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Municipal Affairs

ABSA
the pressure equipment safety authority

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Use of Mandatory Appendix 44 of ASME 2013 Section VIII, Division 1 in Alberta

Background

Mandatory Appendix 44 provides the requirements for design and construction of cold-stretched austenitic stainless steel pressure vessels under the rules of ASME Boiler and Pressure Vessel Code, Section VIII, Division 1 2013 edition.

This Mandatory Appendix 44 is, with minimal editorial modifications, identical with previously issued ASME Code Case 2596. For vessels designed and constructed to the earlier editions of the adopted ASME Code (prior to 2013-07-01) and with the use of ASME Code Case 2596, compliance with IB13-008 is mandatory.

Although the effects of cold work hardening on metal properties have been known for a long time, the use of cold-stretching of pressure vessels to enhance material properties is a relatively new technology. Austenitic stainless steel work hardens and thereby increases the yield strength when deformed plastically at room temperature. The increased yield strength results in the use of higher allowable design stress per provisions of Mandatory Appendix 44 rules in which design stresses are controlled by a design factor to yield strength only.

Mandatory Appendix 44 rules do not apply a design factor of 3.5 to the minimum specified tensile strength of the material to establish the allowable design stress values published in Table 44.4.1 in the Mandatory Appendix, even though the design factor of 3.5 is normally used in Section VIII, Division 1 to establish allowable stress values for materials where maximum design temperatures do not exceed 120°F (50°C).

Provisions

This document defines the requirements that must be met for the use of Mandatory Appendix 44 in the design and construction of cold-stretched pressure vessels for use in the Province of Alberta. This document also establishes conditions that must be met for the installation, operation, repair and alteration of cold-stretched pressure vessels in Alberta.

1. General Requirements

    1.1 All provisions of Mandatory Appendix 44 must be adhered to.

    1.2 Use of Mandatory Appendix 44 with ASME Code Case 2695 (Code Case 2695 allows the use of the ASME Section VIII, Division 2 design rules for the construction of a pressure vessel to ASME Section VIII, Division 1) is prohibited.

1.3 Use of any other ASME Code Cases or Code Interpretations in conjunction with Mandatory Appendix 44, must be clearly specified in the design registration submission.

1.4 Mandatory Appendix 44 may only be used for design and construction of cryogenic storage tanks in non-corrosive/erosive service where stored fluid(s) would not have any adverse effect on the pressure vessel austenitic stainless steel.

1.5 In addition to the requirements in Mandatory Appendix 44.2(e), the following conditions shall be met:

1.5.1 If multiple shell cylinders are used, all shell cylinder plates shall be of same uniform nominal thickness;

1.5.2 Dished heads are the only head shape allowed. Heads shall satisfy the following conditions:

1.5.2.1 Head minimum thickness after forming must be at least equal to the minimum calculated design thickness plus the thinning allowance for cold-stretching; and

1.5.2.2 The ratio of the head actual (measured) minimum thickness to the head design minimum thickness must not exceed 1.7.

1.6 Mandatory Appendix 44 is not permitted to be used for vessels which are subject to loadings as defined in:

1.6.1 UG-22(e),(g),(h) and (i)

1.6.2 special service defined in UW-2 (e.g. lethal service).

1.7 The Manufacturer must develop and verify (qualify) the cold-stretching procedure (CSP) before starting to build any pressure vessels using cold-stretching technology. In addition to all requirements specified in Mandatory Appendix 44, the CSP shall include the necessary details to produce the required results. The CSP must address, but it is not limited to, the following:

1.7.1 scope and details of the CSP including cold-stretching operation;

1.7.2 procedure limitations (including material and dimensional limitations);

1.7.3 allowed variation (tolerances) in actual plate thickness (shell and heads);

1.7.4 an explanation as to how the strain is measured and controlled;

1.7.5 locations for measuring critical dimension changes during cold-stretching;

1.7.6 frequency of measuring and frequency of the strain rate calculations;

1.7.7 a repair procedure including the acceptance criteria for the repair, if repairs are to be allowed;

1.7.8 detailed methodology for repeating cold-stretching after repair completion by welding as a result of non-conformance during the manufacturing process; and

1.7.9 verification/qualification of the CSP including:

1.7.9.1 Proof that materials, after cold-stretching is performed in accordance with the procedure requirements, are achieving or exceeding the allowable design stresses specified in Table 44-4-1 of Mandatory Appendix 44;

1.7.9.2 Test coupons shall be cold-stretched in a way to be true representatives of the cold-stretched vessel components;

1.7.9.3 Tensile tests shall be performed and results reported;

1.7.9.4 The procedure qualification shall be witnessed by the Authorized Inspector; and

1.7.9.5 The procedure qualification report signed off by the Manufacturer and an Authorized Inspector.

1.8 The CSP shall be a controlled document with tracking of all revisions. The CSP document number and revision shall be specified both in the design submission drawings for registration and in the Manufacturer's Data Report.

2. Design and Design Submission Requirements

2.1 A User Design Specification (UDS) notes #1 and 2 shall be prepared and be included in the design registration submission. It is the Owner's (User) responsibility to define the format and content of the UDS, which will be subject to review and acceptance as part of the design registration process. Among other details, the UDS shall:

2.1.1 clearly define all requirements for cold-stretching;
2.1.2 include a statement to confirm the acceptance of the manufacturer's cold-stretching procedure;
2.1.3 specify how the requirements of this document (IB13-016) will be met; and
2.1.4 specify the number of cold-stretched pressure vessels that are to be built under the UDS.

The UDS shall be reviewed and certified by a Professional Engineer experienced in the design and construction of pressure vessels which utilize cold-stretching technology and who meets the requirement of Section 1(2) of the Pressure Equipment Safety Regulation (AR49/2006) .

2.2 Each design submission application shall include a letter from the owner (user) stating acceptance that:

2.2.1 Mandatory Appendix 44 will be used for this pressure vessel design; and
2.2.2 Any possible future repair and/or alteration can not be performed utilizing welding, without performing additional cold-stretching of the vessel.

2.3 The Manufacturer must submit a Manufacturer Design Report note #3 that will include details of the pressure vessel design and the serial numbers of the cold-stretched pressure vessels.

The Manufacturer Design Report shall be reviewed and certified by a Professional Engineer experienced in the design and construction of pressure vessels which utilize cold-stretching technology and who meets the requirement of Section 1(2) of the Pressure Equipment Safety Regulation (AR 49/2006).

2.4 In addition to the requirements specified in sections 14 and 15 of the Pressure Equipment Safety Regulation (AR 49/2006), the drawings submitted for design registration must also include:

2.4.1 The cold-stretching pressure (P_c);
2.4.2 Reference to the CSP including the document number and revision number;
2.4.3 Design, fabrication, inspection, stamping requirements of Mandatory Appendix 44 and this document;
2.4.4 All non-destructive examination requirements;
2.4.5 Hydrostatic test pressure value per UG-99(b);
2.4.6 Information that full volumetric examination (RT or UT) will be performed on all butt joints before cold-stretching of the vessel in accordance with
2.4.6.1 Mandatory Appendix 44, paragraphs 44-5(e) and 44-6.1(c),
2.4.6.2 ASME Section VIII Division 1, paragraphs UW-11(a) and UW-51, and

2.4.6.3 the acceptance criteria for size of indications as specified in Section 3.1 of this document;

2.4.7 A report of any physical tests conducted for the purpose of establishing the MAWP of the pressure vessel or any part thereof; and

2.4.8 Other information that is necessary to support the design.

2.5 The CSP must be included as a part of the design registration application submission.

2.6 Utilization of cold-stretching is not permitted for parts with primary bending stresses.

2.7 Excessive rigidity and restriction of expansion shall be avoided note #4 in the design of cold-stretched pressure vessels. Circumferential reinforcement shall not be used.

2.8 In compliance with Mandatory Appendix 44.6.1(g) impact test requirements, the design submission (drawings) shall indicate the impact test temperature and energy value.

2.9 For nozzle reinforcement calculations, the rules and provisions of UG-37 are permitted but use of alternative rules under Appendices 1-9 and 1-10, and Code Case 2695 are prohibited. For large openings exceeding the limits specified in UG-36(b)(1), a design submission must address how supplemental rules of 1-7 will be satisfied in addition to the rules of UG-37.

2.10 In addition to the requirements Mandatory Appendix 44, paragraph 44.2(g) and requirements of paragraph UG-37 of ASME Section VIII, Div. 1, reinforcement calculations of openings shall comply with the following conditions:

2.10.1 Spacing between nozzles must be such that limits of reinforcement calculated according to UG-40 do not overlap; and

2.10.2 Provisions of paragraph UG-37 are modified as follows:

2.10.2.1 Area of reinforcement required (A) is calculated A=d t_r where t_r = t;

2.10.2.2 Area of excess thickness in the vessel wall available (A_1) is taken as zero;

2.10.2.3 Required thickness of a nozzle wall (t_{rn}) is calculated using the rules of ASME Section VIII, Div. 1 and applying allowable stress value specified in ASME Section II, Part D;

2.10.2.4 Area of excess thickness in the nozzle wall (A2) is calculated using value for t_{rn} calculated in accordance with the rules in this section;

2.10.2.5 Opening is adequately reinforced If $A_2+A_3+A_{41}+A_{43} > A$.

2.11 In addition to the requirements of paragraph 44-6.1(f) of Mandatory Appendix 44, hydrostatic test shall be in accordance with UG-99(b) and use of UG-99(c) is prohibited.

2.12 Acceptable designs will be registered as Alberta Limited Designs (ALD) note #5.

3. Fabrication and Inspection Requirements

3.1 Full volumetric examination (RT or UT) per UW-11(a) shall comply with paragraph UW-51 of Section VIII, Div.1. Volumetric examination utilizing UT may also be performed in accordance with ASME Code Case 2235.

Volumetric examination shall be performed on all butt joints according to the requirements of Mandatory Appendix 44, paragraphs 44-5(e) and 44-6.1(c).

The acceptance criteria for size of indications specified in paragraph UW-51(b)(2) shall be modified as follows:

3.1.1 instead of UW-51(b)(2)(a), use: 1/5 in (5mm) for t up to ¾ in. (19 mm); and
3.1.2 instead of UW-51(b)(2)(b), use: 1/4t for t from 3/4in (19mm) to 1.2 in (30 mm) [note #6].

3.2 After the volumetric examination is completed, defective welds must be repaired and re-examined. If the vessel has already been cold-stretched prior to repair, it must be cold-stretched again and following the repeated cold-stretching, re-examination in accordance with this paragraph is required.

3.3 If the pressure exceeds 1.6 X MAWP during vessel cold stretching, this vessel does not meet the requirements of Mandatory Appendix 44 paragraph 44.5(c) and shall not be used in Alberta.

4. Certification, Marking and Record Keeping Requirements

4.1 In addition to the requirements of Mandatory Appendix 44 paragraph 44-7(b), the Manufacturer's Data Report, under 'Remarks', must specify/indicate:

4.1.1 Service fluid(s)[note #1];
4.1.2 CPS document number and revision number;
4.1.3 RT or UT report number (document that demonstrates that the sizes of indications in the vessel comply with the acceptance criteria specified in Section 3.1 of this Document);
4.1.4 A statement - *"This vessel has been designed and built in compliance with document IB13-016"*; and
4.1.5 A statement - "*Do not weld or repair without prior authorization by the jurisdictional authority. Cold-stretching may be required after welding on this vessel*".

4.2 "RT-1" marking shall be applied under the Certification Mark on the nameplate, indicating the cold-stretched vessel was constructed in accordance with UW-11(a) rules and requirements of this document, Sections 2.4 and 3.1.

4.3 The completed vessels must be clearly marked on the code stamped vessel (inside) and on the outside non-code vessel with a warning notation (Plate) such as "WARNING - COLD-STRETCHED VESSEL- DO NOT WELD, GRIND, OR IN ANY OTHER WAY MODIFY THE PRESSURE BOUNDARY."

4.4 The Manufacturer's Data Report shall also include the following documentation:

4.4.1 the UDS (see Section 2.1),
4.4.2 the owner's letter (see Section 2.2),
4.4.3 Manufacturer Design Report (see Section 2.3); and
4.4.4 report (RT or UT) that demonstrates that the sizes of indications in the vessel comply with the acceptance criteria specified in Section 3.1 of this document.

5. Used Cold-stretched Vessels

5.1 If a person intends to bring into Alberta a used cold-stretched vessel, design registration and a certificate of inspection permit shall be obtained before the vessel is put in service in Alberta.

5.2 Used cold-stretched vessel that does not comply fully with this document, will not be accepted for:

5.2.1 registration;
5.2.2 issuance of certificate of inspection permit; and
5.2.3 installation and service in Alberta.

6. Post-Construction Requirements

After a cold-stretched pressure vessel is put into service, the owner must comply with the following provisions in addition to the requirements specified in the Safety Codes Act and Pressure Equipment Safety Regulation (AR 49/2006):

6.1 Overpressure protection of cold-stretched vessels shall be provided through the use of pressure relief valves in accordance with section 38(1)(a) of the Pressure Equipment Safety Regulation (AR 49/2006).

6.2 The owner shall maintain a file with reports and records of a pressure vessel manufactured using cold-stretching technology. Also, these reports and records will be necessary to prepare and facilitate future repairs or alterations of that vessel.

6.3 Re-rating (pressure increase) of the registered maximum allowable working pressure (MAWP) is not allowed for cold-stretched vessels.

6.4 Sections of the AB-513 document that allow qualified owners (users) to conduct, inspect and certify certain types of repairs and alterations under their Certificate of Authorization Permit do not apply for any repair or alteration of cold-stretched vessels.

6.5 All repair and alteration procedures for cold-stretched vessels require formal assessment and shall be submitted to ABSA Design Survey for review and registration prior to the start of work.

6.6 When welding is utilized for repair and/or alteration, the following conditions shall apply:

6.6.1 The vessel shall be subject to cold-stretching;
6.6.2 Cold-stretching repair/alteration procedure shall be acceptable to the owner of the vessel and ABSA. The cold-stretching repair/alteration procedure shall be submitted for review and registration by ABSA before commencement of any work on the vessel;
6.6.3 Vessel MAWP and all nozzle attachment reinforcements shall be re-evaluated following any additional cold-stretching using renewed (actual) measurements of the affected component dimensions (e.g. thicknesses); and
6.6.4 Some provisions specified in the Alberta Repair and Alterations Requirements (AB-513) document may not be applicable to the repairs and/or alterations of cold-stretched vessels.

6.7 Each submission for registration of repair or alteration procedures must include a cold-stretching procedure developed and verified in accordance with Sections 1.7 and 1.8 above. Please refer to the Pressure Equipment Safety Regulation (AR 49/2006), Section 40(5).

6.8 An ABSA Inspector must be notified before the owner commences any repair or alteration of a cold-stretched pressure vessel. Please refer to the Pressure Equipment Safety Regulation (AR 49/2006), Section 40(3).

6.9 An organization that repairs and/or alters cold-stretched vessels installed in Alberta must have a cold-stretching procedure developed and verified in accordance with Sections 1.7 and 1.8 above, and the organization must hold an appropriate and valid:

- 6.9.1 Alberta Certificate of Authorization Permit that allows the organization to repair or alteration cold-stretched vessels for repair or alteration to be performed in Alberta;
- 6.9.2 Quality control program for repairs or alterations of cold-stretched vessels in accordance with CSA B51 and accepted by the other jurisdiction in Canada where the repair or alteration will be performed; or
- 6.9.3 National Board (NB) R stamp certificate of authorization, and the organization must provide to ABSA an NB repair or alteration report certified by a NB commissioned Inspector for repair or alteration to be performed outside of Canada.

6.10 In the case of a change of ownership to a cold-stretched pressure vessel constructed to Mandatory Appendix 44,

- 6.10.1 The equipment reports and records shall be transferred to the new owner as required under Section 36(3) of the Pressure Equipment Safety Regulation (AR 49/2006);
- 6.10.2 The new owner shall issue a letter in accordance with Section 2.2 above and have a Professional Engineer to:
  - 6.10.2.1 verify and certify the acceptability of the original UDS for the new process/operating conditions and for the condition of the pressure vessel; or
  - 6.10.2.2 prepare a new UDS in accordance with the requirements of Section 2.1 above and the new UDS shall be within the limitations of the Manufacturer's Design Report and the condition of the pressure vessel;

6.11 The new owner shall submit the letter in accordance with Section 2.2 and the certified UDS to ABSA and retain copies as part of the owner's Pressure Equipment Integrity Management program record.

Notes:

1. The Manufacturer may only list multiple fluids (such as LN_2, LO_2, LAR etc.) in the remarks section of the Manufacturer's Data report if so specified in the User's Design Specification and the registered design.
2. Non-mandatory Appendix KK of ASME BPVC, Section VIII, Div. 1 and/or paragraph 2.2.2 of ASME BPVC, Section VIII, Div. 2 may be used as a guide for preparing a UDS.
3. A Manufacturer's Design Report should not be misconstrued with the Manufacturer's Data Report. The Manufacturer's Design Report includes the details of the pressure vessel design and the serial numbers of the cold-stretched pressure vessels. Paragraph 2.3.3 of ASME BPVC, Section VIII, Div. 2 may be used as a guide for preparing a Manufacturer's Design Report.

4. In designing a cold-stretched pressure vessel, particular attention must be paid to weld details and avoidance of areas of stress concentration and high restraint, so that when the vessel is cold-stretched, all components are as evenly stretched (work hardened).
5. Designs accepted and registered with an Alberta Limited Design (ALD) registration number typically may have additional conditions imposed including restrictions with respect to the number of pressure vessels which may be constructed to the registered design and/or location and relocation of pressure vessels built to the design.
6. The vessel wall thickness is limited to 1.2 in (30 mm) according to paragraph 44-2(b) of Mandatory Appendix 44 and the acceptance criteria for size of indications is adjusted accordingly. In addition, there is no need to refer to paragraph UW-51(b)(2)(c) of ASME BPVC, Section VIII, Div. 1.

<original signed by>

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