required if any of the conditions of S11.9(a) are met. These examinations are in addition to the periodic acoustic emission examination requirements of S11.5(c).

S11.5 INSERVICE INSPECTION

a) NBIC Part 2, Section 1 shall apply to inspection of high pressure vessels, except as modified herein. This supplement covers vessels, and is not intended to cover piping and ductwork, although some of the information in this supplement may be used for the inspection of piping and ductwork.

b) The inspection and testing for exposed load sharing metallic portions of vessels shall be in accordance with NBIC Part 2, Section 2.3.
c) All composite vessels shall have an initial acoustic emission examination per S11.10 after the first 3 years from the date of manufacture. Thereafter, vessels shall have a maximum examination interval of 5 years which may be more frequent based on the results of any external inspection per paragraph S11.8 or internal inspections per paragraph S11.9.

All vessels shall be subject to the periodic inspection frequency given in S11.4.

S11.6 ASSESSMENT OF INSTALLATION

a) The visual examination of the vessel requires that all exposed surfaces of the vessel are examined to identify any degradation, defects, mechanical damage, or environmental damage on the surface of the vessel.

The causes of damage to vessels are:

1) abrasion damage;
2) cut damage;
3) impact damage;
4) structural damage;
5) chemical or environmental exposure damage or degradation; and
6) heat or fire damage.

The types of damage found are:

1) cracks;
2) discolored areas;
3) gouges and impact damage;
4) leaks;
5) fiber exposure;
6) blisters;
7) delaminations;
8) surface degradation; and
9) broken supports.

b) The visual examination of the vessel requires that the identity of the vessel must be verified. This should include the construction code (ASME) to which the vessel was constructed, vessel serial number, MAWP, date of manufacture.
vessel manufacturer, date of expiration of the service life of the vessel, and any other pertinent information shown on the vessel or available from vessel documents. The overall condition of the vessel should be noted.

**S11.7 VISUAL EXAMINATION**

a) **Acceptable Damage**

Acceptable damage or degradation is minor, normally found in service, and considered to be cosmetic. This level of damage or degradation does not reduce the structural integrity of the vessel. This level of damage or degradation should not have any adverse effect on the continued safe use of the vessel. This level of damage or degradation does not require any repair to be performed at the time of in-service inspection. When there is an external, non load bearing, sacrificial layer of filaments on the vessel, any damage or degradation should be limited to this layer. Damage or degradation of the structural wall shall not exceed the limits specified in Tables S11.7-a or S11.7-b.

b) **Rejectable Damage (Condemned—Not Repairable)**

Rejectable damage or degradation is so severe that structural integrity of the vessel is sufficiently reduced so that the vessel is considered unfit for continued service and shall be condemned and removed from service. No repair is authorized for vessels with rejectable damage or degradation.

c) **Acceptance Criteria**

Certain, specific types of damage can be identified by the external in-service visual examination. Indications of certain types and sizes may not significantly reduce the structural integrity of the vessel and may be acceptable so the vessel can be left in service. Other types and larger sizes of damages may reduce the structural integrity of the vessel and the vessel shall be condemned and removed from service. Tables S11.7-a or S11.7-b are a summary of the acceptance/rejection criteria for the indications that are found by external examination of the vessel.

d) **Fitness-for-Service**

1) If a visual examination reveals that a vessel does not meet all criteria of Table S11.7-a or S11.7-b, it shall be taken out of service immediately, and either be condemned or a fitness-for-service examination be conducted by the original vessel manufacturer or legal successor who must also hold a National Board R certificate. When the vessel is taken out of service, its contents shall be immediately safely vented or transferred to another storage vessel per the owner’s written safety procedures.

2) If a fitness-for-service examination is to be conducted, the original vessel manufacturer shall be contacted as soon as possible after the rejectable defects have been found. The manufacturer shall then determine the vessel fitness-for-service by applicable techniques, i.e., acoustic emission testing, ultrasonic testing, and/or other feasible methods. The manufacturer shall have documentation that the evaluation method(s) used is satisfactory for determining the condition of the vessel. Repairs to the outer protective layer may be made by a “R” certificate holder other than the original manufacturer following the original manufacturer’s instructions.

(3) Determination of fitness-for-service is restricted to original manufacturer or legal successor.

**S11.8 EXTERNAL INSPECTION**
a) Vessel Service Life

Vessels have been designed and manufactured for a limited lifetime; this is indicated on the vessel marking. This marking should first be checked to ensure that such vessels are within their designated service lifetime.

b) Identification of External Damage

The external surface should be inspected for damage to the laminate. Damage is classified into two levels as shown in Table S11.7-a or Table S11.7-b of this supplement. The acceptance/rejection criteria shown in Table S11.7-a or Table S11.7-b of this supplement shall be followed, as a minimum.

The external surface of the vessel is subject to mechanical, thermal, and environmental damage. The external surface of a vessel may show damage from impacts, gouging, abrasion, scratching, temperature excursions, etc. Areas of the surface that are exposed to sunlight may be degraded by ultraviolet light which results in change in the color of the surface and may make the fibers more visible. This discoloration does not indicate a loss in physical properties of the fibers. Overheating may also cause a change in color. The size (area or length and depth) and location of all external damage shall be noted. Vessel support structures and attachments should be examined for damage such as cracks, deformation, or structural failure.

c) Types of External Damage

1) General

Several types of damage to the exterior of vessels have been identified. Examples of specific type of damage are described below. The acceptance/rejection criteria for each type of damage are described in Table S11.7-a or Table S11.7-b of this supplement.

2) Abrasion Damage

Abrasion damage is caused by grinding or rubbing away of the exterior of the vessel. Minor abrasion damage to the protective outer coating or paint will not reduce the structural integrity of the vessel. Abrasion that results in flat spots on the surface of the vessel may indicate loss of composite fiber overwrap thickness.

3) Damage from Cuts

Cuts or gouges are caused by contact with sharp objects in such a way as to cut into the composite overwrap, reducing its thickness at that point.

4) Impact Damage

Impact damage may appear as hairline cracks in the resin, delamination, or cuts of the composite fiber overwrap.

5) Delamination

Delamination is a separation of layers of fibers of the composite overwrap. It may also appear as a discoloration or a blister beneath the surface of the fiber.

6) Heat or Fire Damage
Heat or fire damage may be evident by discoloration, charring or burning of the composite fiber overwrap, labels, or paint. If there is any suspicion of damage, the vessel shall be qualified fit for service using an acoustic emission examination.

7) Structural Damage

Structural damage will be evidenced by bulging, distortion, or depressions on the surface of the vessel.

8) Chemical Attack

Some chemicals are known to cause damage to composite materials. Environmental exposure or direct contact with solvents, acids, bases, alcohols, and general corrosives can cause damage to vessels. Long-term contact with water can also contribute to corrosive damage. Chemicals can dissolve, corrode, remove, or destroy vessel materials. Chemical attack can result in a significant loss of strength in the composite material. Chemical attack can appear as discoloration and in more extreme cases the composite overwrap can feel soft when touched. If there is any suspicion of damage, the vessel shall be re-qualified using acoustic emission examination.

S11.9 INTERNAL EXAMINATION

a) Requirements for Internal Visual examination

Internal visual examination is normally not required. When vessels have been filled only with uncontaminated fluids, corrosion of the interior of the liner should not occur. Internal visual examination of the tanks should only be carried out when:

1. There is evidence that any commodity except an uncontaminated fluid has been introduced into the tank. In particular, any evidence that water, moisture, compressor cleaning solvents, or other corrosive agents have been introduced into the vessel will require an internal visual examination.

2. There is evidence of structural damage to the vessel, such as denting or bulging.

3. The vessel valve is removed for maintenance or other reason. Internal examination in this case is limited to examination of the threads and sealing surface. When an internal visual examination is conducted, the following procedures should be followed.

b) Identification of Internal Damage

1. Vessels with Metallic Liners

   For vessels with metallic liners, the objective of the internal visual examination is primarily to detect the presence of any corrosion or corrosion cracks.

   The internal surface of the vessel shall be examined with adequate illumination to identify any degradation or defects present. Any foreign matter or corrosion products should be removed from the interior of the vessel to facilitate inspection. Any chemical solutions used in the interior of the vessel should be selected to ensure that they do not adversely affect the liner or composite overwrap materials. After cleaning the vessel should be thoroughly dried before it is examined.
All interior surfaces of the vessel should be examined for any color differences, stains, wetness, roughness, or cracks. The location of any degradation should be noted.

Any vessel showing significant internal corrosion, dents or cracks should be removed from service.

2. Vessels with Non-Metallic Liners or No Liners

Vessels with non-metallic liners may show corrosion on the plastic liner or metal boss ends. Vessels with non-metallic liners or no liners may also show internal degradation in the form of cracks, pitting, exposed laminate, or porosity.

The internal surface of vessels should be examined with adequate illumination to identify any degradation or defects present. Any foreign matter or corrosion products should be removed from the interior of the vessel to facilitate examination. Chemical solutions used in the interior of the vessel should be selected to ensure they do not adversely affect the liner or composite overwrap materials. After cleaning the vessel should be thoroughly dried before it is examined.

The Inspector should look for cracks, porosity, indentations, exposed fibers, blisters, and any other indication of degradation of the liner and/or laminate. Deterioration of the liner may include softening of the matrix or exposed fibers.

S11.10 ACOUSTIC EMISSION EXAMINATION

S11.10.1 USE AND TEST OBJECTIVES

All high pressure composite pressure vessels shall be subject to an acoustic emission examination to detect damage that may occur while the vessel is in service. This method may be used in conjunction with the normal filling procedure.

S11.10.2 TEST PROCEDURE

AE transducers shall be acoustically coupled to the vessel under test and connected to waveform recording equipment. Waveforms shall be recorded and stored on digital media as the vessel is pressurized. All analysis shall be done on the waveforms. The waveforms of interest are the E (Extensional Mode) and F (Flexural Mode) plate waves.

Prior to pressurization, the velocities of the earliest arriving frequency in the E wave and the latest arriving frequency in the F wave shall be measured in the circumferential direction in order to characterize the material and set the sample time (the length of the wave window).

The E and F waves must be digitized and stored for analysis. The test pressure shall be recorded simultaneously with the AE events. Permanent storage of the waveforms is required for the life of the vessel.

S11.10.3 TECHNICIAN REQUIREMENTS

The acoustic emission technician conducting the examination required per S9.5(c) and in accordance with S9.10 shall be certified per the guidelines of ASNT SNT-TC-1A or CP-189 AE Level II or III. A technician performing this test shall have training in and experience with measuring \( C_e \) and \( C_f \) in composites and identifying wave modes.
S11.10.4-a

S11.10.4 EQUIPMENT

a) Testing System

A testing system shall consist of:

1) sensors;
2) preamplifiers;
3) high pass and low pass filters;
4) amplifier;
5) A/D (analog-to-digital) converters;
6) a computer program for the collection of data;
7) computer and monitor for the display of data; and
8) a computer program for analysis of data.

Examination of the waveforms event by event must always be possible and the waveforms for each event must correspond precisely with the pressure and time data during the test. The computer program shall be capable of detecting the first arrival channel. This is critical to the acceptance criteria below.

Sensors and recording equipment shall be checked for a current calibration sticker or a current certificate of calibration.

b) Sensor Calibration

Sensors shall have a flat frequency response from 50 kHz to 400 kHz. Deviation from flat response (signal coloration) shall be corrected by using a sensitivity curve obtained with a Michelson interferometer calibration system similar to...
the apparatus used by National Institute for Standards and Technology (NIST). Sensors shall have a diameter no greater than 0.5 inches for the active part of the sensor face. The aperture effect must be taken into account. Sensor sensitivity shall be at least 0.1 V/nm.

c. Scaling Fiber Break Energy

The wave energy shall be computed by the formula:

\[ U = \int V^2 \, dt/Z \]

Figure S11.10.4 - b  Front End Waveform

which is the formula for computing energy in the AE signal, where \( V \) is the voltage and \( Z \) is the input impedance. A rolling ball impactor shall be used to create an acoustical impulse in an aluminum plate. The measured energy in the wave shall be used to scale the fiber break energy. This scaling is illustrated later on.
The impact setup, an example of which is shown in Figure S11.10.3.a, shall be arranged as follows. The steel ball shall be ½ inch (13 mm) in diameter. The steel ball is a type typically used in machine shops for measuring taper and is commercially available. The ball shall be made of chrome steel alloy hardened to R/C 63, ground and lapped to a surface finish of 1.5 micro-inch (0.0000381 mm), within 0.0001 inch (0.0025 mm) of actual size and sphericity within 0.000025 inch (0.00064 mm). The plate shall be made of 7075 T6 aluminum, be at least 4 ft x 4 ft (1200 mm x 1200 mm) in size, the larger the better to avoid reflections, be 1/8 inch (3.2 mm) in thickness and be simply supported by steel blocks. The inclined plane shall be aluminum with a machined square groove 3/8 inch (9.5 mm) wide which supports the ball and guides it to the impact point. The top surface of the inclined plane shall be positioned next to the edge of the plate and stationed below the lower edge of the plate such that the ball impacts with equal parts of the ball projecting above and below the plane of the plate. A mechanical release mechanism shall be used to release the ball down the plane.

The ball roll length shall be 12 inches (305 mm) and the inclined plane angle shall be six degrees. The impact produces an impulse that propagates to sensors coupled to the surface of the plate 12 inches (305 mm) away from the edge. The sensors shall be coupled to the plate with vacuum grease. The energy of the leading edge of the impulse, known as the wave front shall be measured. The vertical position of the ball impact point shall be adjusted gradually in order to “peak up” the acoustical signal, much as is done in ultrasonic testing where the angle is varied slightly to peak up the response. The center frequency of the first cycle of the E wave shall be confirmed as 125 kHz ± 10 kHz. See Figure S11.10.3. The energy value in joules of the first half cycle of the E wave shall be used to scale the fiber break energy in criterion 2, as illustrated there. This shall be an “end to end” calibration meaning that the energy shall be measured using the complete AE instrumentation (sensor, cables, preamplifiers, amplifiers, filters and digitizer) that are to be used in the actual testing situation.

The front end of a waveform created by rolling ball impact calibration setup is described herein. FFT shows center frequency of the first cycle is approximately 125kHz. The energy linearity of the complete AE instrumentation (sensor, cables, preamplifiers, amplifiers, filters and digitizer) shall be measured by using different roll lengths of 8, 12 and 16 inches (203, 305, and 406 mm). The start of the E wave shall be from the first cycle of the waveform recognizable as the front end of the E wave to the end of the E wave which shall be taken as 10 microsecond (μs) later. (The time was calculated from the dispersion curves for the specified aluminum plate.) A linear regression shall be applied to the energy data and a goodness of fit $R^2 > 0.9$ shall be obtained.

d. Preamplifiers and Amplifiers - See ASME Section V Article 11.

e. Filters

A high pass filter of 20 kHz shall be used. A low pass filter shall be applied to prevent digital aliasing that occurs if frequencies higher than the Nyquist frequency (half the sampling rate) are in the signal.

f. A/D

The sampling speed and memory depth (wave window length) are dictated by the test requirements and calculated as follows: Vessel length = L inches (meters). Use $C_E = 0.2 \text{ in}/\mu\text{s} (5080 \text{ m/s})$ and $C_F = 0.05 \text{ in}/\mu\text{s} (1270 \text{ m/s})$, the speeds of the first arriving frequency in the E wave and last arriving frequency in the F wave, respectively, as a guide. The actual dispersion curves for the material shall be used if available.

$L / C_E = T_1 \mu\text{s}. \text{ This is when the first part of the direct E wave will arrive.}$

$L / C_F = T_2 \mu\text{s}. \text{ This is when the last part of the direct F wave will arrive.}$
(T2 – T1) x 1.5 is the minimum waveform window time and allows for pretrigger time.

The recording shall be quiescent before the front end of the E wave arrives. This is called a “clean front end”. Clean is defined in S9.10 (f)(2)(b) below.

The sampling rate, or sampling speed, shall be such that aliasing does not occur.

The recording system (consisting of all amplifiers, filters and digitizers beyond the sensor) shall be calibrated by using a 20 cycle long tone burst with 0.1 V amplitude at 100, 200, 300, and 400 kHz. The system shall display an energy of \[ U = \frac{V^2 NT}{2Z} \] joules at each frequency, where \( V = 0.1 \text{ volts}, N = 20, Z \) is the preamplifier input impedance and \( T \) is the period of the cycle.

g) Sensor Placement

At least two sensors shall be used in any AE test regardless of vessel size so that electromagnetic interference (EMI) is easily detected by simultaneity of arrival. Sensors shall be placed at equal distances around the circumference of the vessel on the cylindrical portion of the vessel adjacent to the tangent point of the dome such that the distance between sensors does not exceed 24 inches (610 mm). Adjacent rings of sensors shall be offset by \( \frac{1}{2} \) a cycle. For example, if the first ring of sensors is placed at 0, 120 and 240 degrees, the second ring of sensors is placed at 60, 180 and 300 degrees. This pattern shall be continued along the vessel length at evenly spaced intervals, such intervals not to exceed two feet (610 mm), until the other end of the vessel is reached. See Figure 3. The diameter referred to is the external diameter of a vessel.

Figure S11.10.5 Sensor Spacing and Pattern
Maximum distance between sensors in the axial and circumferential directions shall not exceed 24 inches (609 mm) unless it is demonstrated that the essential data can still be obtained using a greater distance and the Jurisdiction having authority concurs.

This spacing allows for capturing the higher frequency components of the acoustic emission impulses and high channel count wave recording systems are readily available.

S11.10.6 TEST PROCEDURE

Couple sensors to the vessel and connect to the testing equipment per ASME Section V Article 11. Connect the pressure transducer to the recorder. Conduct sensor performance checks prior to the test to verify proper operation and good coupling to the vessel. The E and F waveforms shall be observed by breaking pencil lead at approximately 8 in. (20 cm) and 16 in. (40.6 cm) from a sensor along the fiber direction. All calibration data shall be recorded.

The recording threshold shall be 60 dB ref 1 μV at the transducer.

Performance checks shall be carried out by pencil lead breaks (Pentel 0.3 mm, 2H) six inches (150 mm) from each transducer in the axial direction of the cylinder and a break at the center of each group of four sensors.

Pressurize the vessel to >98% of normal fill pressure and monitor AE during pressurization and for 15 minutes after fill pressure is reached. See Figure S11.10.5 for a schematic of the pressurization scheme. If at any time during fill the fill rate is too high in that it causes flow noise, decrease the fill rate until flow noise disappears. Record events during pressurization and for 15 minutes after fill pressure is reached and save the data. Then conduct a post-test performance check and save the data. The test temperature shall be between 50°F (10°C) and 120°F (49°C).

A threshold of 60 dBAE ref 1 μV at the sensor shall be used during all phases of testing.

Figure S11.10.6 Typical Pressurization Plan when Filling Vessels

AE shall be monitored for 15 min after operating fill pressure is reached.
S11.10.7 ACCEPT/REJECT CRITERIA

a) Stability Criterion

Theory of AE monitoring of high pressure composite pressure vessels for stability - A stable vessel will exhibit cumulative curves with exponentially decaying curvature. The shape of the cumulative events curve is similar for pressure vessels made of fiberglass, aramid and carbon fiber that exhibit a fiber dominated failure mode. This is essentially a test that demonstrates the composite is not progressing to failure at the hold pressure.

b) Analysis Procedure

Data will include matrix splits, matrix cracks, fiber breaks, and matrix chirps due to fracture surface fretting, and fiber/matrix debonding. Extraneous noise, identified by waveform characteristics, may also be included in the data.

1) Filter the data to eliminate any external noise such as electromagnetic interference (EMI), mechanical rubbing, flow noise, etc. Identify noise events by their shape, spectral characteristics, or other information known about the test such as a temporally associated disturbance due to the pressurization system or test fixturing. EMI is characterized by a lack of any mechanical wave propagation characteristics, particularly a lack of dispersion being apparent. EMI can be further identified by simultaneity of arrival on more than one channel. The two criteria shall be considered together to ensure it’s not simply an event that happened to be centered between the sensors. Mechanical rubbing frequencies are usually very low and can be determined by experiment. There should be no flow noise. If the vessel, or a fitting, leaks, this will compromise the data as AE is very sensitive to leaks. Leak noise is characterized by waves that look uniform across the entire length of the waveform window. If a leak occurs during the load hold, the test must be redone. Flow noise is characterized by waves that fill the waveform window.

2) Use only events that have clean front ends and in which first arrival channel can be determined. Clean means having a pre-trigger energy of less than 0.01 x 10^-10 joules. Energy is computed by the integral of the voltage squared over time.

3) Plot first arrival cumulative events versus time. Plots shall always show the pressure data.

4) Apply exponential fits by channel for pressure hold time and display both data and fit. The values are determined by the fit to $y = A_0 e^{B t} + C$.

The B value is the shape factor of the cumulative curves. C is an intercept and A is a scale factor. The time t shall be equal intervals during the hold with events binned by time interval. Record exponents and goodness of fit (R^2). Plot energy decay curves. One third or one fourth of hold time shall be used for event energy binning (cumulative energy). The formula is $y = A_0 e^{B t}$.

The sequence of energy values must monotonically decrease.

This is similar to using other energy criteria, such as historic index. A sequence that is not properly decreasing will be indicated by a low R^2 value.

5) Save all plots (all channels) to report the document.

6) Record exponents and R^2 values.
7) **Vessel B Values**

a. Vessel B values shall be tracked and compiled in order to develop a statistically significant database.

b. B is the critical value that measures the frequency of occurrence of events during pressure hold.

c. Not every vessel will have the exact same B value.

d. Data on B values should cluster.

The criteria given below apply to each individual sensor on the vessel.

a) The stability criteria as described above shall be met. (Also see ASME Section X Mandatory Appendix 8.) Any vessel that does not meet the stability criteria must be removed from service. The criteria are:

1) Cumulative Event Decay Rate \(-0.1 < B < -0.0001, R^2 \geq 0.80\)

2) Cumulative Energy Decay Rate \(-0.2 < B < -0.001, R^2 \geq 0.80\)

If these criteria are not met, the vessel does not pass. The vessel may be retested. An AE Level III examiner must review the data from the initial testing and the subsequent loading test before the vessel can be passed. Retest loadings shall follow the original pressurization rates and pressures and use a threshold of 60 dBAE. If the vessel fails the criteria again, the vessel shall not be certified by the Inspector as meeting the provisions of this Section.

b) Events that occur at the higher loads during pressurization having significant energy in the frequency band \(f > 300\) kHz are due to fiber bundle, or partial bundle, breaks. These should not be present at operating pressure in a vessel that has been tested to a much higher pressures and is now operated at the much lower service pressure. For fiber bundles to break in the upper twenty percent of load during the test cycle or while holding at operating pressure, the vessel has a severe stress concentration and shall be removed from service.

**S11.10.8 FIBER BREAKAGE CRITERION**

a) **Analysis Procedure**

In order to determine if fiber bundle breakage has occurred during the filling operation the frequency spectra of the direct E and F waves shall be examined and the energies in certain frequency ranges shall be computed as given below.

b) **Definitions**

Energies (\(U\)) in the ranges are defined as:

- \(50 \text{ – } 400\) kHz: \(U_0\)
- \(100 \text{ – } 200\) kHz: \(U_1\)
- \(250 \text{ – } 400\) kHz: \(U_2\)
The criteria for determining if high frequency spectrum events have occurred is given by the following formulas:

\[ \frac{U_0}{U_{FB}} \geq 10\% \]
\[ \frac{U_2}{(U_1 + U_2)} \geq 15\% \]
\[ \frac{U_2}{U_0} \geq 10\% \]

\( U_{FB} \) is the energy of a fiber bundle break calculated using the average breaking strength from the manufacturer’s data or independent test data. The manufacturer’s data shall be used if available. The formula that shall be used for calculating average fiber break energy is

\[ U_{FB} = \frac{E\varepsilon^2}{2A}l \]

where \( \varepsilon \) is the strain to failure of the fiber, \( E \) the Young’s modulus of the fiber, \( A \) is area of the fiber and \( l \) is the ineffective fiber length for the fiber and matrix combination. If the ineffective length is not readily available, four (4) times the fiber diameter shall be used. Set \( U_{FB} = 100 \times U_{FB} \), where \( U_{FB} \) has been calculated and scaled by the rolling ball impact energy as in the examples below. If these criteria are met, fiber bundle break damage has occurred during the test and the vessel shall be removed from service.

c) Example of Fiber Break Energy Calculation

Suppose \( d = 7 \mu m \), \( E = 69.6 \text{ GPa} \) and \( \varepsilon = 0.01 \) (average breaking strain) for some carbon fiber. Using \( A = \pi d^2/4 \) and \( l = 4d \),

\[ U_{FB} = \frac{E\varepsilon^2}{2A}l \]

\[ U_{FB} = \frac{(69.6)(0.01)^2}{2} \pi \frac{(7)(10)^{-6})^2}{4}[4(7)(10)^{-6}] \]

\[ U_{FB} \approx 3 \times 10^{-8} \text{ J} \]

d) Example of Scaling Calculation

Suppose that the rolling ball impact (RBI) acoustical energy measured by a particular high fidelity AE transducer is \( U_{RBI}^{AE} = 5 \times 10^{-10} \text{ J} \) and the impact energy \( U_{RBI} = 1.9 \times 10^{-3} \text{ J} \) (due to gravity). Suppose \( d = 7 \mu m \), \( E = 69.6 \text{ GPa} \) and \( \varepsilon = 0.01 \) (average breaking strain) for some carbon fiber. Using \( A = \pi d^2/4 \) and \( l = 4d \), \( U_{FB} = 3 \times 10^{-8} \text{ J} \). A carbon fiber with a break energy of \( U_{FB} = 3 \times 10^{-8} \text{ J} \) would correspond to a wave energy,

\[ U_{FB}^{AE} = U_{FB} \times U_{RBI}^{AE} / U_{RBI} \]

\[ U_{FB}^{AE} = 3 \times 10^{-8} \text{ J} \times 5 \times 10^{-10} \text{ J} / 1.9 \times 10^{-3} \text{ J} \]

\[ U_{FB}^{AE} = 7.9 \times 10^{-15} \text{ J} \]
This is the number that is used to calculate the value of $U_{FB}$ that is used in the fiber break criterion in the second acceptance criterion and the energy acceptance criterion in the third criterion below.

e) Amplifier Gain Correction

All energies shall be corrected for gain. (20 dB gain increases apparent energy 100 times and 40 dB gain 10,000 times.)

Fiber break waves may look similar to matrix event waves in time space but in frequency space the difference is clear. A fiber break is a very fast source, while a matrix crack evolves much more slowly due to greater than ten to one difference in their tensile moduli. The speed of the fiber break produces the high frequencies, much higher than a matrix crack event can produce. Frequencies higher than 2 MHz have been observed in proximity to a fiber break, however these very high frequencies are attenuated rapidly as the wave propagates. Practically speaking, the observation of frequencies above 300 kHz, combined with certain other characteristics of the frequency spectrum and pressure level, is enough to confirm a fiber break. It should also be noted that it is fiber bundle breaks that are usually detected in structural testing and not the breaking of individual fibers. The energies of individual fiber breaks are very small, about $3 \times 10^{-8}$ Joules for T-300 carbon fibers for example.

S11.10.8 FRICTION BETWEEN FRACTURE SURFACES

Friction between fracture surfaces plays a very important role in understanding AE in fatigue testing. It is an indicator of the presence of damage because it is produced by the frictional rubbing between existing and newly created fracture surfaces. Even the presence of fiber bundle breakage can be detected by examining the waveforms produced by Frictional Acoustic Emission or FRAE. Increasing FRAE intensity throughout a pressure cycle means more and more damage has occurred.

Therefore, for a vessel to be acceptable no AE event shall have an energy greater than $(F) \times U_{FB}$ at anytime during the test. $F$ is the acoustic emission allowance factor. The smaller the allowance factor, the more conservative the test. An $F = 10^4$ shall be used in this testing. It is the equivalent of three plus fiber tows, each tow consisting of 3,000 fibers, breaking simultaneously near a given transducer.

S11.10.9 BACKGROUND ENERGY

Background energy of any channel shall not exceed 10 times the quiescent background energy of that channel. After fill pressure is reached, any oscillation in background energy with a factor of two excursions between minima and maxima shows that the vessel is struggling to handle the pressure. Pressure shall be reduced immediately and the vessel removed from service.

S11.11 DOCUMENT RETENTION

a) The vessel owner shall retain a copy of the Manufacturer’s Data Report for the life of the vessel.

b) After satisfactory completion of the periodic in-service inspection, vessels shall be permanently marked or labeled with date of the inspection, signature of the Inspector, and date of the next periodic in-service inspection.

c) The vessel owner shall retain a copy of the in-service inspection report for the life of the vessel.
<table>
<thead>
<tr>
<th>Type of Degradation or Damage</th>
<th>Description of Degradation or Damage</th>
<th>Acceptable Level of Degradation or Damage</th>
<th>Reject able Level of Degradation or Damage</th>
</tr>
</thead>
<tbody>
<tr>
<td>Abrasion</td>
<td>Abrasion is damage to the filaments caused by wearing or rubbing of the surface by friction</td>
<td>Less than 0.050 in. depth in the pressure bearing thickness</td>
<td>≥ 0.050 in. depth in the pressure bearing thickness</td>
</tr>
<tr>
<td>Cuts</td>
<td>Linear indications flaws caused by an impact with a sharp object</td>
<td>Less than 0.050 in. depth in the pressure bearing thickness</td>
<td>≥ 0.050 in. depth in the pressure bearing thickness</td>
</tr>
<tr>
<td>Impact Damage</td>
<td>Damage to the vessel caused by striking the vessel with an object or by being dropped. This may be indicated by discoloration of the composite or broken filaments and/or cracking</td>
<td>Slight damage that causes a frosted appearance or hairline cracking of the resin in the impact area</td>
<td>Any permanent deformation of the vessel or damaged filaments</td>
</tr>
<tr>
<td>Delamination</td>
<td>Lifting or separation of the filaments due to impact, a cut, or fabrication error</td>
<td>Minor delamination of the exterior coating</td>
<td>Any loose filament ends showing on the surface. Any bulging due to interior delaminations</td>
</tr>
<tr>
<td>Heat or Fire Damage</td>
<td>Discoloration, charring or distortion of the composite due to temperatures beyond the curing temperature of the composite</td>
<td>Merely soiled by soot or other debris, such that the cylinder can be washed with no residue</td>
<td>Any evidence of thermal degradation, discoloration, or distortion</td>
</tr>
<tr>
<td>Type of Degradation or Damage</td>
<td>Description of Degradation or Damage</td>
<td>Acceptable Level of Degradation or Damage</td>
<td>Rejectable Level of Degradation or Damage</td>
</tr>
<tr>
<td>-----------------------------------------------</td>
<td>------------------------------------------------------------------------------------------------------</td>
<td>------------------------------------------</td>
<td>------------------------------------------</td>
</tr>
<tr>
<td>Structural Damage – Bulging, Distortion,</td>
<td>Change in shape of the vessel due to severe impact or dropping</td>
<td>None</td>
<td>Any visible distortion, bulging, or</td>
</tr>
<tr>
<td>depressions</td>
<td></td>
<td></td>
<td>depression</td>
</tr>
<tr>
<td>Chemical attack</td>
<td>Environmental exposure that causes a change in the composite or failure of the filaments</td>
<td>Any attack that can be cleaned off and</td>
<td>Any permanent discoloration or loss of</td>
</tr>
<tr>
<td></td>
<td></td>
<td>that leaves no residue</td>
<td>material under the exterior coat</td>
</tr>
<tr>
<td>Cracks</td>
<td>Sharp, linear indications</td>
<td>None</td>
<td>None</td>
</tr>
<tr>
<td>Scratches/Gouges</td>
<td>Sharp, linear indications caused by mechanical damage.</td>
<td>Less than 0.050 in. depth in the pressure</td>
<td>≥ 0.050 in. depth in the pressure bearing</td>
</tr>
<tr>
<td></td>
<td></td>
<td>bearing thickness or structural fibers</td>
<td>thickness or structural fibers cut or</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>broken</td>
</tr>
<tr>
<td>Soot</td>
<td>A deposit on the composite caused by thermal or environmental exposure</td>
<td>Soot that washes off and leaves no residue</td>
<td>Any permanent marking that will not</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>wash off the surface under the exterior</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>coating</td>
</tr>
<tr>
<td>Over pressurization</td>
<td>Excessive pressure due to operational malfunction</td>
<td>None reported</td>
<td>Any report of pressurization beyond the</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>MAWP or any indication of distortion</td>
</tr>
<tr>
<td>Corrosion</td>
<td>Degradation of the composite due to exposure to specific corrosive environments</td>
<td>None visible</td>
<td>Any surface damage to structural</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>identified as corrosion. See Note 2</td>
</tr>
<tr>
<td>Dents</td>
<td>A depression in the exterior of the vessel caused by impact or dropping</td>
<td>&lt; 1/16 in. in depth</td>
<td>Any dents with a depth &gt; 1/16 in. Or</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>with a diameter greater than 2 inches</td>
</tr>
<tr>
<td>Reported Collision, Accident, or Fire</td>
<td>Damage to the vessel caused by unanticipated excursion from</td>
<td>None reported</td>
<td>Any indication or report of impact or</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>heat damage</td>
</tr>
<tr>
<td>Type of Degradation or Damage</td>
<td>Description of Degradation or Damage</td>
<td>Acceptable Level of Degradation or Damage</td>
<td>Rejectable Level of Degradation or Damage</td>
</tr>
<tr>
<td>--------------------------------</td>
<td>--------------------------------------</td>
<td>------------------------------------------</td>
<td>------------------------------------------</td>
</tr>
<tr>
<td>Environmental Damage or Weathering</td>
<td>Ultraviolet or other environmental attack under the exterior coating</td>
<td>None</td>
<td>Any discoloration that can not be washed off*</td>
</tr>
<tr>
<td>Damage to a Protective or Sacrificial Layer</td>
<td>Abrasion, cuts, chemical attack, scratches/gouges, corrosion, environmental damage, or crazing that are limited only to the protective or sacrificial layer.</td>
<td>The depth of any damage to the protective or sacrificial layer that does not exceed the thickness of the protective or sacrificial layer plus 0.050 inch</td>
<td>The depth of any damage to the protective or sacrificial layer that exceeds the thickness of the protective or sacrificial layer plus 0.050 inch</td>
</tr>
<tr>
<td>Crazing</td>
<td>Hairline surface cracks only in the composite resin</td>
<td>Light hairline cracks only in the resin</td>
<td>Any damage to the filaments</td>
</tr>
</tbody>
</table>

Note 1: Only damage beyond the sacrificial or coated layer should be considered, and that any damage to sacrificial or coated layers should be repaired by suitable techniques (i.e. epoxy filler). Refer to ASME data report for sacrificial layer thickness.

Note 2 - Washing off UV scale will accelerate attack into lower composite layers. For this reason, if there is superficial UV damage the affected area should be cleaned and painted with a UV tolerant paint. If broken, frayed, or separated fibers to the non sacrificial layer, are discovered during the cleaning process then the vessel shall be condemned.

Table 1b - Visual Acceptance/Rejection Criteria for Composite Pressure Vessels (SI Units)
<table>
<thead>
<tr>
<th>Type of Degradation or Damage</th>
<th>Description of Degradation or Damage</th>
<th>Acceptable Level of Degradation or Damage</th>
<th>Rejectable Level of Degradation or Damage</th>
</tr>
</thead>
<tbody>
<tr>
<td>Impact Damage</td>
<td>Damage to the vessel caused by striking the vessel with an object or by being dropped. This may be indicated by discoloration of the composite or broken filaments and/or cracking.</td>
<td>Slight damage that causes a frosted appearance or hairline cracking of the resin in the impact area</td>
<td>Any permanent deformation of the vessel or damaged filaments</td>
</tr>
<tr>
<td>Delamination</td>
<td>Lifting or separation of the filaments due to impact, a cut, or fabrication error.</td>
<td>Minor delamination of the exterior coating</td>
<td>Any loose filament ends showing on the surface. Any bulging due to interior delaminations</td>
</tr>
<tr>
<td>Heat or Fire Damage</td>
<td>Discoloration, charring or distortion of the composite due to temperatures beyond the curing temperature of the composite</td>
<td>Merely soiled by soot or other debris, such that the cylinder can be washed with no residue</td>
<td>Any evidence of thermal degradation or discoloration or distortion</td>
</tr>
<tr>
<td>Structural Damage – bulging, distortion, depressions</td>
<td>Change in shape of the vessel due to sever impact or dropping</td>
<td>None</td>
<td>Any visible distortion, bulging, or depression</td>
</tr>
<tr>
<td>Chemical attack</td>
<td>Environmental exposure that causes a change in the composite or failure of the filaments</td>
<td>Any attack that can be cleaned off and that leaves no residue</td>
<td>Any permanent discoloration or loss or softening of material under the exterior coat.</td>
</tr>
<tr>
<td>Cracks</td>
<td>Sharp, linear indications</td>
<td>None</td>
<td>None</td>
</tr>
<tr>
<td>Scratches/Gouges</td>
<td>Sharp, linear indications caused by mechanical damage.</td>
<td>Less than 1.3 mm depth in the pressure bearing thickness No structural fibers cut or broken</td>
<td>&gt; 1.3 mm depth in the pressure bearing thickness or structural fibers cut or broken</td>
</tr>
<tr>
<td>Soot</td>
<td>A deposit on the composite caused by thermal or environmental exposure</td>
<td>Soot that washes off and leaves no residue</td>
<td>Any permanent marking that will not wash off the surface under the exterior coating</td>
</tr>
<tr>
<td>Over pressurization</td>
<td>Excessive pressure due to operational malfunction</td>
<td>None reported</td>
<td>Any report of pressurization beyond</td>
</tr>
<tr>
<td>Type of Degradation or Damage</td>
<td>Description of Degradation or Damage</td>
<td>Acceptable Level of Degradation or Damage</td>
<td>Rejectable Level of Degradation or Damage</td>
</tr>
<tr>
<td>-------------------------------</td>
<td>--------------------------------------</td>
<td>------------------------------------------</td>
<td>------------------------------------------</td>
</tr>
<tr>
<td>Corrosion</td>
<td>Degradation of the composite due to exposure to specific corrosive environments</td>
<td>None visible</td>
<td>Any surface damage to structural identified as corrosion</td>
</tr>
<tr>
<td>Dents</td>
<td>A depression in the exterior of the vessel caused by impact or dropping</td>
<td>&lt; 1.6 mm depth</td>
<td>Any dents with a depth &gt; 1.6 mm Or with a diameter greater than 51 mm</td>
</tr>
<tr>
<td>Reported Collision, Accident, or Fire</td>
<td>Damage to the vessel caused by unanticipated excursion from normally expected operating conditions</td>
<td>None reported</td>
<td>Any indication or report of impact or heat damage</td>
</tr>
<tr>
<td>Environmental Damage or Weathering</td>
<td>Ultraviolet or other environmental attack under the exterior coating</td>
<td>None</td>
<td>Any discoloration that can not be washed off (See Note 2)</td>
</tr>
<tr>
<td>Damage to a Protective or Sacrificial Layer</td>
<td>Abrasion, cuts, chemical attack, scratches/gouges, corrosion, environmental damage, or crazing that are limited only to the protective or sacrificial layer</td>
<td>The depth of any damage to the protective or sacrificial layer that does not exceed the thickness of the protective or sacrificial layer plus 1.3 mm</td>
<td>The depth of any damage to the protective or sacrificial layer that exceeds the thickness of the protective or sacrificial layer plus 1.3 mm</td>
</tr>
<tr>
<td>Crazing</td>
<td>Hairline surface cracks only in the composite resin</td>
<td>Light hairline cracks only in the resin</td>
<td>Any damage to the filaments</td>
</tr>
</tbody>
</table>

**Note 1:** Only damage beyond the sacrificial or coated layer should be considered, and that any damage to sacrificial or coated layers should be repaired by suitable techniques (i.e. epoxy filler). Refer to ASME data report for sacrificial layer thickness.

**Note 2:** Washing off UV scale will accelerate attack into lower composite layers. For this reason, if there is superficial UV damage the affected area should be cleaned and painted with a UV tolerant paint. If broken, frayed, or separated fibers to the non sacrificial layer, are discovered during the cleaning process then the vessel shall be condemned.
1.2 CONSTRUCTION STANDARDS FOR PRESSURE-RETAINING ITEMS

Add new paragraph as follows

f) For transport tanks, the Competent Authority (DOT) shall be consulted for any requirements which it has established since they take precedence for repairs.

1) Transport tanks manufactured prior to the adoption of ASME Section XII by the Competent Authority (DOT) were constructed in accordance with ASME Section VIII Division 1. Certain transport tanks manufactured to this Code were required to be stamped in accordance with Section VIII Division 1, if the design pressure of the transport tank was 241 kPa (35 psi) (depending on material being transported) and greater. If the design pressure was less than 241 kPa (35 psi) (depending on material being transported), the transport tank was manufactured in accordance with Section VIII Division 1, but not required by the Competent Authority (DOT) to be stamped.

2) ASME stamped transport tanks are subject to the requirements of NBIC Part 3 for inservice repairs, alterations, or modifications, unless exempted by the Competent Authority (DOT).

NBIC Part 3 Sections 1.8 through 1.8.9 are being replaced with the following:

1.8 “NR” Program Requirements

1.8.1 Scope

a) This section provides requirements that must be met for an organization to obtain a National Board Certificate of Authorization to use the “NR” Symbol Stamp for repair/replacement activities to nuclear items constructed in accordance with the requirements of the ASME Code or other internationally recognized codes or standards for construction or inservice inspection of nuclear facilities.

b) For administrative requirements to obtain or renew a National Board “NR” Certificate of Authorization and the “NR” Symbol Stamp, refer to National Board Procedure NB-417 Accreditation

1 Requirements for Accreditation of “NR” Repair Organizations NB-417 may be found on the NB Web site
of “NR” Repair Organizations.

1.8.2 General

a) An organization applying for an “NR” Certificate of Authorization shall have a written Quality Assurance Program (QAP) that details the specific requirements to be met based on the intended category of activities selected by that organization as described below and shown in Table 1.8.2-1. Controls used, including electronic capabilities, in the Quality Assurance Program shall be documented in a Quality Assurance Manual. Controls required to be included within the QAM shall include who, what, when, where, why and how with an understanding that the how can be a reference to an implementation procedure or instruction. Quality activities to be described in the Quality Assurance Program is identified in Section 1.8.5 of this Part. Applicants shall address all requirements in their Quality Assurance Program based on the category of activity and scope of work to be performed (organization’s capabilities) to which certification is requested.

b) Category 1

Any ASME Code certified item or system requiring repair/replacement activities irrespective of physical location and installation status prior to fuel loading.

c) Category 2

After fuel loading, any item or system under the scope of ASME Section XI requiring repair/replacement activities irrespective of physical location.

d) Category 3

Items constructed to codes or standards other than ASME, requiring repair/replacement activities irrespective of physical location, installation status and fuel loading.

<table>
<thead>
<tr>
<th>TABLE 1.8.2-1 “NR” Quality Assurance Program (QAP) Requirements</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Category of Activity</strong></td>
</tr>
<tr>
<td>--------------------------</td>
</tr>
<tr>
<td>Category 1</td>
</tr>
</tbody>
</table>

[¹ Code of Federal Regulations (CFR) – rules and regulations published by the executive departments and agencies of the federal government under www.nationalboard.org under tab Stamps and Marks.]
<table>
<thead>
<tr>
<th>Category 2</th>
<th>and ASME Section III NCA-4000</th>
<th>ASME Section III NCA-4000</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>10 CFR Part 50, Appendix B(^2) or NQA-1, Part 1 and ASME Section XI, IWA-4142</td>
<td>10 CFR Part 50, Appendix B(^2) supplemented as needed with Owners QA program; or ASME NQA-1, Part 1; or ASME Section III, NCA-4000</td>
</tr>
<tr>
<td>Category 3</td>
<td>ASME NQA-1. or Specify the Standard to which certification is desired</td>
<td>ASME NQA-1. or Specify the Standard to which certification is desired</td>
</tr>
</tbody>
</table>

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of the United States.

\(^2\) 10 CFR 50 Appendix B – Title 10 of the Code of Federal Regulations Part 50 Appendix B describes the quality assurance criteria for nuclear plants and fuel reprocessing plants.
1.8.2.1 Definitions

The terms and definitions used within this section shall be as specified below:

For Category 1 terms and definitions shall be as specified in ASME Section III

For Category 2 terms and definitions shall be as specified in ASME Section XI

For Category 3 terms and definitions shall be as specified in ASME NQA-1 and other standards specified by the Regulatory Authority

The following terms are as defined in the NBIC Glossary of Terms Section 9:

Authorized Inspection Agency

Authorized Nuclear Inspection Agency

An Authorized Inspection Agency intending to perform nuclear inspection activities and employing nuclear Inspectors / Supervisors] – NBIC Glossary

Jurisdiction

“NR” Certificate Holder

Table 1.8.2.2 Acronyms

<table>
<thead>
<tr>
<th>ASME</th>
<th>American Society of Mechanical Engineers</th>
</tr>
</thead>
<tbody>
<tr>
<td>Applicant</td>
<td>An Organization applying for “NR” Certificate of Authorization (new or renewal)</td>
</tr>
<tr>
<td>CFR</td>
<td>Code of Federal Regulations</td>
</tr>
<tr>
<td>Code</td>
<td>ASME Code of Construction, Section III, Division I, (NCA, NB, NC, ND, NE, NF, NG, and NH) or ASME Section XI Rules for Inservice Inspection of Nuclear Power Plant Components as applicable.</td>
</tr>
<tr>
<td>Jurisdiction</td>
<td>Enforcement Authority</td>
</tr>
</tbody>
</table>
### Note: *Latest Edition endorsed by the Regulatory Authority*

#### 1.8.3 Prerequisites for issuing a National Board “NR” Certificate of Authorization

Before an organization can obtain a National Board “NR” Certificate of Authorization, the organization shall:

a) Have and maintain an inspection agreement with an Authorized Nuclear Inspection Agency accepted in accordance with NB-360\(^4\) or accredited in accordance with NB-369\(^5\).

b) Have a written Quality Assurance Program that complies with the requirements of this section and address all controls for the intended category and scope of activities.

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\(^4\) NB-360, Criteria for Acceptance of Authorized Inspection Agencies for New Construction.

\(^5\) NB-369, Qualifications and Duties for Authorized Inspection Agencies (AIAs) Performing Inservice Inspection Activities and Qualification of Inspectors of Boilers and Pressure Vessels.
c) Have a current edition of the NBIC.

d) Have available ASME Section XI, the Code of Construction and referenced code sections and standards appropriate for the scope of work to be performed. ASME Section XI and Codes of Construction (Editions/Addenda) shall meet the requirements of the Regulatory Authority\(^6\) and the Owner.

1.8.4 Obtaining or Renewing a National Board “NR” Certificate of Authorization

a) Before an “NR” Certificate of Authorization will be issued or renewed, the applicant must have the Quality Assurance Program and the implementation of the program reviewed and found acceptable by representatives of the National Board, the Jurisdiction, and the Authorized Nuclear Inspection Agency. The Jurisdiction will be the National Board Member Jurisdiction in which the applicant is located or the location where the Quality Assurance Program is demonstrated/implemented. At the request of the Jurisdiction, or where there is no National Board Member Jurisdiction, the National Board representative shall act on behalf of the Jurisdiction. The implementation of the Quality Assurance Program shall be satisfactorily demonstrated by the organization. Demonstration of implementation shall meet the most stringent (classification) code requirements for the scope and category of work to be specified on the Certificate of Authorization or as requested by the applicant.

b) If the applicant is an ASME “N” type Certificate of Authorization holder, has satisfactorily demonstrated within the last twelve (12) months, the implementation of their Quality Assurance Program and can provide documentation that the organization is capable of implementing its’ Quality Assurance Program as being in compliance with this Section, a further hardware verification implementation may not be necessary.

c) The Regulatory Authority or Jurisdiction, upon request to the National Board, may attend the survey process for an “NR” Certificate of Authorization to be issued or renewed.

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\(^6\) Regulatory Authority. A government agency, such as the United States Nuclear Regulatory Commission, empowered to issue and enforce regulations concerning the design, construction, and operation of nuclear power plants.
**d)** The “NR” **Certificate of Authorization** holder shall be subject to an audit annually by the Authorized Nuclear Inspection Agency to assure compliance with the Quality Assurance Program.

### 1.8.5 Quality Assurance Program

**a)** An applicant or a holder of a National Board “NR” Certificate of Authorization (“NR” Certificate Holder) shall have and maintain a written **Quality Assurance Program**. The **Quality Assurance Program** shall satisfactorily meet the requirements of this Section, and Jurisdictional and Regulatory requirements as applicable. The **Quality Assurance Program** may be brief or voluminous, depending on the circumstances. It shall be treated confidentially by the National Board and available for review by the survey team.

**b)** Each applicant or “NR” Certificate Holder is responsible for establishing and executing a Quality Assurance Program. The applicant or “NR” Certificate Holder may subcontract activities needed to implement the Quality Assurance Program, as limited by ASME Section III and XI, but responsibility for adherence to the Quality Assurance Program remains with the Applicant or “NR” Certificate Holder.

**c)** These rules set forth the requirements for planning, managing, and implementing the organization’s Quality Assurance Program to control and assure quality is performed and maintained during repair/replacement activities of components, items, parts, and systems for nuclear facilities. These rules are to be the basis for evaluating such programs prior to the issuance or renewal of the National Board “NR” **Certificate of Authorization**. Rules identified in paragraphs 1.8.6, 1.8.7 and 1.8.8 of this Section details the Quality Assurance Program requirements for each Category of activity. These rules are established to meet and follow the requirements specified in Table 1.8.2-1 of this Section.

### 1.8.6 Quality Assurance Program Requirements for Category 1 Activities

#### 1.8.6.1 Scope
Owners or Organizations other than Owners shall have a written Quality Assurance Program meeting the criteria specified in Table 1.8.2-1 of this Section for Category 1 activities. The following quality elements shall be specified and described within the QAM.

1.8.6.2 Quality Program Elements

a) Organization

The provisions identified in ASME NQA-1, Part 1, Requirement 1, shall apply in its entirety. The Authority and responsibility for individuals involved in activities affecting quality shall be clearly established and documented throughout the Quality Assurance Program and identified on a functional organizational chart contained within the QA Manual.

b) Quality Assurance Program (QAP)

The provisions identified in ASME NQA-1, Part 1, Requirement 2, shall apply, except paragraph 301. Additionally, the following criteria shall be used when developing and maintaining the QAP.

1) The Quality Assurance Program as used in this Section shall include a written Quality Assurance Manual, with supporting procedures and instructions used to meet all the requirements of this Section.

2) Qualification of non-destructive examination personnel shall be as required by the Code of Construction or as specified in the Owners Quality Assurance Program.

3) The “NR” Certificate Holder shall be responsible for advising the Authorized Nuclear Inspection Agency of proposed changes to the Quality Assurance Manual to obtain acceptance of the Authorized Nuclear Inspector Supervisor before putting such changes into effect. The “NR” Certificate Holder shall make a current controlled copy of the Quality Assurance Manual available to the Authorized Nuclear Inspector and Authorized Nuclear Inspector Supervisor. The Certificate Holder shall be responsible for notifying the Authorized Nuclear Inspector of QAM changes, including evidence of acceptance by the Authorized Nuclear Inspector Supervisor.

4) The Quality Assurance Manual need not be in the same format or sequential arrangement as the requirements in these rules as long as all applicable requirements have been covered.
5) The “NR” Certificate Holder shall implement and maintain a program for qualification, indoctrination, training and maintaining proficiency of personnel involved with quality functions, including personnel of subcontracted services.

6) The “NR” Certificate Holder shall address in their QAM the requirements for interfacing with the Owner specified in 1.8.9 of this Section.

c) Design Control

The provisions identified in ASME NQA-1, Part 1, Requirement 3, shall apply except Paragraph 601. The following additional requirements shall be considered when applicable.

1) The NR Certificate Holder shall establish measures to ensure applicable requirements of the Owner’s Design Specifications, Owner’s requirements, and Code of Construction requirements are correctly translated into drawings, specifications, procedures and instructions.

2) All design documents, including revisions, shall be verified by the “NR” Certificate Holder to be correct and adequate in accordance with the Owners requirements.

3) Repair/replacement plans shall be completed prior to performing any work, inspections, examinations or testing; however repair/replacement plans are not required for the design phase of a repair/replacement activity including activities that require design only (except rerating).


5) The repair/replacement plan shall identify expected life of the item when less than the intended life as specified in the Owner’s Design Specification.

6) The “NR” Certificate Holder shall assure that specifications, drawings, procedures and instructions do not conflict with the Owners Design Specifications. A system must be described
in the Quality Assurance Manual to resolve or eliminate such conflicts. Resolution shall consider the Design Specification Requirements, as well as, the Owner Requirements, Jurisdictional and Regulatory Authority Requirements as applicable.

d) Procurement Document Control

The provisions identified in ASME NQA-1, Part 1, Requirement 4, shall apply. Procurement documents shall require suppliers to provide a Quality Assurance Program consistent with the applicable requirements of ASME Section III and this Section:

e) Instructions, Procedures and Drawings

The provisions identified in ASME NQA-1, Part 1, Requirement 5, shall apply. All activities affecting quality shall be prescribed by documented instructions, procedures or drawings appropriate for the scope of work to be performed. Instructions, procedures or drawings shall describe acceptance criteria to ensure quality activities are accomplished.

f) Document Control

The provisions identified in ASME NQA-1, Part 1, Requirement 6, shall apply. The Quality Assurance Program shall detail measures to control the preparation, review, issuance, use, approval and distribution of all documents related to quality as identified in the applicants Quality Assurance Program. Revisions shall meet the same requirements as the originals unless the applicant specifies other measures within their program. Measures shall ensure the latest approved documents represent the repair/replacement activities performed.

g) Control of Purchased Material, Items, and Services

The provisions identified in ASME NQA-1, Part 1, Requirement 7 shall apply, except:

1) Procurement of Authorized Inspection Agency services is not applicable as specified in paragraph 507.

2) The decision to perform bid evaluation as described in paragraph 300 is the responsibility of the “NR” Certificate Holder.
3) For Certificates of Conformance specified in paragraph 503 changes, waivers, or deviations including resolution of non-conformances must meet the requirements of ASME Section III and this Section.

4) The provisions identified in ASME NQA-1, Part 1, Requirement 7, paragraph 700 are not applicable to this section.

5) Documentary evidence for items shall conform to the requirements of ASME Section III, NCA and this Section. Materials shall meet the material certification requirements as specified in ASME Section III, NCA-3800 or NCA-3970 as applicable. Documented evidence for ASME stamped items is satisfied by a data report. Utilization of unqualified source material shall meet the requirements of ASME Section III, NCA-3855.5.

6) The “NR” Certificate Holder may obtain items from an Owner, provided the Owner provides the required documentation and items are identified to meet Code and the Certificate Holders Quality Assurance Program. The “NR” Certificate Holder shall not be required to audit the Owner as an approved supplier, provided the items used are exclusively for the Owner and the Owner procured and controlled the items under the Owner’s Quality Assurance Program.

7) The Quality Assurance Program shall establish controls to ensure all purchased materials, items, and services conform to the requirements of the Owner’s Design Specifications and the Code of Construction Edition/Addenda used to perform the work. Materials shall meet the requirements specified in ASME Section III, NCA-3800 or NCA-3970 as applicable.

h) Identification and Control of Items

The provisions identified in ASME NQA-1, Part 1, Requirement 8, shall apply and include the following additional requirements.

1) Controls shall assure only correct and acceptable items, parts and components are used or installed when performing repair/replacement activities.

2) Welding, brazing and fusing materials shall be identified and controlled.
3) Required Certified Material Test Reports and Certificates of Conformance shall be received, traceable to the items, reviewed to comply with the material specification and found acceptable.

4) The “NR” Certificate Holder shall utilize checklists to identify required characteristics using accepted procedures, compliance with records received, results of examinations and tests performed, range of valves when required, and spaces for inclusion of document numbers and revision levels, signatures/initials /stamps and dates of examinations or tests performed, verified, and/or witnessed by the “NR” Certificate Holder’s qualified Representative and Authorized Nuclear Inspector.

i) Control of Processes

The provisions identified in ASME NQA-1, Part 1, Requirement 9, shall apply. Documents used to control processes shall include spaces for signatures, initials, stamps and dates that activities were performed by the Certificate Holders representative and the Authorized Nuclear Inspector when the processes conforms to the specified acceptance criteria as listed on drawings, procedures, instructions, specifications or other appropriate documents including revisions.

j) Examinations, Tests and Inspections

The provisions identified in ASME NQA-1, Part 1, Requirement 10, shall apply, except paragraph 700 for Inspections during Operations is not required.

1) A repair/replacement plan shall be described in the Quality Assurance Manual that addresses required information to perform the work needed for repair/replacement activities. Spaces shall be included for mandatory hold points where witnessing is required by the “NR” Certificate Holder’s Qualified Representative, the Authorized Nuclear Inspector or the Owner’s Representative, if required. Work shall not proceed beyond designated mandatory hold points without documented consent as appropriate.

2) The following guidance is provided for information to be included within the repair/replacement plan:
a. A detailed description of repair/replacement activities to be performed;

b. Describe any defects and examination methods used to detect the defects;

c. Defect removal method and requirements for identifying reference points;

d. Any procedures including revisions utilized; (i.e. welding, brazing, heat treat, examination, testing) and material requirements;

e. Required documentation and stamping; and

f. Acceptance criteria used to verify acceptability.

3) Repair/Replacement plans and evaluations shall be subject to review by the Jurisdictional and Regulatory Authority when required.

k) Test Control

The provisions identified in ASME NQA-1, Part 1, Requirement 11, shall apply.

Testing shall be performed in accordance with written test procedures with acceptance criteria clearly defined. Pre-requisites for performing each test to include calibration, equipment, trained personnel, environmental conditions and provisions for data acquisition shall be described. Test results shall be documented and evaluated by qualified personnel.

l) Control of Measuring and Test Equipment

The provisions identified in ASME NQA-1, Part 1, Requirement 12, shall apply.

1) The “NR” Certificate Holder may perform periodic checks on equipment to determine calibration is maintained. When periodic checks are used the method and frequency shall be included in the “NR” Certificate Holder’s Quality Assurance Program and if discrepancies are found, shall be resolved to the prior periodic check.
2) The “NR” Certificate Holder may accept accreditation for calibration activities by National Voluntary Laboratory Accreditation Program (NVLAP), American Association for Laboratory Accreditation (A2LA) or other accrediting body recognized by NVLAP through the International Laboratory Accreditation Cooperation (ILAC) mutual recognition arrangement (MRA) provided the following requirements are met:


b. Scope of the accreditation for the calibration laboratory covers needed measurement parameters, ranges and uncertainties;

c. “NR” Certificate Holder shall specify that calibration reports shall include; laboratory equipment/standards used and as found and as left data;

d. The “NR” Certificate Holder shall verify conformance to the requirements of this process;

and

e. Utilization of this process shall be described and documented in the NR Certificate Holder’s QAM.

m) Handling, Storage and Shipping

The provisions of ASME NQA-1, Part 1, and Requirement 13 shall apply.

n) Quality Assurance Records

The provisions identified in ASME NQA-1, Part 1, Requirement 17, shall apply, except Paragraphs 400, 500, and 600 are not applicable. The following requirements shall be followed:

1) Records shall be identifiable and retrievable;

2) Records shall be retained consistent with the Owners requirements for duration, location and assigned responsibility;
3) Forms NR-1 and NVR-1 as applicable shall be completed by the “NR” Certificate Holder upon completion of all repair/replacement activities. Completion of forms, registrations and stamping of the “NR” symbol stamp shall meet the requirements of NBIC Part 3, Section 5; and

4) Lifetime and non-permanent records shall be as specified in ASME Section III, NCA-4134, Tables NCA-4134.17-1, and 4134.17-2.

5) Radiographs (digital images or film) may be reproduced provided that:
   a. The process shall be subject to Owner’s approval;
   b. The “NR” Certificate Holder is responsible for the process used and shall include a system for controlling and monitoring the accuracy so that the image will provide the same information as the original; and
   c. Procedures shall contain requirements for exposure scanning, focusing, contrast, resolution and distinguishing film artifacts as applicable for reproduced images.

6) Records shall be classified, maintained and indexed and shall be accessible to the Owner, Owner’s Designee, and the Authorized Nuclear Inspector.

7) When the “NR” Certificate Holder is the Owner, designated records and reports received by the Owner, shall be filed and maintained in a manner to allow access by the ANII. Suitable protection from deterioration and damage shall be provided by the Owner. All records and reports shall be retained as specified in the Owners QAP for the lifetime of the component or system.

9) Corrective Action
   The provisions identified in ASME NQA-1, Part 1, Requirement 16, shall apply.
1) Measures shall be established to ensure that conditions adverse to quality such as failures, malfunctions, deficiencies, deviations, defective material and equipment, and other non-conformances are promptly identified and corrected.

2) In the case of significant conditions adverse to quality, the measures shall also ensure that the cause of these conditions be determined and corrected to preclude repetition. The identification of significant conditions adverse to quality, the cause, condition, and the corrective action taken shall be documented and reported to the appropriate levels of management.

3) These requirements shall also extend to the performance of subcontractors' corrective action measures.

p) Inspection or Test Status (not to include operating status)

The provisions identified in ASME NQA-1, Part 1, Requirement 14, shall apply.

Measures shall be established to indicate inspection and test status of parts, items, or components during the repair/replacement activity. The system used shall provide positive identification of the part, item, or component by means of stamps, labels, routing cards, or other acceptable methods. The system shall include any procedures or instructions necessary to achieve compliance. Procedures shall be provided for the identification of acceptable and unacceptable items and for the control of status indicators. The Authority for Application and removal of status indicators shall also be specified.

g) Nonconforming Materials or Items

The provisions identified in ASME NQA-1, Part 1, Requirement 15, shall apply. Measures shall be established to control materials or items that do not conform to requirements to prevent their inadvertent use, including measures to identify and control the proper installation of items and to preclude nonconformance with the requirements of these rules. These measures shall include procedures for identification, documentation, segregation when practical, and disposition. Nonconforming items shall be reviewed for acceptance, rejection, or repair in accordance with documented procedures. The responsibility and authority for the disposition of nonconforming
items shall be defined. Repaired or replaced items shall be re-examined in accordance with the applicable procedures. Measures that control further processing of a nonconforming or defective item, pending a decision on its disposition, shall be established and maintained. Ultimate disposition of nonconforming items shall be documented.

r) Audits

The provisions identified in ASME NQA-1, Part 1, and Requirement 18, shall apply and shall include the following.

A comprehensive system of planned and periodic internal audits shall be performed by the “NR” Certificate Holder. Audit frequency shall be specified in the organization’s Quality Assurance Manual. Audits shall be conducted at least annually for any ongoing code activity to verify compliance with Quality Assurance Program requirements, performance criteria and to determine the effectiveness of the Quality Assurance Program. When no Code work has been performed, the required annual audit need only include those areas of responsibility required to be continually maintained such as training, audits, organizational structure, and Quality Assurance Program revisions. The Quality Assurance Manual shall as a minimum describe the following:

1) Audits shall be performed in accordance with written procedures or checklists by qualified audit personnel not having direct responsibility in areas being audited;

2) Audit personnel shall be qualified in accordance with the current requirements of ASME NQA-1;

3) Audit results shall be documented and reviewed by responsible management;

4) Requirements for follow-up actions shall be specified for any deficiencies noted during the audit;

5) Audit records and applicable documentation shall be made available to the Authorized Nuclear Inspector for review;

6) Audit records shall include as a minimum;
a. Written procedures;
b. Checklists;
c. Reports;
d. Written replies; and
e. Completion of corrective actions.

s) Authorized Nuclear Inspector

Measures shall be taken to reference the commissioned rules for National Board Authorized Nuclear Inspector, in accordance with NB-263 *Rules for National Board Inservice and New Construction Commissioned Inspectors*. The “NR” Certificate Holder shall ensure that the latest documents including the Quality Assurance Manual, procedures and instructions are made available to the Authorized Nuclear Inspector. The Authorized Nuclear Inspector shall be consulted prior to the issuance of a repair/replacement plan by the “NR” Certificate Holder in order that the Authorized Nuclear Inspector may select any in-process inspection or hold points when performing repair/replacement activities. The “NR” Certificate Holder shall keep the Authorized Nuclear Inspector informed of progress of the repair/replacement activity so that inspections may be performed. The Authorized Nuclear Inspector shall not sign Form NR-1 or Form NVR-1, as applicable, unless satisfied that all work carried out is in accordance with this Section. The Authorized Nuclear Inspector and Authorized Nuclear Inspector Supervisor shall have access to areas where work is being performed including subcontractors facilities in order to perform their required duties. The ANI shall be involved in dispositions and verification for non-conformances and corrective actions involving quality or Code requirements.

t) Exhibits

Forms and exhibits referenced in the Quality Assurance Manual shall be explained in the text and included as part of the referencing document or as an appendix to the Quality Assurance Manual. Forms shall be controlled and identified to show the latest approved revision, name, and other corresponding references as stated in the Quality Assurance Manual.

1.8.7 Quality Assurance Program Requirements for Category 2 Activities

1.8.7.1 Scope
Owners or Organizations other than Owners shall have a written Quality Assurance Program meeting one of the criteria specified in Table 1.8.2-1 of this Section. Organizations applying for a Category 2 “NR” Certificate of Authorization shall specify in their written Quality Assurance Program which program criteria their Quality Assurance Program follows. Owners shall have a Quality Assurance Program meeting the requirements of either 10 CFR 50, Appendix B or NQA-1 Part 1 and shall include the additional requirements specified in ASME Section XI, IWA-4142 when applicable. Organizations other than the Owner shall comply with requirements specified in either 10 CFR 50, Appendix B supplemented as needed with the Owner’s QAP; NQA-1 Part 1; or NCA-4000. Organizations may elect to choose to follow all the rules specified in one of the allowed QAP criteria specified in Table 1.8.2-1 or they may elect to combine or supplement requirements from other specified QAP’s. When organizations elect to combine QAP requirements, it shall be clearly specified and understood in the QAM which QAP requirement is being followed for each activity specified in their QAM. The following quality elements shall be specified and described within the QAM.

1.8.7.2 Quality Program Elements

a) Organization

The Authority and responsibility for individuals involved in activities affecting quality shall be clearly established and documented throughout the Quality Assurance Program and identified on a functional organizational chart contained within the QA Manual.

b) Quality Assurance Program (QAP)

1) Qualification of non-destructive examination personnel shall be as required by the Code or as specified in the Owners Quality Assurance Program.

2) Prior to returning an item to service, the Owner shall evaluate the suitability of the item subjected to the repair/replacement activity. Corrective actions shall be taken when an item is determined to be deficient or does not satisfy the requirements of this Section.

3) The “NR” Certificate Holder shall provide a copy of the Quality Assurance Manual to the Owner for review and acceptance. The “NR” Certificate Holder shall make a current controlled copy of
the Quality Assurance Manual available to the Authorized Nuclear Inspector and Authorized Nuclear Inspector Supervisor. When a repair/replacement activity is split between the Owner and an “NR” Certificate Holder, each Quality Assurance Program shall comply with this Section for their respective activities. The Owner shall establish interfaces for assuring this Section is met for the two Quality Assurance Programs.

4) The “NR” Certificate Holder shall be responsible for advising the Authorized Nuclear Inspection Agency of proposed changes to the Quality Assurance Manual to obtain acceptance of the Authorized Nuclear Inspector Supervisor before putting such changes into effect. The Certificate Holder shall be responsible for notifying the Authorized Nuclear Inspector of QAM changes, including evidence of acceptance by the Authorized Nuclear Inspector Supervisor.

5) The Quality Assurance Manual need not be in the same format or sequential arrangement as the requirements in these rules as long as all applicable requirements have been covered.

6) The “NR” Certificate Holder shall implement and maintain a program for qualification, indoctrination, training and maintaining proficiency of personnel involved with quality functions, including personnel of subcontracted services.

7) The “NR” Certificate Holder shall address in their QAM the requirements for interfacing with the Owner specified in 1.8.9 of this Section.

c) Design Control

1) Repair/replacement activities, Code Edition and Addenda used shall correspond with the Owner’s Inservice Inspection Program unless later Code Editions and Addenda have been accepted by the Owner, Jurisdictional and/or the Regulatory Jurisdiction having authority at the plant site.

2) The repair/replacement plan [see 1.8.7 j)] shall identify expected life of the item when less than the intended life as specified in the Owner’s requirements and the Owner shall be advised of the condition.
3) The “NR” Certificate Holder shall assure that specifications, drawings, procedures and instructions do not conflict with the Owner’s requirements. A system must be described in the Quality Assurance Manual to resolve or eliminate such conflicts. Resolution shall consider the design specification requirements, as well as, the Owner Requirements, Jurisdictional and Regulatory requirements as applicable.

4) ASME Section XI establishes that the Owner is responsible for design in connection with repair/replacement activities. The “NR” Certificate Holder must ensure that the design specification, drawings, or other specifications or instructions furnished by the Owner satisfy the Code edition and addenda of the Owner’s requirements. To satisfy this requirement, the “NR” Certificate Holder shall establish requirements that correctly incorporate the Owner’s requirements into their specifications, drawings, procedures, and instructions, which may be necessary to carry out the work. The “NR” Certificate Holder’s system shall include provisions to ensure that the appropriate quality standards are specified and included in all quality records. These records shall be reviewed for compliance with the Owner’s requirements and the requirements of ASME Section XI.

d) Procurement Document Control

Procurement documents shall require suppliers to provide a Quality Assurance Program consistent with the applicable requirements of ASME Section III, NCA and this Section.

Documents for procurement of materials, items, and subcontracted services shall include requirements to the extent necessary to ensure compliance with the Owner’s requirements and IWA-4000 of ASME Section XI. To the extent necessary, procurement documents shall require suppliers to maintain a Quality Assurance Program consistent with the applicable requirements of the edition and addenda of the Code of Construction to which the items are constructed. Measures shall be established to ensure that all purchased material, items, and services conform to these requirements.

e) Instructions, Procedures and Drawings

Repair/replacement plans and any verification of acceptability (evaluations) shall be subject to
Activities affecting quality shall be prescribed by documented instructions, procedures or drawings of a type appropriate to the circumstances and shall be accomplished in accordance with these instructions, procedures, or drawings. Instructions, procedures, or drawings shall include appropriate quantitative and qualitative criteria for determining that activities affecting quality have been satisfactorily accomplished. The “NR” Certificate Holder shall maintain a written description of procedures, instructions, or drawings used by the organization for control of quality and examination requirements detailing the implementation of the Quality Assurance Program requirements. Copies of these procedures shall be readily available to the Authorized Nuclear Inspector and Authorized Nuclear Inservice Inspector, as applicable.

f) Document Control

The program shall include measures to control the issuance, use, and disposition of documents, such as specifications, instructions, procedures, and drawings, including changes thereto. These measures shall ensure that the latest applicable documents, including changes, are reviewed for adequacy and approved for release by authorized personnel and distributed for use at the location where the prescribed activity is performed.

g) Control of Purchased Material, Items, and Services

When the Owner performs repair/replacement activities, purchase of materials and small products shall meet the requirements specified in ASME Section XI, IWA 4142.

Measures shall be established to ensure that purchased material, items, and services conform to the Owner’s requirements and applicable edition and addenda of the Code of Construction and ASME Section XI. These measures shall include identification for material traceability. Provisions shall be identified for source evaluation and objective evidence shall be provided evidencing quality standards for material examination upon receipt.

h) Identification and Control of Items
1) Measures shall be established for identification and control of material and items, including partially fabricated assemblies. These measures shall ensure that identification is maintained and traceable, either on the material or component, or on records throughout the repair/replacement activity. These measures shall be designed to prevent the use of incorrect or defective items and those which have not received the required examinations, tests, or inspections.

2) Identification for traceability shall be applied using methods and materials that are legible and not detrimental to the component or system involved. Such identification shall be located in areas that will not interfere with the function or quality aspects of the item.

3) Certified Material Test Reports shall be identified as required by the applicable material specification in ASME Section II and shall satisfy any additional requirements specified in the original Code of Construction. The Certified Material Test Report or Certificate of Compliance need not be duplicated for submission with compliance documents when a record of compliance and satisfactory reviews of the Certified Material Test Report and Certificate of Compliance is provided. Quality documents shall provide a record that the Certified Material Test Report and Certificate of Compliance have been received, reviewed, and found acceptable. When the “NR” Certificate Holder authorizes a subcontracted organization to perform examinations and tests in accordance with the original Code of Construction, the “NR” Certificate Holder shall certify compliance either on a Certified Material Test Report or Certificate of Compliance that the material satisfies the original Code of Construction requirements.

i) Control of Processes

1) The “NR” Certificate Holder shall operate under a controlled system such as process sheets, checklists, travelers, plans or equivalent procedures. Measures shall be established to ensure that processes such as welding, nondestructive examination, and heat treating are controlled in accordance with the rules of the applicable section of the ASME Code and are accomplished by qualified personnel using qualified procedures.
2) Process sheets, checklists, travelers, or equivalent documentation shall be prepared, including the document numbers and revisions to which the process conforms with space provided for reporting results of completion of specific operations at checkpoints of repair/replacement activities.

j) Examinations, Tests and Inspections

1) A repair/replacement plan shall be prepared in accordance with the Quality Assurance Program whenever repair/replacement activities are performed. As a minimum, the repair/replacement plan shall include the requirements specified in ASME Section XI, IWA-4150.

2) In-process and final examinations and tests shall be established to ensure conformance with specifications, drawings, instructions, and procedures which incorporate or reference the requirements and acceptance criteria contained in applicable design documents. Inspection, test and examination activities to verify the quality of work shall be performed by persons other than those who performed the activity being examined. Such persons shall not report directly to the immediate supervisors responsible for the work being examined.

3) Process sheets, travelers, or checklists shall be prepared, including the document numbers and revision to which the examination or test is to be performed, with space provided for recording results.

4) Mandatory hold/inspection points at which witnessing is required by the “NR” Certificate Holder’s representative or the Authorized Nuclear Inspector/Authorized Nuclear Inservice Inspector shall be indicated in the controlling documents. Work shall not proceed beyond mandatory hold/inspection points without the consent of the “NR” Certificate Holder’s representative or the Authorized Nuclear Inspector/Authorized Nuclear Inservice Inspector, as applicable.

k) Test Control
1) Testing shall be performed in accordance with the Owner’s written test procedures that incorporate or reference the requirements and acceptance criteria contained in applicable design documents.

2) Test procedures shall include provisions for ensuring that prerequisites for the given test have been met, that adequate instrumentation is available and used, and that necessary monitoring is performed. Prerequisites may include calibrated instrumentation, appropriate equipment, trained personnel, condition of test equipment, the item to be tested, suitable environmental conditions, and provisions for data acquisition.

3) Test results shall be documented and evaluated to ensure that test requirements have been satisfied.

l) Control of Measuring and Test Equipment

Measures shall be established and documented to ensure that tools, gages, instruments, and other measuring and testing equipment and devices used in activities affecting quality are of the proper range, type, and accuracy to verify conformance to established requirements. A procedure shall be in effect to ensure that they are calibrated and properly adjusted at specified periods or use intervals to maintain accuracy within specified limits. Calibration shall be traceable to known national standards, where these standards exist, or with the device manufacturer’s recommendation.

m) Handling, Storage and Shipping

Measures and controls shall be established to maintain quality requirements for handling, storage, and shipping of parts, materials, items, and components.

n) Quality Assurance Records

Documentation, reports and records shall be in accordance with ASME Section XI, IWA-6000.

1) The Owner is responsible for designating records to be maintained. Measures shall be established for the “NR” Certificate Holder to maintain these records [See NBIC Part 3, 1.8.7 n] required for Quality Assurance of repair/replacement activities. These shall include
documents such as records of materials, manufacturing, examination, and test data taken before and during repair/replacement activity. Procedures, specifications, and drawings used shall be fully identified by pertinent material or item identification numbers, revision numbers, and issue dates. The records shall also include related data such as personnel qualification, procedures, equipment, and related repairs. The “NR” Certificate Holder shall take such steps as may be required to provide suitable protection from deterioration and damage for records while in his care. Also, it is required that the “NR” Certificate Holder have a system for correction or amending records that satisfies the Owner’s requirements. These records may be either the original or a reproduced, legible copy and shall be transferred to the Owner at his request.

2) Records to be maintained as required in NBIC Part 3, 1.8.7 n) 1) above shall include the following, as applicable:

a. An index that details the location and individual responsible for maintaining the records;

b. Data reports, properly executed, for each replacement component, part, appurtenance, piping system, and piping assembly, when required by the design specification or the Owner;

c. The required as-constructed drawings certified as to correctness;

d. Copies of applicable Certified Material Test Reports and Certificates of Compliance;

e. As-built sketch(es) including tabulations of materials repair/replacement procedures, and instructions to achieve compliance with ASME Section XI;

f. Nondestructive examination reports, including results of examinations, shall identify the ASNT, SNT-TC-1A, CP-189, or ACCP certification level of personnel interpreting the examination results. Final radiographs shall be included where radiography has been performed. Radiographs may be microfilmed or digitally reproduced. The accuracy of the reproduction process shall be verified and monitored for legibility, storage, retrievability and reproduction quality;
g. Records of heat treatments may be either the heat treatment charts or a summary description of heat treatment time and temperature data certified by the “NR” Certificate Holder. Heat treatments performed by the material manufacturer to satisfy requirements of the material specifications may be reported on the Certified Material Test Report; and

h. Nonconformance reports shall satisfy IWA-4000 of ASME Section XI and shall be reconciled by the owner prior to certification of the Form NR-1 or NVR-1, as applicable.

3) After a repair/replacement activity, all records including audit reports required to verify compliance with the applicable engineering documents and the “NR” Certificate Holder’s Quality System Program, shall be maintained at a place mutually agreed upon by the Owner and the “NR” Certificate Holder. The “NR” Certificate Holder shall maintain records and reports for a period of five years after completion of the repair/replacement activity.

4) When the “NR” Certificate Holder is the Owner, designated records and reports received by the Owner, shall be filed and maintained in a manner to allow access by the ANII. Suitable protection from deterioration and damage shall be provided by the Owner. These records and reports shall be retained as specified in the Owner’s QAP for the lifetime of the component or system.

5) The original of the completed Form NR-1 or Form NVR-1, as applicable, shall be registered with the National Board and, if required, a copy forwarded to the Jurisdiction where the nuclear power plant is located.

o) Corrective Action

1) Measures shall be established to ensure that conditions adverse to quality such as failures, malfunctions, deficiencies, deviations, defective material and equipment, and other non-conformances are promptly identified, controlled and corrected.

2) In the case of significant conditions adverse to quality, the measures shall also ensure that the cause of these conditions be determined and corrected to preclude repetition. The identification
of significant conditions adverse to quality, the cause, condition, and the corrective action taken shall be documented and reported to the appropriate levels of management.

3) Corrective action requirements shall also extend to the performance of subcontractors’ activities.

p) **Inspection or Test Status (not to include operating status)**

Measures shall be established to indicate examination and test status of parts, items, or components during the repair/replacement activity. The system used shall provide positive identification of the part, item, or component by means of stamps, labels, routing cards, or other acceptable methods. The system shall include any procedures or instructions necessary to achieve compliance. Also, measures shall be provided for the identification of acceptable and unacceptable items. They shall also include procedures for control of status indicators, including the authority for application and removal of status indicators.

q) **Nonconforming Materials or Items**

Measures shall be established to control materials or items that do not conform to requirements to prevent their inadvertent use, including measures to identify and control the proper installation of items and to preclude nonconformance with the requirements of these rules. These measures shall include procedures for identification, documentation, segregation, and disposition. Nonconforming items shall be reviewed for acceptance, rejection, or repair in accordance with documented procedures. The responsibility and authority for the disposition of nonconforming items shall be defined. Repaired/replaced or altered items shall be re-examined in accordance with the applicable procedures. Measures that control further processing of a nonconforming or defective item, pending a decision on its disposition, shall be established and maintained. Ultimate disposition of nonconforming items shall be documented.

r) **Audits**

A comprehensive system of planned and periodic internal audits shall be performed by each organization, audit frequency shall be specified in the organization’s Quality Assurance Manual. Audits shall be conducted at least annually to verify compliance with Quality Assurance Program requirements, performance criteria and to determine the effectiveness of the Quality Assurance
Program. When no Code work has been performed, the required annual audit need only include those areas of responsibility required to be continually maintained such as training, audits, organizational structure, Quality Assurance Program revisions, etc. The Quality Assurance Manual shall as a minimum describe the following:

1) Audits shall be performed in accordance with written procedures or checklists by qualified audit personnel not having direct responsibility in areas being audited;

2) Audit personnel shall be qualified in accordance with the current requirements of NQA-1;

3) Audit results shall be documented and reviewed by responsible management;

4) Requirements for follow-up actions for any deficiencies noted during the audit;

5) Audit records and applicable documentation shall be made available to the Authorized Nuclear Inspector for review;

6) Audit records shall include as a minimum:
   a. written procedures;
   b. checklists;
   c. reports;
   d. written replies; and
   e. completion of corrective actions.

s) Authorized Nuclear Inspector

Measures shall be taken to reference the commissioned rules for National Board Authorized Nuclear Inspector, in accordance with NB-263 Rules for National Board Inservice and New Construction Commissioned Inspectors. The “NR” Certificate Holder shall ensure that the latest documents including the Quality Assurance Manual, procedures and instructions are made available to the Authorized Nuclear Inspector. The Authorized Nuclear Inspector shall be consulted prior to the issuance of a repair/replacement plan by the “NR” Certificate Holder in order that the Authorized Nuclear Inspector may select any in process inspection or hold points when performing
repair/replacement activities. The “NR” Certificate Holder shall keep the Authorized Nuclear Inspector informed of progress of the repair/replacement activity so that inspections may be performed. The Authorized Nuclear Inspector shall not sign Form NR-1 or Form NVR-1, as applicable, unless satisfied that all work carried out is in accordance with this Section. The Authorized Nuclear Inspector and Authorized Nuclear Inspector Supervisor shall have access to areas where work is being performed including subcontractors facilities in order to perform their required duties. The ANI shall be involved in dispositions and verification for non-conformances and corrective actions involving quality or Code requirements.

t) Exhibits

Forms and exhibits referenced in the Quality Assurance Manual shall be explained in the text and included as part of the referencing document or as an appendix to the Quality Assurance Manual. Forms shall be controlled and identified to show the latest approved revision, name, and other corresponding references as stated in the Quality Assurance Manual.

1.8.8 Quality Assurance Program Requirements for Category 3 Activities

1.8.8.1 Scope

Organizations requesting a Category 3 “NR” Certificate of Authorization may elect to follow the requirements specified in ASME NQA-1 Part 1 or follow specific Quality Assurance Program requirements outlined in other specified standards as required by the Owner, Regulatory Authority or Jurisdiction. Organizations shall specify in the QAM what QAP requirements are followed. When standards other than ASME NQA-1 are followed, the organization shall have available a copy of that standard for review by the NB Survey Team and the ANIA, as applicable. Each organization shall, as a minimum, include in their written QAM the specified elements listed in Category 1 and/or 2 (NBIC Part 3, 1.8.6, 1.8.7) QAP requirements. Additional requirements, as specified within this Section, including paragraph 1.8.9, shall be included within the QAP. Also, limitations or additions to ASME NQA-1, as specified for Category 1 or 2 may be incorporated and referenced within the QAM.

1.8.8.2 Quality Program Elements

a) Organization
Persons and organization shall have authority and freedom to identify quality problems; initiate, recommend or provide solutions and verify implementation of solutions.

b) QAP

Shall account for special controls, processes, test equipment, tools and skills to obtain quality and for verification of quality by inspections and tests. Indoctrination, training and maintaining proficiency of personnel effecting quality shall be described. The status and adequacy of the QAP shall be regularly reviewed. The scope shall be included within the written QAM. The “NR” Certificate Holder shall make a current controlled copy of the Quality Assurance Manual available to the Authorized Nuclear Inspector and Authorized Nuclear Inspector Supervisor. The “NR” Certificate Holder shall address in their QAM the requirements for interfacing with the Owner specified in NBIC Part 3, 1.8.9.

c) Design Control

Established measures to assure approximate quality standards are specified and included in design documents. Any deviations shall be identified and controlled.

d) Document Control

Documents for procurement of material, equipment and services shall assure regulatory requirements, design bases and other quality requirements and are included or referenced. Procurement documents shall require contractors or subcontractors provide a Quality Assurance Program consistent with the provisions specified in NBIC Part 3, 1.8.8.

e) Instructions, Procedures and Drawings

Activities affecting quality shall be accomplished in accordance with prescribed instructions, procedures or drawings and shall include approximate quantitative or qualified acceptance criteria to determine activities are satisfactorily accomplished.

f) Document Control

Shall detect measures to control the preparation, issuance, use, approval, revisions and distribution of all documents related to quality.
g) Control of Purchases, Materials, Items and Services

Purchased material, items and services shall conform to the procurement documents. Measures shall be established for source evaluation and selection, objective evidence of quality, inspections at the source and examination of products upon delivery. Effectiveness of quality shall be assessed by the applicant or designee at specified intervals.

h) Identification and Control of Items

Specified controls shall assure only correct and acceptable items, parts and components are used and installed.

i) Control of Processes

Documents used to control processes and conform to specified acceptance criteria shall include spaces for signatures, initials, stamps and dates for activities performed by the Certificate Holders Representative and the Authorized Nuclear Inspector.

j) Examinations, Tests and Inspections

A repair / replacement plan shall address all required information for performing examinations, tests and inspections including but not limited to:

- Establishing hold points
- Identifying procedures, methods, acceptance criteria
- Defects identified, removal methods, welding and material requirements, reference points used for identification
- Evaluations of results

k) Test Control

Tests performed to written procedures identifying acceptance limits, calibration, equipment, personnel qualifications, environmental conditions, and documentation required.

l) Control of Measuring and Test Equipment

Procedures, methods and frequency of calibration shall be described for all types of measuring and test equipment used to verify quality. Any discrepancies shall be identified and resolved.

m) Handling, Storage and Shipping
Processes or procedures shall be established to prevent damage, deterioration or misuse of material, items or components used and stored.

n) Records

All quality related records shall be classified, identified, verified, maintained, distributed, retraceable, and accessible. When the “NR” Certificate Holder is the Owner, designated records and reports received by the Owner, shall be filed and maintained in a manner to allow access by the ANII. Suitable protection from deterioration and damage shall be provided by the Owner. These records and reports shall be retained as specified in the Owner’s QAP for the lifetime of the component or system.

o) Corrective Action

Measures established to assure conditions adverse to quality are promptly identified and corrected and action taken to preclude repetition.

p) Inspection or Test Status

Measures shall be established to indicate inspection and test status of parts, items or components during repair/replacement activity. Measures shall include identification, procedures, control indicators (acceptable, unacceptable) and responsibility of personnel.

q) Nonconforming Material or Items

Measures to control material or items, nonconforming to specified criteria shall be established. Measures shall include identifying, controlling, documenting, reviewing, verifying, dispositioning and segregation when practical.

r) Audits

A system of planned and periodic audits shall be established to verify compliance of the Quality Assurance Program. Audits shall include: written procedures, checklists, trained/qualified personnel not having direct responsibility for areas being audited, documentation, review by management and follow up actions when required.

s) Authorized Nuclear Inspector
Qualifications and duties shall be as specified in ASME QAI-1 and NB-263 for the Authorized Inspection Agencies, Authorized Nuclear Inspector and the Authorized Nuclear Inspector Supervisor. Additional requirements are specified in NBIC Part 3, 1.8.6.2 s), 1.8.7.2 s), and 1.8.9.

t) Exhibits

Quality related forms and exhibits described in the Quality Assurance Program shall be identified, controlled and where applicable included as a reference document within the QAM or referenced procedures.

1.8.9 Interface with the Owner’s Repair/Replacement Program

(For Categories 1, 2, and 3 as applicable)

Interface with the Owner’s repair/replacement program shall meet the following:

a) The “NR” Certificate Holder’s repair/replacement plan shall be subject to the acceptance of the Owner and the Owner’s Authorized Nuclear Inservice Inspector (ANII) and shall be subject to review by the Jurisdiction and Regulatory Authorities having Jurisdiction at the plant site.

b) Repair/Replacement activities of nuclear components shall meet the requirements of ASME Section III, ASME Section XI, and/or other applicable standard, and the Owner’s requirements, and shall be subject to verification by the Jurisdiction and Regulatory Authorities having jurisdiction at the plant site.

c) Documentation of the repair/replacement activities of nuclear components shall be recorded on the Report of Repair/Replacement Activities of Nuclear Components and Systems for Nuclear Facilities, Form NR-1, or Report of Repair/Replacement Activities for Nuclear Pressure Relief Devices, Form NVR-1, in accordance with the NBIC Part 3, Section 5. The completed forms shall be signed by a representative of the “NR” Certificate Holder and the Authorized Nuclear Inspector when the repair/replacement activity meets the requirements of this Section. For repair/replacement activities that involve design changes, Form NR-1, or Form NVR-1, as applicable, shall indicate the Organization responsible for the design or design reconciliation in accordance with the Owner’s requirements.
d) The “NR” Certificate Holder shall provide a copy of the signed Form NR-1 or Form NVR-1, as applicable, to the Owner, the Jurisdiction, and the Regulatory Authority if required, and the Authorized Nuclear Inspection Agency. The original Form NR-1 or Form NVR-1, as applicable, shall be registered with the National Board by the “NR” Certificate Holder. A NB registration log shall be maintained by the “NR” Certificate Holder. See NBIC Part 3, Section 5.5 and 5.6.

e) The “NR” Certificate Holder shall provide a nameplate/stamping for repair/replacement activities for each nuclear component unless otherwise specified by the Owner’s Quality Assurance Program. The required information and format shall be as shown in NBIC Part 3, Section 5.

2.5.3.2 (f)

f) The qualification thickness for the test plates and repair groove depths shall be in accordance with ASME Section IX. For pressure retaining items repaired using this temper bead method, hardness testing and carbon equivalency requirements may be waived for ASME Section IX temper bead procedure qualification provided the pressure retaining item operates in steam service above 900 deg F (482 deg C).

2.5.3 ALTERNATIVE WELDING METHODS WITHOUT POSTWELD HEAT TREATMENT

e) Nondestructive Examination of Welds

Prior to welding, the area prepared for welding shall be examined using either the Magnetic Particle (MT) or the Liquid Penetrant (PT) examination method to determine that no defects exist. After the finished weld has reached ambient temperature, and, when required by the specific welding method, the surface temper bead reinforcement layer has been removed substantially flush with the surface of the base metal, the weld shall be examined again by either of the above methods to determine that no defects exist using acceptance standards acceptable to the Inspector or original code of construction. In addition, welds greater than 3/8 in. (9.6 mm) deep or welds in a boiler, pressure vessel, or piping system that were originally required to be radiographed by the rules of the original code of construction, shall be radiographically examined. In situations where it is not practical to perform radiography, the accessible surfaces of each non-radiographed repair weld shall
be fully examined using the MT or PT method to determine that no defects exist and the maximum allowable working pressure and/or allowable temperature shall be re-evaluated to the satisfaction of the jurisdiction at the location of installation.

2.5.3.4 f)

f) The qualification thickness for the test plates and repair groove depths shall be in accordance with ASME Section IX. For pressure retaining items fabricated to ASME Section I and repaired using this temper bead method, hardness testing and carbon equivalency requirements may be waived for ASME Section IX temper bead procedure qualification provided the pressure retaining item operates in steam service above 900 deg F (482 deg C).

2.5.3.5 d)

d) The WPS shall be qualified in accordance with the temper bead rules of QW-290 in ASME Section IX. For pressure retaining items fabricated to ASME Section I and repaired using this temper bead method, hardness testing and carbon equivalency requirements may be waived for ASME Section IX temper bead procedure qualification provided the pressure retaining item operates in steam service above 900 deg F (482 deg C).

2.5.3.6 Welding Method 6

This welding method provides guidance for welding only Grade 91 tube material within the boiler setting and when it's impracticable to perform local post weld heat treatment (PWHT). This repair method utilizes a controlled fill technique.

When using this welding method, the following is required:

a) This method is limited to butt welds in tubing 5“ NPS or less in diameter and ½” or less in wall thickness for which the applicable rules of the original code of construction did not require notch toughness testing.
b) Application shall be limited to only boiler tube repairs at a location internal to the boiler setting.

c) Upon the completion of weld repair, the repair region shall be kept from humid or moist environments until the return to service.

1) The material shall be limited to P-No 15E, Group 1, Grade 91, creep strength enhanced ferritic steel (CSEF).

2) The welding shall be limited to the SMAW or GTAW processes, manual or automatic, using suitably controlled maintenance procedures to avoid contamination by hydrogen producing sources. The surface of the metal shall be free of contaminants and kept dry.

3) The test material for the welding procedure qualification shall be P-No 15 E, Group 1, Grade 91 for the repair.

4) Qualification thickness for the test plates and repair groove depths shall be in accordance with ASME Section IX, QW-451.

5) The Welding Procedure Specification (WPS) shall be qualified in accordance with the requirements of ASME Section IX, except that no postweld heat treatment shall be applied to the test coupon. Additionally, the qualification shall include the following requirements:

   a. The minimum preheat for the GTAW process shall be 200 deg F (93 deg C). The minimum preheat for the SMAW process shall be 300 deg F (150 deg C). The preheat temperature shall be checked to ensure the minimum preheat temperature is maintained during welding and until welding is completed. The maximum interpass temperature shall be 400 deg F (200 deg C).

   b. When the SMAW process is specified for a fill pass layer as a controlled filled welding technique, the electrode diameter is restricted to a maximum size of 1/8” (3.2 mm). When
the GTAW-process is specified, any limits in filler size is to be reflected in the qualified PQR and WPS.

c. Regardless of the welding process (SMAW or GTAW), only the use of stringer beads shall be permitted.

d. The filler metal shall be limited to an austenitic, nickel-base filler metal having a designation F-No. 43 and limited to the following consumables: ERNiCr-3 (Filler Metal 82), ENiCrFe-3 (INCONEL Welding Electrode 182), ENiCrFe-2 (INCO-WELD A), ASME B&PV Code Cases 2733 and 2734 (EPRI P87).

3.2.7 CHANGE OF SERVICE

See NBIC Part 2, Supplement 9 for requirements and guidelines to be followed when a change of service or service type is made to a pressure retaining item.

Whenever there is a change of service, the local jurisdiction where the pressure retaining item is to be operated, shall be notified for acceptance, when applicable. Any specific jurisdictional requirements shall be met.

3.3.4.9 TUBE PLUGGING IN FIRETUBE BOILERS

When the replacement of a tube in a firetube boiler is not practicable at the time the defective tube is detected, with the concurrence of the owner, Inspector, and when required, the Jurisdiction, the tube may be plugged using the following course of repair:

a) The scope of work, type of plug and method of retention; whether welded or mechanical interface, shall be evaluated by the “R”-Certificate Holder performing the repair and reviewed with the Inspector, and when required, the Jurisdiction.
b) When the method of plugging is by welding, strength calculations for the size of the weld shall be in accordance with the original code of construction. The “R” Certificate Holder performing this repair shall weld the plug to the tube, or to the tube sheet, or a combination of both.

c) Plugging a tube in a firetube boiler is recognized as an alternative to the replacement of a firetube and may be further limited as a method of repair by the number of tubes plugged and their location; scattered or clustered. The operational effects on the waterside pressure boundary or membrane and the effects on the combustion process throughout the boiler should be considered prior to plugging.

d) The boiler may be returned to service for a period of time agreed upon by the owner, the Inspector, and when required, the Jurisdiction.

e) The Form R-1 shall be completed for the plugging of firetubes and identifying the means of plug retention; mechanical or by welding.

5.7.5 SPECIFIC REQUIREMENTS FOR STAMPING AND NAMEPLATES

g) The subject nameplate shall be securely attached using a method compatible with the structure or stand-off bracket supporting the nameplate, in a manner that will impede easy removal. The method of attaching this nameplate, as permitted by the original Code of construction, may include, but is not limited to:

1) Welding

2) Adhesive, bonding or cementing

3) Tamper-resistant mechanical fasteners of suitable metal construction.

5.13.5.1 GUIDE FOR COMPLETING NATIONAL BOARD FORM NR-1 REPORTS

Title Block: Check category of activity, 1, 2, or 3
Check type of activity, repair, replacement, alteration/modification, and/or rerating, as applicable.

1. Name and address of the organization, as shown on the National Board “NR” Certificate of Authorization, which performed the activity.

2. Indicate NR Form Registration Number.

3. Indicate the purchase order number, job number, etc., as applicable, assigned by the organization that performed the work.

4. Name and address of the owner of the nuclear power plant.

5. Name and address of the nuclear power plant and, if applicable, identification of the unit.

6. Identify the system (e.g., residual heat removal, reactor coolant) with which the repair, replacement, alteration/modification, or rerating activity is associated.

7. ASME Code Section XI or Section III, as applicable to the repairs, alterations/modification, replacement or rerating activity performed.

8. Name of the organization, as shown on the Certificate of Authorization, which performed the design activity including:

   a. Original Design Specification Number and Revision Number.
   
   b. Original Design Report Number and Revision Number.
   
   c. Revised Design Specification Number and Revision Number.
   
   d. Revised Design Report Number and Revision Number.
e. Design Reconciliation Number and Revision Number.

f. Applicable Code Edition and Addenda Date(s)

9. Check the type of test conducted (e.g., hydrostatic, pneumatic, system leakage, exempt, or other) and indicated the pressure applied when applicable.

10. Sequential number assigned to each item reported.

11. Indicate the type of component (e.g., vessel, line valve, pump, piping system).

12. Manufacturer’s name of the affected item.

13. Manufacturer’s serial number.

14. National Board number, if applicable, of the affected item.

15. Indicate Jurisdictional number, if applicable, of the affected item.

16. Indicate plant tag or identification number, if applicable, of the affected item.

17. Year the affected item was manufactured.

18. Identify the name, section, and division of the original construction code for the affected item.

19. Identify the edition, addenda, and as applicable, code cases, and class of the original construction code for the affected item.

20. Indicate the activity performed on this item (e.g., repair, alteration or modification).

21. Manufacturer’s name of this replacement item.
22. Manufacturer’s serial number of this replacement item.

23. National Board number, if applicable, of this replacement item.

24. Indicate plant tag or identification number, if applicable, of this replacement item.

25. Year this replacement item was manufactured.

26. Identify the name, section, and division of the original construction code for this replacement item.

27. Identify the edition, addenda, and as applicable, code cases and class of the original construction code for this replacement item.

28. Provide a detailed summary describing the scope of work completed. Information to be considered should include type of work (e.g. welding, brazing, fusing), location, steps taken for removal or acceptance of defects, examinations, testing, heat treat, and other special processes or methods utilized. If necessary, attach additional data, sketch, drawing, Form R-4, etc. If additional data is attached, so state in the remarks section.

29. Indicate any additional information pertaining to the work.

30. Type or print name of authorized representative from the certificate holder.

31. Indicate ASME Section III or Section XI as applicable to the repair, replacement, alteration/modification, and/or rerating activity performed.

32. Indicate National Board Certificate of Authorization number.

33. Indicate month, day, and year the certificate expires.
34. Name of the organization that performed the identified work, using the full name as shown on the Certificate of Authorization, or an abbreviation acceptable to the National Board.

35. Indicate month, day and year of signature by the Authorized Representative.

36. Signature of authorized representative from the certificate holder defined in item 30 above.

37. Title of authorized representative as defined in the Quality Program.

38. Type or print name of Authorized Nuclear Inspector.

39. Indicate the Jurisdiction where the activity is performed, when required.

40. Indicate Authorized Nuclear Inspector’s employer.

41. Indicate address of Authorized Nuclear Inspector’s employer (city and state or province).

42. Indicate month, day, and year of inspection by the Authorized Nuclear Inspector.

43. Indicate month, day, and year of signature by the Authorized Nuclear Inspector.

44. Signature of Authorized Nuclear Inspector defined in item 38 above.

45. National Board Commission number and required endorsements.

5.13.6.1 INSTRUCTIONS FOR COMPLETING NATIONAL BOARD FORM NVR-1 REPORTS

Title Block: Check category of activity, 1, 2, or 3

Check type of activity, repair, replacement, and/or rerating, as applicable.
1. Name and address of the organization, as shown on the National Board “VR” and “NR” Certificates of Authorization, which performed the activity.

2. Indicate NVR Form Registration Number.

3. Indicate the purchase order number, job number, etc., as applicable, assigned by the organization that performed the work.

4. Name and address of the organization for which the work was performed.

5. Name and address of the owner nuclear power plant.

6. Name and address of the nuclear power plant and, if applicable, identification of the unit.

7. Describe the type of pressure relief device (e.g., safety valve, safety relief valve, pressure relief valve).

8. Manufacturer's name of the affected item.

9. Indicate the pressure relief device by the manufacturer’s valve series or catalog number.

10. Manufacturer’s serial number of the affected item.

11. National Board number, if applicable, of the affected item.

12. Indicate the service as steam, liquid, air/gas, etc.

13. Indicate the pressure relief device by inlet size, in inches.

14. Year the affected item was manufactured.

15. Indicate the name, section and division of the original construction code for the affected item.
16. Identify the edition, addenda, and as applicable, code cases, and class of the original construction code for the affected item.

17. Identify the edition, addenda, and as applicable, code cases of the ASME Section XI code for the in-service inspection activity.

18. Identify the edition, addenda, and as applicable, code cases of the ASME Section XI code for the repair/replacement activity.

19. Identify the edition, addenda, and as applicable, code cases of the construction code for the repair/replacement activity.

20. Identify the organization responsible for design or design reconciliation, if applicable.

21. Indicate the set pressure of the valve.

22. Indicate the blowdown, if applicable, as a percentage of set pressure.

23. Indicate repair organization’s name and address.

24. Indicate medium (e.g. steam, air, etc.) used for the adjustment of the set pressure and, if applicable, blowdown.

25. Provide a detailed summary describing the scope of work completed. Information to be considered should include type of work (e.g. welding, brazing, fusing), location, steps taken for removal or acceptance of defects, examinations, testing, heat treat, and other special processes or methods utilized. If Necessary, attach additional data, sketch, drawing, Form R-4, etc. If additional data is attached, so state in the remarks section.

26. Indicate any additional information pertaining to the work.
27. Type or print name of authorized representative from the certificate holder.

28. Indicate ASME Section XI or construction code as applicable to the repair, replacement, and/or rerating activity performed.


30. Indicate month, day, and year the certificate expires.

31. Indicate month, day, and year of signature by the authorized representative.

32. Signature of authorized representative from the certificate holder defined in item 27 above.

33. Title of authorized representative as defined in the Quality Program.

34. Type or print name of Authorized Nuclear Inspector.

35. Indicate the Jurisdiction where the activity is performed, when required.

36. Indicate Authorized Nuclear Inspector’s employer.

37. Indicate address of Authorized Nuclear Inspector’s employer (city and state or province).

38. Indicate month, day, and year of inspection by the Authorized Nuclear Inspector.

39. Indicate month, day, and year of signature by the Authorized Nuclear Inspector.

40. Signature of Authorized Nuclear Inspector defined in item 34 above.

41. National Board Commission number and required endorsements.
FORM NR-1, REPORT OF REPAIR/REPLACEMENT ACTIVITIES FOR NUCLEAR FACILITIES

CATEGORY OF ACTIVITY:  1 ☐  2 ☐  3 ☐

1. Work Performed by
   Name of “NR” certificate holder _____________________________
   NR Form Registration No. _____________________________
   Address _____________________________

2. Owner
   Name _____________________________
   Address _____________________________

3. Name, address and identification of nuclear power plant _____________________________

4. System _____________________________

5. ASME Code Section XI or III used for repairs, alterations/ modification, replacement or rerating activity acceptance:

6. Design responsibility:
   Original Design Specification No./Rev.: ___________
   Original Design Report No./Rev.: ___________
   Revised Design Specification No./Rev.: ___________
   Revised Design Report No./Rev.: ___________
   Design Reconciliation No./Rev.: ___________
   Code ED/AD: ___________

7. Tests conducted:  ☐ Hydrostatic  ☐ Pneumatic  ☐ System Leakage  ☐ Exempt  ☐ Other ___________

8a. Repair/Alteration/Modification Activities

<table>
<thead>
<tr>
<th>Identification</th>
<th>Construction Code</th>
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<tbody>
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8b. Replacement Activities

<table>
<thead>
<tr>
<th>Identification</th>
<th>Construction Code</th>
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<tbody>
<tr>
<td>Type of Item</td>
<td>Mfg. Name</td>
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</tbody>
</table>
9. **Description of work** (use of properly identified additional sheet[s] or sketch[es] is acceptable):

   1. 
   2. 
   3. 
   4. 
   5. 

10. **Remarks:**

       1. 
       2. 
       3. 
       4. 
       5. 
       6. 
       7. 
       8. 
       9. 

---

**CERTIFICATE OF COMPLIANCE**

I, ________________, certify that to the best of my knowledge and belief the statements made in this report are correct and the repair/replacement activities described above conform to and the *National Board Inspection Code* “NR” rules.

National Board Certificate of Authorization No. __________ to use the “NR” stamp expires ________________

“NR” Certificate Holder ________________

(Date) 

(Signed) 

(Approved by Representative) 

(Title)

---

**CERTIFICATE OF INSPECTION**

I, ________________, holding a valid commission issued by the National Board of Boiler and Pressure Vessel Inspectors and certificate of competency, where required, issued by the Jurisdiction of ________________ and employed by ________________ of ________________ have inspected the repair, alteration/modification, replacement, and/or rerating activities described in this report on ________________ and state that to the best of knowledge and belief, these activities have been completed in accordance with the Codes specified and the *National Board Inspection Code* “NR” rules.

By signing this certificate, neither the undersigned nor my employer makes any warranty, expressed or implied, concerning the work described in this report. Furthermore, neither the undersigned nor my employer shall be liable in any manner for any personal injury, property damage, or loss of any kind arising from or connected with this inspection.

Date ________________ Signed ________________ Commissions ________________

(Inspector) 

(National Board and Endorsement)
FORM NVR-1, REPORT OF REPAIR/REPLACEMENT ACTIVITIES FOR NUCLEAR PRESSURE RELIEF DEVICES

1. Work Performed by
   name of “NVR” authorized organization
   NVR form registration no.
   address

2. Work performed for
   name

3. Owner
   name
   address

4. Name, address, and identification of nuclear power plant:

5. a: Repaired pressure relief device:
   (Edition)
   (name/section/division)
   (code class)
   (addenda)
   (Code Case(s))
   (mfg. serial no.)
   (Nat’l Bd No.)
   (Service)
   (size)
   (year built)

6. ASME Code Section XI applicable for inservice inspection:
   (edition)
   (addenda)
   (Code Case(s))

7. ASME Code Section XI used for repair/replacement/rerate:
   (edition)
   (addenda)
   (Code Case(s))

8. Construction Code used for repair/replacement/rerate:
   (edition)
   (addenda)
   (Code Case(s))

9. Design responsibility:

10. Opening pressure: ____________ Blowdown (if applicable): ____________ Set pressure and blowdown
    adjustment made at: ____________ using ____________

11. Description of work: (include name and identifying number of replacement parts):

12. Remarks:

   CERTIFICATE OF COMPLIANCE
   I, ______________________, certify that to the best of my knowledge and belief the statements made in this report are correct and the repair, replacement, or rerate of the pressure relief devices described above conform to ______________________ and the National Board Inspection Code “VR” & “NR” rules.
   National Board Certificate of Authorization No. ______________________ to use the “VR” stamp expires ______________________
   National Board Certificate of Authorization No. ______________________ to use the “NR” stamp expires ______________________
   Date ______________________ Signed ______________________
   (Authorized Representative) (Title)

   CERTIFICATE OF INSPECTION
   I, ______________________ holding a valid commission issued by the National Board of Boiler and Pressure Vessel Inspectors and certificate of competency, where required, issued by the Jurisdiction of ______________________ and employed by ______________________ have inspected the repair, replacement, and/or rerate described in this report on ______________________ and state that to the best of my knowledge and belief, this repair or replacement has been completed in accordance with the Code specified and the National Board Inspection Code “VR” & “NR” rules.
   By signing this certificate, neither the undersigned nor my employer makes any warranty, expressed or implied, concerning the repair or replacement described in this report. Furthermore, neither the undersigned nor my employer shall be liable in any manner for any personal injury, property damage, or loss of any kind arising from or connected with this inspection.
   Date ______________________ Signed ______________________
   (Inspector) (National Board and Endorsement)
S1.1.3.1 MATERIAL LIST FOR STEAM LOCOMOTIVE BOILERS

Table S1.1.3.1 is intended as a basic guideline only and covers basic carbon steel and some alloy steel material specifications. Other alloy materials may be available for these applications if necessary.

S2.13.9.5 BARREL REPLACEMENT

An entire course of a barrel may be replaced as a repair provided that:

- a) The replacement material is code-accepted material (see NBIC Part 3, S2.7.1) that has a nominal composition and strength that is equal to or greater than the original, and is suitable for the intended service.

- b) The minimum required thickness shall be at least equal to the original material thickness. The original thickness may be determined from the original Manufacturer’s Data Report, original drawings, or by measuring the original material thickness in an area unaffected by corrosion.

- c) The longitudinal joint efficiency of the new barrel course meets or exceeds the original design/construction;

- d) All doubling/reinforcing plates, stays and openings in the original barrel are duplicated or retained on the new barrel and installed in a manner that meets or exceeds the original design/construction;

- e) All attachments and connections with other portions of the boiler are attached in the same manner as the original; and

- f) The boiler will not be re-rated at a MAWP greater than the original design MAWP.
S3.5.2.4 FINISHING THE REPAIR

a) The parts should be held in place to prevent movement while curing the cemented joint to achieve a proper repair. The repair firm should take care to ensure that the cement joint thickness is within the range recommended by the cement manufacturer. Care spent in precisely aligning the parts while clamping will avoid many finishing and machining operations later. Particular attention should be given to gasket and other bearing surfaces.

b) Gasket and bearing surfaces may have to be machined, filed, or sanded before the job is completed. Gasket serrations must be clean and continuous. Serrations can be easily re-cut into graphite and any repair plugs that cross the gasket surface.

S3.5.5 TUBE REPLACEMENT

Tube replacement should be performed with the unit preferably in the horizontal position. Avoid replacing adjacent tubes simultaneously because the replacement areas may overlap or reduce the ligament between holes and possibly damage the tubesheet. The general steps used in horizontal tube replacement follow below.

a) The material used for tube replacement shall comply with the requirements of the ASME Boiler and Pressure Vessel Code, Section VIII, Division 1, Part UIG.

b) Tube replacement shall be performed by qualified cementing technicians, using qualified cementing procedures, in accordance with the requirements of the ASME Boiler and Pressure Vessel Code, Section VIII, Division 1, Part UIG-79(b), (e), and UIG-80(b).

c) Determine the thickness of each tubesheet and inside distance between the tubesheets to obtain tube and sleeve length.
d) Access each tubesheet face, clearly identify and mark each tube hole on each tubesheet of the tubes to be replaced.

e) Prepare/clean the existing tube hole in preparation for extracting the damaged tube. Some holes may contain plugs which require removal. A boring tool slightly larger than the outside diameter of the tube being replaced is required.

f) Drill/bore out the tube hole in each tubesheet to release the tube from the tubesheet. Exercise caution when centering and align cutting to the common axis of the tube.

g) The damaged tube should disengage and become loose. Using guides, remove the damaged tube. Ensure that no debris is trapped in the space where the tube was removed (Fig. S3.5.5.1).

h) Replacement tube shall have sleeves at the ends cemented in the bored holes to replace the material in the tubesheet that was bored out to access the damaged tube (Fig. S3.5.5.2 and S3.5.5.3).

1) Dry-fit a new tube and sleeve.

2) The sleeve length may vary.

3) Prior to applying cement, prepare and clean all surfaces to be cemented.

i) Cement the ID of the prepared bore in the floating tubesheet and the tube end OD at the fixed tubesheet (Fig. S3.5.5.2).

j) Insert the tube through the fixed tubesheet and through the floating tubesheet cemented bore so that it protrudes. Cement the ID of the fixed tubesheet bore as shown in (Fig. S3.5.5.3). The use of alignment dowels can assist/guide in tube handling.
k) Cement the OD of the tube end protruding from the floating tubesheet. Cement the ID of the mating sleeve end, fit it to the cemented tube end and push the assembly part-way into the floating tubesheet. Cement the remainder of the OD of the floating tube end sleeve. Push this cemented assembly the rest of the way into the floating tubesheet (Fig S3.5.5.3).

l) Cement the ID and OD of the sleeve for the fixed tubesheet and insert it until it mates with the tube end inside. Push together cemented tube/sleeve assemblies. (Fig S3.5.5.4). Clean/wipe away any excess cement.

m) Apply slight pressure on the sleeves to seat the joints. Remove excess cement.

n) Maintain pressure and cure both ends of the cemented assembly according to the cement manufacturer’s instructions.

o) Sleeves may be trimmed after curing.

p) Replaced tubes shall be tested in accordance with this Code per a written procedure acceptable to the Inspector.

g) The scope of work completed shall be described and reported on a Form R-1.
Fig S3.5.5.1  Cleaned and Prepared Tubesheets

Figure S3.5.2.2 Starting Tube Replacement

*Cement shown in RED*
**S3.5.7 REIMPREGNATION OF GRAPHITE PARTS (TUBESHEETS, HEADS, AND BLOCKS)**

**Fig S3.5.5.3**  
Sleeve Cementing

![Diagram showing Sleeve Cementing](image)

- Cement Tube end and Sleeve
- Floating Tubesheet
- Fixed Tubesheet
- Cement shown in RED

**Fig S3.5.5.4**  
Completed Tube Replacement

![Diagram showing Completed Tube Replacement](image)

- Apply Pressure
- Floating Tubesheet
- Fixed Tubesheet
- Cement shown in RED
S3.5.7.1 CONTROL OF IMPREGNATION MATERIAL

S6.14 GENERAL STAMPING REQUIREMENTS

S6.14.1 SPECIFIC “TR” STAMPING AND NAMEPLATE REQUIREMENTS

Replace existing text.

The holder of a “TR” Certificate of Authorization is required to affix a stamping or nameplate on the Transport Tank that indicates, as appropriate, that the repair, alteration, or modification has been performed in accordance with the requirements of NBIC Part 3, Supplement 6 and the additional requirements of the code of construction. All repairs, alterations, and modifications, after acceptance by the Registered Inspector, shall have the “TR” Symbol affixed to the stamping or the nameplate.

The stamping or nameplate information shall satisfy the requirements of (a) through (g) below:

a) The required data shall be in characters at least 4 mm (5/32 in.) high;

b) The markings may be produced by casting, etching, embossing, debossing, stamping, or engraving;

c) The selected method shall not result in any harmful contamination or sharp discontinuities to the pressure-retaining boundary of the Transport Tank;

d) Stamping directly on the Transport Tank, when used, shall be done with blunt-nose continuous or blunt-nose interrupted dot die stamps. If direct stamping would be detrimental to the item, required markings may appear on a nameplate affixed to the Transport Tank;

e) The “TR” Certificate Holder shall use its full name as shown on the Certificate of Authorization or an abbreviation acceptable to the National Board;

f) The stamping, when directly on the item or when a nameplate is used shall be applied adjacent to the original manufacturer’s stamping or nameplate. A single repair, alteration, or modification stamping or nameplate may be used for more than one repair to a Transport Tank, provided the repair, alteration, or modification activity is carried out by the same certificate holder;
g) The date of each repair, alteration, or modification corresponding with the date on the Form TR-1 shall be stamped on the nameplate.

S6.14.12 REMOVAL OF ORIGINAL STAMPING OR NAMEPLATE
If it becomes necessary to remove the original stamping, the Inspector shall, subject to the approval of the Competent Authority, witness the making of a facsimile of the stamping, the obliteration of the old stamping, and the transfer of the stamping. When the stamping is on a nameplate, the Inspector shall witness the transfer of the nameplate to the new location. Any relocation shall be described on the applicable NBIC “TR” Form. The re-stamping or replacement of a code symbol stamp shall be performed only as permitted by the governing code of construction.

S6.15 “TR” FORMS

S6.17.3 15.1 DOCUMENTATION Wording moved from S6.17.3

S6.15.1 DOCUMENTATION

Repairs, alterations, or modifications that have been performed in accordance with the NBIC shall be documented on Form TR-1, Report of Repair, Alteration, or Modification, as shown in NBIC Part 3, Section 5. Form TR-2, Report Supplementary Sheet, shall be used to record additional data when space is insufficient on Form TR-1.

S6.15.2 PREPARATION OF “TR” FORMS Wording moved from S6.18
Preparation of “TR” Forms shall be the responsibility of the “TR” Certificate Holder performing the repairs, alterations, or modifications. An Inspector shall indicate acceptance by signing the appropriate “TR” form.

S6.18.1 15.3 DISTRIBUTION Wording moved from S6.18.1

S6.15.3 DISTRIBUTION

a) Legible copies of the completed Form TR-1 together with attachments shall be distributed to the owner or user, the Inspector, and the Competent Authority, as required, and the Authorized Inspection Agency responsible for the inspection.

b) Distribution of the Form TR-1 and attachments shall be the responsibility of the organization performing the repair.
S6.15.4 REGISTRATION OF FORM TR-1 AND FORM TR-2  
Wording moved from S6.19.1

a) Organizations performing repairs, alterations, or modifications under the “TR” program must register such repairs, alterations, or modifications with the National Board.

b) The repair organization shall maintain a sequential Form “TR” Log that shall identify the following:

1) Form number assigned for Form TR-1;

2) Identify if the activity was a repair, alteration, or modification; and

3) Date sent to the National Board.
repairs, alterations, or modifications. An Inspector shall indicate acceptance by signing the appropriate "TR" form.

S6.18.1—DISTRIBUTION

a) Legible copies of the completed Form TR-1 together with attachments shall be distributed to the owner or user, the Inspector, and the Competent Authority, as required, and the Authorized Inspection Agency responsible for the inspection.

b) Distribution of the Form TR-1 and attachments shall be the responsibility of the organization performing the repair.

S6.18.2—REGISTRATION

Form TR-1 and TR-2 shall be registered with the National Board.

S6.19.2 GENERAL REQUIREMENTS “TR” STAMPING AND NAMEPLATES

The holder of a “TR” Certificate of Authorization is required to affix a stamping or nameplate on the Transport Tank that indicates, as appropriate, that the repair, alteration, or modification has been performed in accordance with the requirements of NBIC Part 3, Supplement 6 and the additional requirements of the code of construction. The stamping or nameplate information shall satisfy the requirements of (a) thru (g) below:

a) The required data shall be in characters at least 4 mm (5/32 in.) high;

b) The markings may be produced by casting, etching, embossing, debossing, stamping, or engraving;

c) The selected method shall not result in any harmful contamination or sharp discontinuities to the pressure-retaining boundary of the Transport Tank;

d) Stamping directly on the Transport Tank, when used, shall be done with blunt-nose continuous or blunt-nose interrupted dot die stamps. If direct-stamping would be detrimental to the item,
required markings may appear on a nameplate affixed to the Transport Tank;

e) The “TR” Certificate Holder shall use its full name as shown on the Certificate of Authorization or an abbreviation acceptable to the National Board;

f) The stamping, when directly on the item or when a nameplate is used shall be applied adjacent to the original manufacturer’s stamping or nameplate. A single repair, alteration, or modification stamping or nameplate may be used for more than one repair to a Transport Tank, provided the repair, alteration, or modification activity is carried out by the same certificate holder;

g) The date of each repair, alteration, or modification corresponding with the date on the Form TR-1 shall be stamped on the nameplate.

S6.19.3 STAMPING OF THE “TR” SYMBOL
All repairs, alterations, and modifications, after acceptance by the Registered Inspector, shall have the “TR” Symbol affixed to the stamping or the nameplate.

S7.14.2 SPRING-LOADED PRESSURE RELIEF VALVES

b. Complete original PRV nameplate data, plus any important information received from customer;

h) Bearing Points

i) Assembly

1. Install nozzle

2. Install lower ring and guide ring to the, or to measurement from c) 9) above or to manufacturer’s specifications.

3. Install guide

4. Install disc and holder

5. Install spindle

6. Install spring washers

7. Install bonnet
8. Install bonnet bolting
9. Install adjusting screw and lock nut to the measurement from c) 4) above.
10. Install release nut and lock nut, and cap and lever assembly, and
**Biomass Fired Boiler** – A boiler which fires biomass as its primary fuel.

**Conveyor system(s)** - A fuel transport system utilized on biomass boilers that drops fuel onto a moving belt, bucket elevator, drag link conveyor or a screw or auger mechanism. (The speed of the conveyor may be varied to meet fuel demand.)

**Dense phase pneumatic system(s)** – A batch feed transport system used on solid fuel fired boilers for both fuel delivery and/or ash removal. In this system the material to be transported is dropped through a valve in a pressure vessel. When the vessel is filled the valve closes and air at a pressure from 30 to 100 psig (207 to 690 kPa) is admitted and the material leaves the vessel in the form of a “slug”. The sequence then repeats.

**Lean phase pneumatic system(s)** - A fuel transport system utilized on biomass boilers that drops fuel into a moving airstream, mixes with the air, and travels through a pipe at a velocity of approximately 5000 ft/min. (1525 m/min). Air pressures are in the region of 25 inches (635 mm) water column.

**Seal weld** - any weld designed primarily to provide a specific degree of tightness against leakage. A seal weld is not intended to provide structural integrity to a pressure retaining item.