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RPP-WTP PDC

RIVER PROTECTION PROJECT – WASTE TREATMENT PLANT

ENGINEERING SPECIFICATION

FOR

Pressure Vessel Fatigue Analysis

Content applicable to ALARA? ☐ Yes ☒ No

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N/A

Specification changes retroactive? ☒ Yes ☐ No
☐ N/A (alpha revision or revision 0)

NOTE: Contents of this document are Dangerous Waste Permit affecting.

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24590-WTP-3PS-MV00-T0003

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Revision History

Revision	Reason for Revision
0	Issued for Design
1	Rewritten, Issued for Use
2	Incorporated 24590-WTP-3PN-MV00-00004, Issued for Use
3	Incorporates Change Documents Listed in Section 13. Incorporated relevant requirements from Appendix L section of SRD Issued for Use. Document revised substantially and complete reading required.

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1 Introduction

1.1 This specification is supplementary to 24590-WTP-3PS-MV00-T0001 and covers fatigue evaluation and fatigue analysis requirements. The documents should be read in conjunction, particularly for definitions, conditions of conflict, and responsibilities of the parties. However, the clauses of the above document shall apply, unless specified otherwise here.

1.2 This document shall be used by the Seller.

1.3 Any communication between the Seller and the Buyer regarding the interpretation or interim findings of design must be in accordance with the instructions provided in the purchase order.

2 Definitions and Acronyms

Black Cell (BC)	Shielded cells for which no maintenance or entry is planned for the 40-year design life of the plant.
Charge Vessel	A vertical cylindrical vessel in a pump system which is pressurized cyclically
ECDS	Equipment Cyclic Data Sheet
Equipment Cyclic Data Sheet	A table in the MDS which contains the cyclic data for that particular component
Fatigue Analysis	Calculations to determine fatigue life expectancy of the equipment
Fatigue Evaluation	A documented exercise that determines whether fatigue is a significant design criterion and must be considered by subsequent fatigue analysis
Hard-to-Reach (HTR)	Facility areas where piping and equipment is not designed for manual or remote access, replacement, or repair.
MDS	Mechanical Data Sheet.
Parent Vessel	A vessel that contains other vessels. This arrangement is typically a storage vessel with internal Charge Vessel and Pulse Jet Mixer equipment submerged within the normal liquid contents
Pulse Jet Mixer	A vertical cylindrical vessel that is open at the lower end and is pressurized cyclically to act as a mixer
RPP-WTP	River Protection Project – Waste Treatment Plant
SC / SS	Safety Class / Safety Significant

3 Applicable Documents

3.1 Codes and Industry Standards

3.1.1 American Society of Mechanical Engineers Codes:

3.1.1.1 ASME Section VIII, Division 1, *"Rules for Construction of Pressure Vessels".*

3.1.1.2 ASME Section VIII, Division 2, *Rules for Construction of Pressure Vessels - Alternative Rules,* American Society of Mechanical Engineers *(Note: Code year not later than 2004 Edition with 2005 and 2006 Addenda).* Linearization of Stress Results for Stress Analysis *(ASME VIII Div 2, Annex 5.A, 2007 Edition, no Addenda)*

3.1.1.3 ASME SA 480/SA 480M, *"Standard Specification for General Requirements for Flat-Rolled Stainless and Heat Resisting Steel Plate, Sheet, and Strip."*

3.1.1.4 ASME B31.3, *Process Piping*, 1996, American Society of Mechanical Engineers.

3.1.2 American Institute of Steel Construction Standards:

3.1.2.1 AISC M016, *ASD Manual of Steel Construction, 9th Edition*, American Institute of Steel Construction.

3.1.2.2 ANSI/AISC N690-94, *Specification for the Design, Fabrication, and Erection of Steel Safety-Related Structures for Nuclear Facilities*, American Institute of Steel Construction.

3.2 Project Documents

3.2.1 24590-WTP-3PS-MV00-T0001, *"Engineering Specification for Pressure Vessel Design and Fabrication".*

3.2.2 *24590-WTP-3PS-MV00-T0002, "Engineering Specification for Seismic Qualification Criteria for Pressure Vessels."*

4 Buyer's Responsibilities

4.1 The Buyer shall provide the necessary cyclic data for the Seller to make an evaluation regarding the fatigue life of the equipment.

5 Seller's Responsibilities

5.1 Evaluation: The Seller shall perform an evaluation of the equipment based on the cyclic data provided by the Buyer and also on any necessary data provided by others as contracted by the Seller.

5.2 Interpretation: The Seller shall confirm with the Buyer that the cyclic data has been accurately interpreted before proceeding to a fatigue analysis exercise.

5.3 Analysis: The Seller shall perform a fatigue analysis based upon the Buyer's data.

5.4 Documentation: The Seller shall provide statements and calculations for the fatigue evaluation and any analysis to the Buyer for review and approval, to support the satisfactory design life of the equipment.

5.5 Design Changes: The Seller shall make the resulting design changes to ensure the required life expectancy of equipment and subsequently obtain the Buyer's approval. The design changes shall be restricted to material thickness increases, weld types and weld seam locations. Buyer's opinion of changes shall be obtained at an early stage of the design development to ensure compliance with criteria outside the Seller's scope.

6 Fatigue Design Code

6.1 The overall design code for pressure vessels is the ASME Section VIII, Division 1. Paragraph UG-22 (e) of Division 1, requires consideration of cyclic loading. This shall be in accordance with ASME Section VIII, Division 2 Paragraph AD-160. When fatigue analysis is required it shall be in accordance with ASME Section VIII, Division 2, Appendix 4 and 5, using the allowable stress (S) from ASME Section VIII, Division 1 in lieu of design stress intensity (S_m) of ASME Section VIII, Division 2.

7 Cyclic Load Data

7.1 The Buyer provides cyclic data for pressure vessels in the form of Equipment Cyclic Data Sheets (ECDS), refer to Figure 1 The ECDS is part of the equipment MDS. This contains the information on pressure, temperature, and mechanical load cycles along with notes regarding the coincidence in time of the various loads. It may be necessary for the Seller to obtain information originating from sources such as agitator suppliers. Where the Seller must obtain additional cyclic data information, the Buyer will identify this in the MDS.

Figure 7-1: Example of Equipment Cyclic Data Sheet

Equipment Cyclic Data Sheet

Component Plant Item Number:	
Component Description	

The information below is provisional and envelopes operational duty for fatigue assessment. It is not to be used as operational data.

Materials of Construction	
Design Life	
Component Function and Life Cycle Description	

Load Type		Min	Max	Number of Cycles	Comment
Design Pressure	psig				
Operating Pressure	psig				
Operating Temperature	°F				
Contents Specific Gravity					
Contents Level	inch				
Localized Features					
Nozzles					
Supports					

Notes

- ***Cycle Increase: The Seller must increase the numbers of operational cycles given above by 10% to account for commissioning duty unless otherwise noted.***

7.2 Shipping and transportation is a potential source of fatigue damage. Dip pipes and other susceptible components shall be considered in relation to typical transport excitation frequencies.

7.3 Equipment must be designed to avoid excessive vibration during service. For example, shell and tube heat exchangers are designed to avoid potentially damaging tube vibration.

7.4 The RPP-WTP plant contains several batch processes that utilize equipment designed to ASME Section VIII, Division 1, and subsequently, this specification. The vessel equipment shall be designed for a period of 40 years operation unless otherwise stated on the MDS or ECDS.

8 Fatigue Evaluation

8.1 The Seller shall make an evaluation of the cyclic loading on the proposed design for approval by the Buyer.

8.2 The evaluation is a procedure to identify equipment that may not require a full fatigue analysis. The details of this calculation, the assumptions made, and the effects from mechanical loads, shall be submitted for Buyer approval.

8.3 The rules of ASME Section VIII, Division 2, Paragraph AD160, apply for the following:

8.3.1 Black Cell Vessels

8.3.2 Hard-to-Reach Area Vessels

8.3.3 Safety Class and Safety Significant (SC/SS) Vessels

8.4 The equipment must not have the features described in AD-160.1 unless specific agreement is obtained from the Buyer. The requirements of AD-100 (b) that are necessary for the evaluation and analysis to be applicable shall be observed.

8.5 The liquid static head pressure affecting the stress at any location of interest shall be considered, in addition to other loads.

8.6 Non-safety pressure vessels outside Black Cells and Hard-to-Reach areas require a fatigue evaluation in accordance with Section VIII, Division 1, Paragraph UG-22(e).

9 Fatigue Analysis

9.1 If the Buyer approves the conclusion that Paragraph AD-160 requires a fatigue analysis, it shall be performed in accordance with ASME Section VIII, Division 2, Appendix 5. When required to determine an elastic-plastic correction factor (Ke), the requirements of the simplified Elastic-Plastic analysis of ASME Section VIII, Division 2, Appendix 4, 4-136.7 shall be satisfied.

9.2 The thickness of corrosion allowance shall be completely removed from components when determining stress levels.

9.3 The fatigue analysis for all cyclic loads identified on the ECDS shall demonstrate that the maximum cumulative usage factor, 'U', does not exceed 1.0 at any critical location or discontinuity on the vessel wall such as near nozzles, supports, and structural attachment.

9.4 Seismic loading shall not be considered (see reference 3.2.2) when performing a fatigue analysis.

9.5 The acceptance criteria for all vessels within the Black Cells, Hard-to-Reach Areas, and safety (SC/SS) vessels outside Black Cells and Hard-to-Reach areas shall be in accordance with Appendix 4 of ASME Section VIII, Division 2, using the allowable stress, S, from ASME Section VIII, Division 1 in lieu of the design stress intensity, S_m, of ASME Section VIII, Division 2.

9.6 The acceptance criteria for non-safety vessels outside Black Cells and Hard-to-Reach Areas shall be considered in accordance with ASME Section VIII, Division 1,UG-22 (e), using the allowable stress, S, from ASME Section VIII, Division 1.

10 Surface Finishes

10.1.1 The equipment surface finish assumed for a fatigue analysis shall not exceed 2B plate mill finish in accordance with ASME SA 480/SA 480M.

10.1.2 Surface finish enhancements for cleaning or inspection purposes are not to be assumed to enhance fatigue life.

10.1.3 Local contour dressing of welds for fatigue life improvement shall not be acknowledged in any fatigue analysis. However, where the fabrication code tolerates any undercut at a weld toe this shall be acknowledged in fatigue analysis as an additional stress concentration unless fabrication and inspection procedures confirm that undercut is not present or has been repaired.

10.1.4 Welds should be assumed to be descaled as-laid for fatigue analysis purposes. The finish of welds must be full throat thickness with a blended form at the parent metal.

11 Nozzle Loads

11.1.1 The minimum nozzle design loads in the applicable table of 24590-WTP-3PS-MV00-T0001, Appendix A shall be used for analysis unless other loads have been specified in the MDS, in which case the MDS specified loads are to be used. The seismic component of loads shall be ignored in fatigue analysis as the seismic design is based on a single design basis event making negligible contribution to the fatigue life. The thermal and weight component of loads shall be considered in the analysis.

11.1.2 The maximum peak stress intensity range values from the combination of all piping loads, pressure, and temperature at a nozzle shall be used for fatigue analysis. If maximum values from different locations are combined then this must be identified in the calculations.

11.1.3 If the vessel has internal piping, such as for charge vessels and pulse jet mixers, the loads listed in the applicable table of 24590-WTP-3PS-MV00-T0001, Appendix A (or in the applicable MDS) shall be combined with the loads calculated by the Seller for the reaction of the internal piping on the attached nozzle.

12 Documentation

12.1 The ASME, Section VIII, Division 1, UG-22 requirement, for the consideration of cyclic loads, must be addressed by a fatigue evaluation and, where required, a fatigue analysis. This must be documented and submitted for the Buyer's approval prior to commencement of fabrication.

12.2 Typical evaluation documents shall contain:

- An appraisal of the equipment cyclic duty data and the locations that are sensitive to fatigue
- Histograms of the load cycles assumed for the evaluation
- The calculation of the evaluation criteria values
- The conclusions, assumptions and limitations of the evaluation
- Supporting references

12.3 Typical analysis documents shall contain the following as a minimum:

- The stress derivations, classifications and combinations considered as cyclic
- The cumulative usage factor at each critical location analyzed for fatigue
- The conclusions, assumptions and limitations of the analysis
- Supporting references

13 Revision History (Internal Use Only)

NOTE: Asterisk (*) denotes a new entry for this revision of the Specification

13.1 Design Changes Incorporated by Design

24590-WTP-3PN-MV00-00004
* 24590-WTP-3PN-MV00-00024

13.2 Design Changes Incorporated by Reference

None.