Alberta Municipal Affairs

ABSA
the pressure equipment safety authority

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Industry Task Group Report
Proposing Requirements for the Integrity Management of Grade 91 Pressure Components Used Above Currently-Permitted Allowable Stress Levels

In January of 2018, a joint task group was formed between ABSA and industry in order to address the reductions of allowable stresses for Grade 91 steels at high service temperatures expected to be published in the 2019 edition of the ASME Boiler and Pressure Vessel Code.

The task group met every two months for a period of approximately one year in order to share expertise and to propose to ABSA a method of ensuring the continued safe operation of in-service equipment that was designed to a previous code edition which relies on the older, higher allowable stresses for this material.

The task group issued the attached final report on February 25, 2019, and it was presented to The Pressure Equipment Sub-Council of the Safety Codes Council who voted to endorse it at their meeting on March 14, 2019.

This attached report is being published on behalf of the joint industry task group and represents the task group's recommendations to ABSA. It is a representation of the joint effort between industry and ABSA to ensure the continued safety and integrity of existing equipment that will be affected by the lowering of these allowable stresses.

The task group report was used as the foundation for ABSA document AB-536 *Requirements for the Integrity Management of Grade 91 Steel Used Above Currently-Permitted Allowable Stresses.*

<original signed by>

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Chief Inspector, ABSA the pressure equipment safety authority

TYPE: INFORMATION	DESCRIPTION: Industry Report Proposing Requirements for the Integrity Management of Grade 91 Steel Pressure Components	REGULATION: PESR

A PROPOSAL

for

THE MANAGEMENT OF GRADE 91 MATERIALS IN EXISTING PRESSURE EQUIPMENT FOR CONTINUED USE AT THE ALLOWABLE STRESS LEVELS PERMITTED BY THE ORIGINAL CONSTRUCTION CODES, NOTWITHSTANDING THE REDUCTION OF ALLOWABLE STRESSES EXPECTED TO BE PUBLISHED IN ASME SECTION II-D, 2019 EDITION

Submitted to

PRESSURE EQUIPMENT SUB-COUNCIL
of the
SAFETY CODES COUNCIL

Prepared by

The Grade 91 Material Joint Industry and ABSA Task Group

February 25, 2019

Contents

1. EXECUTIVE SUMMARY

A steel alloy known as Grade 91 creep-strength-enhanced ferritic steel has been used in pressure-retaining components since it was introduced in the early 1980s due to the superior strength characteristics it has exhibited in the time-dependent temperature regime. Recent evidence has shown, however, that this material needs more stringent controls on alloy chemistry and fabrication practices than was previously thought in order to fully realize its superior strength properties, and the allowable stresses permitted for its use at high temperatures are now expected to be reduced in the upcoming 2019 edition of the ASME Boiler and Pressure Vessel Code when it is published in July of 2019.

A task group was formed comprising several representatives from ABSA, owner-user organizations, and other subject-matter experts to recommend requirements for engineering assessment, integrity management, and for repairs, alterations, and fitness-for-service assessments of existing pressure equipment in order to justify continued reliance on the higher allowable stress values permitted by the original construction codes.

The task group recommends that requirements be established for an engineering assessment of affected pressure equipment, to be carried out by a competent engineer representing the pressure equipment owner, with the aim of establishing ongoing inspection and monitoring requirements to ensure the pressure equipment's continued integrity. These extra measures are then used as a basis to justify continued operation at the higher allowable stress levels permitted by the original construction codes. The task group recommends also that requirements be established for repairs, alterations, and fitness-for-service assessments of such pressure equipment, based on known issues and best practices for Grade 91 steel. It is noted that there are specific provisions in Alberta pressure equipment legislation to establish such requirements.

2. TASK GROUP MEMBERSHIP

- Several members representing owner-user organizations and subject-matter experts:
  - Vern Trimble, Capital Power
  - John Wolff, TransAlta
  - Diederic Godin, TransAlta
  - Erick Liebl, Liebl Engineering Ltd.
  - Derek Rasmussen, ATCO Power
  - Jed Shaw, ATCO Power
  - David Corbin, ENMAX
  - Geoff Kutz, NOVA Chemicals
  - Charles Turner, Charles G. Turner & Associates Ltd.
- Several members representing the jurisdiction:
  - Djordje Srnic, ABSA (Chair)
  - Robin Antoniuk, ABSA
  - Mike Prefumo, ABSA
- One member representing the Government of Alberta:
  - Allan Hantelmann, Alberta Municipal Affairs

3. ACKNOWLEDGEMENTS

- The task group wishes to acknowledge the following individuals for their contributions:
    - Doug Ferber, EPRI
    - Kent Coleman, EPRI
    - Bill Carson, EPRI
    - Greg Gaudet, CNRL
    - Scott Thomson, APPCA
    - Trevor Seipp, Becht Engineering
    - Greg Brandon, ABSA
    - Lou Petrusevski, ABSA
    - George Galanes, Diamond Technical Services, Inc.

4. DEFINITIONS

ABSA Safety Codes Officer (SCO) – means a safety codes officer, designated under the Act, in the pressure equipment discipline [PESR 1(1)(ee)]

Affected Pressure Equipment – any pressure equipment which makes use of an allowable stress for Grade 91 material which is permitted by the code edition to which it was constructed, and which is higher than the allowable stress permitted by the current in-force edition of the applicable construction code

Alteration – means any change to an item of pressure equipment as described in the original manufacturer's data report that requires a change of design calculations or otherwise affects the pressure-containing capability of the item of pressure equipment. [PESR 1(1)(d)] Non-physical changes such as a change in the maximum allowable working pressure or design temperature of a boiler or pressure vessel pressure retaining item are considered alterations, as are reductions, such as reduction in minimum temperature.

Competent – in relation to a person, means possessing the appropriate qualifications, knowledge, skills, and experience necessary to perform the work safely and in accordance with the Act. [PESR]

Competent Engineer – means a professional engineer, as defined by the Pressure Equipment Safety Regulation, who has knowledge and experience with Grade 91 materials in creep service.

Fitness-for-service – quantitative engineering evaluations that are performed to demonstrate the structural integrity of an in-service component that may contain a flaw or damage.

Grade 91 – refers to a creep-strength-enhanced ferritic steel alloy identified in various ASME and ASTM material specifications as grade C12A, F91, P91, T91, or WP91, which has a specified chemical composition and which when properly processed, exhibits enhanced creep strength at high temperatures, making it useful for high-temperature, high-stress applications.

Owner's Inspector – means the owner's chief inspector or person employed by the owner and authorized to perform duties in regard to owner's responsibilities and commitments related to pressure equipment safety and regulatory compliance.

Owner-User – an owner that has established an integrity management system in accordance with the Pressure Equipment Safety Regulation and has been issued a quality management system certificate of authorization permit under PESR section 11(3)

Registered Design – means a design as defined in the Safety Codes Act and registered in accordance with the Pressure Equipment Safety Regulation. For existing pressure equipment this includes the original registered design and any consequent designs of repair, alteration, or other applied procedures to the subject pressure equipment.

Repair – work necessary to restore an item of pressure equipment to a safe and satisfactory operating condition, and which complies with the new proposed document, provided that there is no deviation from the original registered design.

Note: "Original registered design" includes previously registered design alterations.

5. REFERENCES

AB-512: Owner-User Pressure Equipment Integrity Management Requirements, Alberta Boilers Safety Association; Edition 2, Revision 0, Issued 2015-06-25

AB-513: Pressure Equipment Repair and Alteration Requirements, Alberta Boilers Safety Association; Edition 3, Revision 2, Issued 2018-06-28

AB-535: Requirements for Alteration Design Registration Based on Fitness-for-Service, Alberta Boilers Safety Association; Edition 1, Revision 0, Issued 2018-06-27

ASME B31.1: Power Piping, The American Society of Mechanical Engineers; 2018 Edition

ASME B31.3: Process Piping, The American Society of Mechanical Engineers; 2016 Edition

ASME Boiler and Pressure Vessel Code / Code Cases: Boilers and Pressure Vessels, Supplement 3: Page 1 (2864), "Case 2864: 9Cr-1Mo-V Material", The American Society of Mechanical Engineers; 2017 Edition

ASME Boiler and Pressure Vessel Code / Section I: Rules of Construction for Power Boilers, The American Society of Mechanical Engineers; 2017 Edition

ASME Boiler and Pressure Vessel Code / Section II: Materials / Part D: Properties (Customary) *(and)* Part D: Properties (Metric), The American Society of Mechanical Engineers; 2017 Edition

ASME Boiler and Pressure Vessel Code / Section V: Nondestructive Examination, The American Society of Mechanical Engineers; 2017 Edition

ASME Boiler and Pressure Vessel Code / Section IX: Welding, Brazing, and Fusing Qualifications, The American Society of Mechanical Engineers; 2017 Edition

API 579-1 / ASME FFS-1: Fitness-For-Service, The American Society of Mechanical Engineers / American Petroleum Institute; 2016 Edition

AWS D10.10/D10.10M: Recommended Practices for Local Heating of Welds in Piping and Tubing, The American Welding Society; 1999 (R2009) Edition

BS 7910:2013+A1:2015: Guide to Methods for Assessing the Acceptability of Flaws in Metallic Structures, British Standards Institute; December 2013 Edition, Amended July 2015

Best Practice Guideline for Well-Engineered Weld Repair of Grade 91 Steel (EPRI Product ID 3002003833), Electric Power Research Institute; December 2014

Guidelines and Specifications for High-Reliability Fossil Power Plants, 2nd Edition (EPRI Product ID 3002006390), Electric Power Research Institute; June 2015

Integrated Life Management of Grade 91 Steel Components: A Summary of Research Supporting the Electric Power Research Institute's Well-Engineered Approach (EPRI Product ID 3002012262), Electric Power Research Institute; May 2018

NB-23: The National Board Inspection Code, The National Board of Boiler and Pressure Vessel Inspectors; 2017 Edition

Safety Codes Act (Revised Statutes of Alberta 2000 / Chapter S-1), Province of Alberta; December 2017

Safety Codes Act: Pressure Equipment Safety Regulation (Alberta Regulation 49/2006), Province of Alberta; With Amendments up to and Including Alberta Regulation 195/2015

6. BACKGROUND

At high temperatures, certain materials are subject to a failure mechanism known as creep – a phenomenon whereby a material will exhibit suitable strength characteristics for a significant period of time, but then fail due to the gradual accumulation of damage. The allowable stresses permitted by certain codes of construction for use of these materials at high temperatures are therefore not based on a traditional safety factor, but on a level of stress that can be expected to give a component a particular lifespan, typically 100,000 hours.[1] Components which operate at temperatures where the allowable stress is governed by these time-dependent properties are said to be operating in the creep regime, and their life expectancies can be highly dependent on the temperature and pressure conditions they are exposed to in service.

[1] More information on the derivation of allowable stresses, including in the time-dependent creep regime, can be found in mandatory appendices 1, 2, and 10 of ASME Section II-D.

A creep-strength-enhanced ferritic steel alloy known as Grade 91 was introduced in the early 1980s which provides significantly superior strength properties at high service temperatures than other materials that were available at the time. Since it was introduced, industry has learned that the material's superior properties depend more significantly on certain manufacturing and fabrication practices than previously thought. In particular, the material's superior properties depend on material chemistry and careful management of welding and heat treatment practices during fabrication.

Significant industry experience, coupled with recent long-term creep rupture testing, have led to a new evaluation of a more current, comprehensive dataset used to support the allowable stress values permitted by construction codes. This reevaluation has resulted in a reduction of the time-dependent allowable stresses permitted for this material expected to be published in the upcoming 2019 edition of the ASME Boiler and Pressure Vessel Code. Although the new lower allowable stresses will be mandatory for the construction of new pressure equipment, the question has been raised as to under what circumstances it is safe to continue to rely on the older, higher allowable stresses for the maintenance and continued use of existing pressure equipment.

An industry task group was formed to propose conditions under which affected pressure equipment owners may continue to rely upon the older, higher allowable stresses for continued use of their existing pressure equipment. In particular, the task group aimed to determine what considerations may be required for inspection and monitoring, for repairs and alterations, and for fitness-for-service assessments of affected pressure equipment.

7. TERMS OF REFERENCE

- The task group was assembled in January 2018 to review concerns surrounding the continued use of Grade 91 materials in existing pressure equipment in the province of Alberta, despite the expected reduction of allowable stresses in the 2019 code edition.
- The task group met in Red Deer, Alberta, for full-day meetings every second month, in order to discuss and obtain general agreement on the key issues.
- The task group was chaired by Mr. Djordje Srnic, Assistant Chief Inspector and Codes and Standards Manager for ABSA.
- The task group comprised several representatives from the jurisdiction (ABSA and Alberta Municipal Affairs) and from organizations known to own affected pressure equipment, and several subject-matter experts.
- The output of the task group is this report, giving a brief background and discussion on the topics of interest and recommending that requirements be established to justify the continued use of the previous allowable stresses for existing pressure equipment.

8. REGULATORY CONTEXT

The following excerpts from the Safety Codes Act and the associated Pressure Equipment Safety Regulation represent a partial list of applicable requirements and provisions that may support special consideration for affected pressure equipment in Alberta:

- Safety Codes Act, Section 38(1):
  - An Administrator or a safety codes officer may issue a written variance with respect to any thing, process or activity to which this Act applies if the Administrator or officer is of the opinion that the variance provides approximately equivalent or greater safety performance with respect to persons and property as that provided for by this Act.

- Pressure Equipment Safety Regulation, Section 9:
  - If, in the opinion of a safety codes officer, the size or complexity of a design or project involving pressure equipment may give rise to safety concerns, the safety codes officer may require that either or both of the following be undertaken:
    (a) all plans, documents and specifications, or any part of them, be affixed with the stamp or seal of a professional engineer;
    (b) the construction, installation, examination or testing of that pressure equipment by reviewed throughout the course of that work by a professional engineer.

- Pressure Equipment Safety Regulation, Section 23(1):
  - The Administrator may accept designs of pressure equipment that are not designed in accordance with the codes and standards declared in force by this Regulation submitted for registration under section 40 of the Act if, in the opinion of the Administrator, they are of an equivalent standard of safety as those codes and bodies of rules declared in force by this Regulation and they meet the requirements for registration.

- Pressure Equipment Safety Regulation, Section 40(3):
  - Repairs or alterations to pressure equipment shall not be undertaken without the prior agreement of a safety codes officer.

- Pressure Equipment Safety Regulation, Section 40(4):
  - An owner of pressure equipment that is to be altered must ensure that the alteration design is registered by the Administrator, in accordance with section 14, prior to commencement of the alteration.

- Pressure Equipment Safety Regulation, Section 40(5):
  - The Administrator or a safety codes officer may require the owner of pressure equipment that is to be repaired to submit a detailed work procedure or design details for acceptance prior to the commencement of the repair.

- Pressure Equipment Safety Regulation, Section 41:
  - An integrity assessment program with respect to pressure equipment must include, but is not restricted to,
    (a) maintaining an inventory of all the pressure equipment,
    (b) assessing the pressure equipment in accordance with the integrity assessment

requirements established by the Administrator,
(c) maintaining equipment records for each item of pressure equipment,
(d) maintaining records of maintenance, service and test for pressure relief devices and other protective devices,
(e) assessing the integrity assessment, maintenance and operating history of the pressure equipment to ensure that the equipment is safe for continued operation, and
(f) any other matter required by the Administrator.

- Pressure Equipment Safety Regulation, Section 42:
  - (1) The owner of pressure equipment must, unless exempted by the Administrator, establish and maintain an integrity assessment program that is acceptable to the Administrator.
  - (2) When the owner of pressure equipment is requested to submit integrity assessment records to the Administrator, the records
    (a) must be submitted in a form acceptable to the Administrator, and
    (b) must be acceptable to the Administrator.

- Pressure Equipment Safety Regulation, Section 43:
  - A person shall not perform an integrity assessment of pressure equipment unless that person
    (a) holds qualifications that are acceptable to the Administrator, and
    (b) satisfies the conditions prescribed in the certificate of competency if such a certificate has been issued to the person.

- Pressure Equipment Safety Regulation, Section 44(1):
  - An owner of pressure equipment must conduct an integrity assessment of pressure equipment when requested to do so by a safety codes officer.

9. GENERAL RECOMMENDATIONS

An AB-500-series or similar document should be developed and published when the 2019 edition of ASME Section II-D is published. This document would establish requirements for the continued use of existing pressure equipment that relies on the use of Grade 91 material at a stress level higher than permitted in the newly published code edition. The document should establish:

- A requirement for an engineering assessment of affected pressure equipment, in which a competent engineer investigates the pressure equipment's condition and determines the extent and frequency of inspections required to ensure its continued integrity and safe operation

- Minimum requirements and additional recommendations with respect to the engineering assessment and periodic integrity assessments of affected pressure equipment, based on known problems that Grade 91 materials may exhibit

- Supplementary requirements for the integrity management systems of owners of affected pressure equipment

- Supplementary requirements for repairs to affected pressure equipment
- Supplementary requirements for alterations of affected pressure equipment
- Supplementary requirements for the use of fitness-for-service principles for affected pressure equipment

10. DISCUSSION

A. Scope, Intent, and Limitations

It should be understood that Grade 91 material can have chemistry and physical properties that adequately justify its use at the older, higher allowable stresses, as long as certain considerations are made. It is therefore recommended that requirements be established for the assessment and management of existing pressure equipment, which if followed, would permit owners of such pressure equipment to continue to rely on the originally permitted allowable stresses for continued safe operation and for future repairs and alterations.

In particular, the general premise that is suggested is that affected pressure equipment be subjected to an engineering assessment in order to identify potential risks specific to it, and that the engineering assessment establish inspection and monitoring requirements which justify continued use at the original design conditions, or, if necessary, derated design conditions. Additional requirements are also recommended to be prescribed for repairs, alterations, and fitness-for-service assessments of affected pressure equipment.

It should be noted also that the recommendations made herein are applicable to components which make use of Grade 91 material at a design temperature at which the allowable stress will be derated in an upcoming edition of a code or standard declared in force by the Pressure Equipment Safety Regulation. At the present time, therefore, the recommendations made herein apply to Grade 91 materials used within the scope of the upcoming 2019 edition of the ASME code which have a design temperature greater than 500°C for metric designs, or greater than 950°F for imperial designs[2].

[2] 950°F is not a direct conversion of 500°C; these temperature limits reflect the points above which the allowable stresses in the customary and metric versions of ASME Section II-D, respectively, are expected to be reduced.

B. Engineering Assessment of Affected Pressure Equipment

It is recommended that an owner of pressure equipment affected by the change in allowable stresses be required to undertake an engineering assessment of the pressure equipment and to take into account all available information, as may be required to determine what special risks pertain to the subject pressure equipment. This engineering assessment would be required to be undertaken by a competent engineer whose competency with respect to Grade 91 materials has been deemed acceptable by the owner, and would establish a list of inspection, monitoring, and/or maintenance tasks as required to ensure continued safe operation of the pressure equipment. It would also establish explicit acceptance criteria, required inspection frequencies, and permitted deferrals as applicable for each prescribed task.

It is recommended that components smaller than NPS 4 be exempt from consideration in the engineering assessment and from associated inspection tasks[3], as they present a lower risk to public safety due to the lesser consequences of a failure. This exemption is intended to provide relief with respect to components such as boiler tubes that are contained within a furnace enclosure and small-diameter vent and drain piping, though for the sake of simplicity, it is suggested that the exemption be applicable to all components smaller than NPS 4. The engineering assessment should be expanded to include these components if deemed necessary by the competent engineer. Some examples of cases that may warrant specific consideration are cases where excessive damage is noted in adjacent components, or where a special risk exists due to proximity to personnel.

Although the engineering assessment is intended to rely heavily on the relevant knowledge and experience of a competent engineer, it is recommended that it be subject to the following minimum prescribed requirements:

- The present physical condition of the equipment, and all readily available additional information pertaining to the pressure equipment, including:
    - Pressure equipment service history (time at temperature), and details of operating changes and excursions
    - Fabrication records, such as manufacturer's data reports and partial data reports
    - Mill test reports for Grade 91 and adjacent welded materials
    - Construction, fabrication, and/or as-built drawings
    - Original design calculations and specifications
    - Stress analyses of components as required to determine expected damage types, and as required to recommend inspection methods, locations, and intervals

[3] This exclusion is intended to apply only for the additional engineering assessment and inspection requirements of this document. The regular inspection / integrity management requirements of AB-506 are still intended to apply to such components, along with the requirements suggested herein for repairs, alterations, and fitness-for-service assessments.

    - Documentation or literature pertaining to risk factors relating to the material that may lead to damage or accelerate the accumulation of damage, such as deviations in chemistry, volumetric deficiencies, deficits in processing or heat treatments, etc.
    - Boiler support readings, measured in the hot and cold conditions
    - Piping system displacement readings, measured in the hot and cold conditions
    - Local component geometries, including thickness transitions
    - Evidence of significant vibrations, malfunctioning supports, or geometry changes
    - Hardness test results
    - Positive material identification (PMI) test results
    - Ultrasonic examination records
    - Surface examination records (magnetic particle or liquid penetrant)
    - Evidence of material deficiencies
    - Evidence of dissimilar metal welds
    - Evidence of previous weld repairs
    - Evidence of improper or incorrect heat treatment
    - Hard / soft material interfaces in Grade 91 cast and forged components

As an outcome, the engineering assessment should be required to prescribe:

- An inspection / monitoring plan, consisting of:
    - A list of examinations, inspections, and in-service monitoring tasks that need to be undertaken on a periodic basis as required to ensure the continued safe operation of the pressure equipment
    - Explicit acceptance criteria for each prescribed item
    - Maximum inspection intervals for each prescribed item
    - A procedure for deferral of inspection points, if permitted
    - Any criteria under which the engineering assessment is to be revised or reaffirmed by a competent engineer

C. Integrity Management System Requirements for Affected Pressure Equipment

In addition to the requirements of AB-512, it is suggested that owners of affected pressure equipment be required to incorporate the following directly or indirectly into their integrity management systems:

- A process for establishing and implementing the engineering assessment
- The inspection / monitoring plan and any other requirements prescribed by the engineering assessment
- All applicable recommendations of ASME B31.1, Non-Mandatory Appendix V, “Recommended Practice for Operation, Maintenance, and Modification of Power Piping Systems” (to be applied for all piping codes)
- The mandatory use of ASME B31.1, paragraph 141.4 (“Failure Analysis”), when a formal failure analysis is required (to be applied for all construction codes)

- The mandatory use of ASME Section I, Nonmandatory Appendix C, as it pertains to the local heat treatment of Grade 91 material welds (to be applied for all construction codes)
- Requirements for repairs and alterations to affected pressure equipment, as required to meet the applicable requirements of AB-513 and the additional requirements of this report and the engineering assessment[4];
- Requirements for fitness-for-service alterations of affected pressure equipment, as required to meet the applicable requirements of AB-513 and AB-535, and the additional requirements of this report and the engineering assessment[4]

D. Repairs to Affected Pressure Equipment

The following requirements, in addition to the applicable requirements of AB-513, should be applied to all repairs of Grade 91 materials and components in affected pressure equipment. These requirements should be required to be incorporated into the owner's integrity management system.

- Prior to undertaking a repair, a complete condition assessment should be required in order to determine the extent of damage and the necessary extent of required repairs. The repair procedure should then be required to address the entire extent of required repairs.
- In addition to the requirements of section 8.1 of AB-513, a formal failure analysis should be required prior to undertaking repairs to components that are NPS 4 or greater. Such an analysis may need to be accompanied by appropriate testing as required to determine or confirm the root cause or to facilitate future integrity management activities. The repair should be required to address the root cause by managing, remediating, or mitigating further damage.
- It is further suggested that a provision be made to permit *urgent* repairs prior to completing a formal failure analysis, provided that the repair is otherwise done in accordance with the requirements established by this document. Such repairs are to be subjected to re-evaluation and the failure analysis is to be completed in accordance with a pre-defined timeline. Any such provision for urgent repairs must be established in the owner's integrity management system, including management of required follow-up and any required monitoring. A maximum timeline of 12 months is suggested for completion of follow-up, unless extenuating circumstances exist.
- Fabrication activities should be required to be carried out in accordance with a written procedure as described in Part F below.

[4] In the case of a discrepancy between this document and AB-513, the requirements of this document are intended to prevail for Grade 91 pressure equipment. It is noted that AB-513 should generally be considered applicable, except the exemption provided in section 8.6.1, and the requirement in section 8.6 that the allowable stresses of the current code edition be used for alterations.

E. Alterations to Affected Pressure Equipment

The following requirements, in addition to the applicable requirements of AB-513, should be required to be applied to all alterations of affected pressure equipment. These requirements should be incorporated into the owner's integrity management system.

- The written alteration procedure should be required to be registered with ABSA Design Survey; it is suggested that the exemption from registration for certain types of alterations given in section 8.6.1 of AB-513 be deemed not applicable to affected pressure equipment.
- Fabrication activities should be required to be carried out in accordance with a written procedure as described in Part F below.

F. Fabrication Practices for Repairs / Alterations of Affected Pressure Equipment

The following requirements should be applied to all fabrication activities pertaining to the repair or alteration of affected pressure equipment. These requirements should be required to be incorporated into the owner's integrity management system.

- All activities for repair or alteration of existing pressure equipment should be required to be undertaken in accordance with a detailed written procedure. For repairs to components NPS 4 and larger and for all alterations, the procedures should be required to be prepared and stamped by a competent engineer.
- Repair and alteration procedures should be required to take into account best industry practices at the time the work is to be performed, such as those described in EPRI's publication, "Guidelines and Specifications for High-Reliability Fossil Power Plants, 2nd Edition: Best Practice Guideline for Manufacturing and Construction of Grade 91 Steel Components," EPRI Product ID 3002006390.
- Design of the repaired or altered components should be in accordance with the original code of construction, including the use of the original allowable stress values as long as these requirements are met.
- Newly purchased materials and replacement parts making use of Grade 91 material should be required to meet the requirements of the original material specification and the more stringent requirements of ASME Code Case 2864. It is recommended that provision be made for the use of material and parts purchased by equipment owners prior to January 1, 2020 without meeting these more stringent chemistry requirements, subject to the owner's specific evaluation of any such use.
- Welding should be required to be conducted to the current edition of the code of construction and ASME Section IX. The repair or alteration procedure should be required to address:
    - Permitted weld bead size
    - Weld metal deposition rate
    - Explicit monitoring and control of weld preheat and inter-pass temperatures
    - Limitation of delays prior to post-weld heat treatment

    - Filler metal chemistry requirements (with particular attention to carbon and nickel content, and to nitrogen-to-aluminum ratio)
    - Minimization of interruptions during welding
    - Post-weld hydrogen bake
- The welded joint design and repair strategy for dissimilar metal welds should be required to be included in the repair / alteration plan.
- Non-destructive examination should be required to be conducted to the current code of construction and ASME Section V, including techniques, extent of coverage, procedures, and qualification of personnel. The acceptance criteria should be the more stringent of the current and the original editions.
- Examination and inspection techniques not covered by ASME Section V should be required to be carried out in accordance with a written and qualified procedure, by qualified personnel.
- Heat treatment should be required to be carried out in accordance with a written procedure that complies with the WPS, meets the current code of construction, and incorporates best industry practices at the time the work is performed. The detailed procedure should include:
    - Applicable joint geometry
    - Thermocouple placement
    - Specification and placement of insulation blankets
    - Maximum temperature ramp rates
    - Required holding time and temperature
- It should be recommended that the heat treatment procedure take into account material hardness of the base materials prior to welding and of the base and weld materials after welding and cooling to the point that martensite transformation is complete, as discussed in EPRI document 3002006390.
- Repair and alteration activities should be required to be overseen by an owner's inspector, or by an Authorized Inspector, as required by the owner's PEIMS.

G. Fitness-for-Service Assessments of Affected Pressure Equipment

Fitness-for-service assessment provides a method for evaluating flaws in existing pressure equipment and determining whether it is safe for service; accepted methods can be found in several recognized international standards. API 579-1 / ASME FFS-1 is one such recognized North American standard that provides assessment procedures for certain types of flaws and damage, however, it may not contain all of the tools necessary for evaluation of the condition of Grade 91 components. It is recommended that other methods of fitness-for-service assessment be considered acceptable for pressure equipment having Grade 91 components, as long as similar methods are employed and the same level of safety is achieved as in the API/ASME standard. It is recommended that responsibility for safe and adequate implementation of fitness-for-service principles for Grade 91 materials be left mainly with a competent engineer representing the owner who is familiar with fitness-for-service assessment and the properties of Grade 91 steel.

The following are recommended as minimum requirements for fitness-for-service assessments pertaining to Grade 91 steel:

- Fitness-for-service alterations should be required to be conducted in accordance with the owner's integrity management system and the existing AB-535 publication, as supplemented and modified herein.
- Involvement of the owner's inspector or an ABSA safety codes officer should be required in accordance with the owner's PEIMS.
- The fitness-for-service assessment should be required to be prepared and stamped by a competent engineer.
- Inspection and non-destructive examination shall be conducted as required to ascertain the condition of the pressure equipment sufficiently to undertake an accurate fitness-for-service assessment, depending on the assessment techniques being used. Non-destructive examination shall:
    - Be conducted to the current edition of the code of construction and ASME Section V, including techniques, extent of coverage, implementation and qualification of procedures, and qualification of personnel
    - Be undertaken in accordance with examination procedures that have been reviewed for compliance with ASME Section V, Article 4, Appendix VIII, if the alteration will include the assessment of crack-like flaws as described in Part 9 of API 579-1 / ASME FFS-1
    - When examination methods are employed which are not described in ASME Section V, they should be required to be conducted in accordance with a written procedure, and personnel should be qualified in accordance with a recognized international standard, acceptable to the pressure equipment owner and to ABSA Design Survey
- Pertinent information relating to the pressure equipment's design, historical operation, and intended future operation should be required to be considered in the fitness-for-service assessment, and detailed in the report.
- Where practical, actual measured data should be required to be used in the fitness-for-service analysis, such as measured tensile strength, yield strength, alloy chemistry, remaining creep life, fracture toughness, and crack-tip opening displacement (CTOD) toughness measurements.
- When fitness-for-service assessments make use of the methods of API 579-1 / ASME FFS-1, the following requirements should apply:
    - All limitations on applicability in each applicable part of API 579-1 / ASME FFS-1 should be considered mandatory
    - Fitness-for-service assessments which make use of stress analysis in accordance with API 579-1 / ASME FFS-1 Annex 2D shall use allowable stresses:
        - From ASME Section IID, 2017 Edition, Table 1A for boilers and pressure vessels
        - From the 2016 edition of the applicable code of construction for piping
    - When a fitness-for-service assessment makes use of API 579-1 / ASME FFS-1, Part 6, for assessment of pitting corrosion, a creep assessment shall also be made in accordance with Part 10.

- When fitness-for-service assessments are undertaken with methods other than API 579-1 / ASME FFS-1, they should be required to be consistent with API 579-1 / ASME FFS-1 in their intents, limitations, and the level of safety achieved. The selected analysis method should be required to be acceptable both to the pressure equipment owner and to ABSA Design Survey.
- When material properties are not given by the ASME code, they should be obtained from suitable sources that are acceptable to the owner and to ABSA Design Survey, with bibliographical references given to support the data.
- When areas subject to a fitness-for-service assessment are within 1·t (wall thickness) of a weld, the assessment shall consider the weld metal, heat-affected zone, and base material.[5]
- Creep life calculations should be required to be no less conservative than those obtained using Part 10 of API 579 / ASME FFS-1, either using the Omega method or using the Larson-Miller method with parameters selected from Table 10B.4 or Table 10B.4M, as appropriate.

11. RECOMMENDATIONS FOR IMPLEMENTATION

The following steps are recommended relating to implementation:

- Generate an AB-500-series document
- Establish a timeline for owners who choose to implement the requirements of the document, permitting owners to alternatively provide their own implementation plan as long as a definite timeline is established
- Invite this present task group to provide feedback on the proposed AB-500-series document
- Issue the AB-500-series document and an associated information bulletin
- Update other applicable ABSA documentation to include references to the new document
- Train ABSA Design Survey and Inspection staff
- Update existing ABSA seminars to include mention of requirements for Grade 91 equipment
- Include a discussion of Grade 91 equipment in the next ABSA Code Update Seminar
- Evaluate adherence to newly established requirements in regular integrity management system audits

[5] There is a concern that ASME FFS-1 may not provide adequate guidance on the degraded properties of Grade 91 in the heat-affected zone, or adequately address the creep life characteristics of the weld itself.