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February 3, 2017
QA-2017-005, Revision 1

Attention: Document Control Desk
U.S. Nuclear Regulatory Commission
Washington, DC 20555-0001

Subject: Reply to Notice of Nonconformance Cited in Nuclear Regulatory Commission Vendor Inspection Report No. 99901383/2016-201

References: 1. Docket No. 99901383
2. Notices of Nonconformance 99901383/2016-201-01 and 9901383/2016-201-02

Curtiss Wright Electromechanical Corporation (CW-EMD) acknowledges receipt of NRC Inspection Report 99901383/2016-201. The NRC's inspection of CW-EMD was an extremely thorough examination of our program and we recognize the significant investment in time that it required of the inspection team. The observations offered by the Inspectors throughout the week will help CW-EMD to continue to improve our business.

CW-EMD is committed to complying with the provisions of Appendix B, "Quality Assurance Criteria for Nuclear Power Plants and Fuel Reporocessing Plants"; to Title 10 Code of Federal Regulations; and Title 10 Code fo Federal Regulations Part 21, "Reporting of Defects and Noncompliance". We have taken the results of this inspection seriously and are taking action to resolve Notices of Nonconformance. CW-EMD respectfully request the NRC to consider Attachments 1and 2 as our response to the Notices.

Yours sincerely,

Stewart A. Shannon, PE
Senior Director
Product Assurance
Curtiss-Wright EMD

Attachments: 1) Response to NON 99901383/2016-201-01, Revision 1
2) Response to NON 99901383/2016-201-02, Revision 1

cc: J. Burke U.S. NRC
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Attachment 1, Revision 1

Notice of Nonconformance 99901383/2016-201-01

A. Criterion III, "Design Control," of Appendix B "Quality Assurance Program Criteria for Nuclear Power Plants and Fuel Reprocessing Plants," to Title 10 of the Code of Federal Regulations (10 CFR) Part 50, "Domestic Licensing of Production and Utilization Facilities," states, in part, that, "Measures shall be established to assure that applicable regulatory requirements and the design basis, as defined in 10 CFR 50.2, and as specified in the license application, for those structures, systems, and components to which the appendix applies are correctly translated into specifications, drawings, procedures, and instructions."

Westinghouse Electric Company's (WEC's) design specification document APP-MP01-M2-001, "AP1000 Reactor Coolant Pump," Revision 4, dated March 1, 2013, Section 5.1.3, "Flywheel Materials," states in part, that, "The flywheel assembly shall be encased within a welded Alloy 625 enclosure to protect the heavy alloy from contact with the reactor coolant."

Contrary to the above, as of November 18, 2016, EMD failed to transfer all pertinent design requirements into applicable instructions and failed to use the material specified in the design specification. Specifically, Alloy 600 weld filler material was used for weld numbers 37, 38, 39 and 61 of the flywheel enclosure. By not correctly transferring the material requirements to the EMD drawings and weld procedures, the flywheel welds are not made from Alloy 625 material, as required by WEC APP-MP01-M2-001.

The safety function of the Reactor Coolant Pump when power is removed is to provide coastdown flow to maintain adequate core cooling. The flywheel enclosure is part of the flywheel assembly which is critical to this function.

Response:

1) The basis for disputing the noncompliance:

Curtiss-Wright Electro-Mechanical Corporation's (EMD) respectfully disagrees and contests the NRC finding. EMD's use of alloy 600 type weld material 82/182 meets the requirements of the Westinghouse design specification document APP-M01-M2-001. EMD's basis for use of alloy 600 type weld filler material 82/182 for the welds in question is as follows:

- Section 5.1.3 does not impose any requirements on the weld filler material used on the AP1000 RCP Flywheel Assemblies. The requirement stated in Section 5.1.3 is interpreted by EMD as requiring the structural components of the enclosure to be made from wrought forms of alloy 625 and welded, but does not define a specific weld material to be used on the wrought alloy 625. The design specification defines the weld material separate from the enclosure.

- In particular, Section 5.1.1.6 of the design specification provides the restrictions or requirements specifically placed on weld materials. The applicable portion of Section 5.1.1.6 is as follows: "The welding materials used for joining nickel-chromium-iron alloy in similar base material combination and in dissimilar ferritic or austenitic base material combination shall conform to ASME Material Specifications SFA 5.11 or SFA 5.14." These include weld filler wire alloy 82 (ERNiCr-3) and welding electrode alloy 182 (ENiCrFe-3) which are well suited for joining dissimilar metals such as joining stainless steels to nickel alloys. These alloy 600 type weld filler materials were used on weld numbers 37, 38, 39 and 61 on the flywheel assembly in compliance with the requirements of the design specification.

- In addition, Section 7.1.d of the design specification addresses nickel alloy weld metals for all fabrication processes and invokes Section 4.2.5 of APP-GW-VLR-010, Revision 1, "AP1000 Supplemental Fabrication and Inspection Requirements", May 11, 2010, which states, "Use of alloy 600 filler metals 82 and 182 (ERNiCr-3, EQNiCr-3 and ENiCrFe-3) are prohibited for any pressure boundary applications or any other application in contact with reactor coolant over 400°F (204°C). Any uses of alloy 600 filler metals in contact with reactor coolant at temperatures less than 400°F (204°C) require engineering evaluation and justification." However, the text of Section 7.1.d regarding prohibition for pressure boundary applications is immaterial because the AP1000 RCP flywheel assembly is not a pressure boundary component. Furthermore, the maximum temperature experienced by the flywheels under steady state operating conditions in the RCP is 260°F (127°C), occurring at the top of the upper flywheel, which is well below the temperature of 400°F (204°C). Under certain emergency conditions, specifically an extended loss of cooling water event, the top of the upper flywheel is exposed to primary water in the range of 420°F (216°C) for a brief period of time. However, under these conditions, the reactor coolant pump is shut down and there are no operational stresses in the weld joints. The stress state and brief time period of exposure of the weld joints on the upper flywheel to stress corrosion cracking initiation conditions during a loss of coolant water transient are negligible and the primary concern for plant safety is the pressure boundary integrity of the RCP which would not be compromised. Therefore, use of alloy 600 type weld filler material 82/182 does not affect the safety-related function of the flywheel. While the use of alloy 600 type weld filler material 82/182 on the flywheel assembly has been technically justified by EMD, it is acknowledged that a single comprehensive document providing the details of the engineering evaluation and justification was not available at the time of the NRC inspection.

- Furthermore, EMD points out that the company has extensive experience with the use of component weld configurations similar to the AP1000 RCP flywheel. In the late 1970s, EMD developed and qualified the process of utilizing alloy 600 weld filler metal 82 to butter 400 Series martensitic SST base materials. The favorable benefit of the alloy 600 weld filler metal 82 is that it can accommodate a post weld heat treatment to temper any untempered martensite in the heat affected zone of 400 Series martensitic SST materials with no negative effects. Conversely, EMD considers the use of an alternate material, such as alloy 625 weld fillers, on the 400 Series component of the flywheel to be more problematic than beneficial.

Specifically, the solidification behavior of alloy 625 weld fillers is inferior and can cause the following weld metal characteristics: 1) Microsegregation – segregation within microscopic grains; 2) secondary phase formation and 3) an increase in solidification temperature range compared to alloy 600 type weld filler material. Thus, buttering of alloy 625 weld filler on the 400 Series martensitic SST flywheel material would produce a microstructure which increases the potential for solidification cracking. Further, the heat treatment required to temper the 400 Series martensitic SST component after buttering would cause the alloy 625 weldment to age, thereby increasing the strength of the weldment and increasing the propensity for it to crack. As can be seen, there are well founded technical reasons for selecting the alloy 600 type weld filler materials 82/182 over alloy 625 weld filler materials for the flywheel welds in question.

- EMD notes that any concerns for primary water stress corrosion cracking (PWSCC) in alloy 600 base metal and related weld metals are associated with high temperature environments. There is evidence to show that temperature has a very strong effect on PWSCC initiation and growth. The water temperature inside the AP1000 RCP is well below the hot leg or cold leg reactor system temperatures, the latter of which can be near 550°F, where PWSCC has been shown to be a concern. The maximum temperature experienced by the flywheels under steady state operating conditions in the RCP is 260°F (127°C), occurring at the top of the upper flywheel, which is well below the 482°F (250°C) threshold temperature for PWSCC susceptibility that is reported in the technical literature. Based on industry test data and predictive models at higher temperatures, EMD estimated the behavior of alloy 600 and related weld filler metals 82/182 at 260 °F. EMD's analytical estimates indicate that stress corrosion crack initiation in alloy 600 weldments would require thousands of years [Reference 1] of exposure and subsequent stress corrosion crack growth rates, if any, would be negligible [Reference 2]. As such, there is no practical concern about any PWSCC occurring in the weldments at issue.

- EMD also evaluated the potential effect of the Low Temperature Crack Propagation (LTCP) phenomenon, despite the fact that it has only been observed in the laboratory and not in service. This phenomenon manifests itself as a reduction in fracture toughness in water in the temperature range of the flywheel and is also dependent on the hydrogen content of the water. At hydrogen concentrations conservatively bounding operating or shutdown conditions of the primary water system, the LTCP fracture toughness of the flywheel alloy 600 type weld filler material 82/182 is at a stress intensity factor of approximately 60 ksi-in^1/2 [Reference 3]. EMD estimates that the maximum stress intensity factor in the subject flywheel welds is 30 ksi-in^1/2, based on the maximum transient stress and inspection-based hypothetical flaw sizes. Therefore, LTCP will not occur in the subject flywheel welds.

- EMD held numerous discussions with Westinghouse during the evolution of the AP1000 RCP regarding the flywheel design due to the critical function of the AP1000 RCP flywheel. These exchanges spanned the years 2005 through 2010, and culminated with agreement by both parties on the use of the materials selected, including the use of alloy 600 type weld filler material 82/182 for a select number of welds on the flywheel assembly. EMD submitted documentation and weld procedures that specifically identified alloy 600 weld filler material 82/182 for welds 37, 38, 39 and 61 on the flywheel assembly to Westinghouse for approval.

- In 2009, as a result of the consensus reached by Westinghouse and EMD regarding the materials to be used on the flywheel assembly, Westinghouse approved the EMD submittals associated with the alloy 600 type weld material 82/182 on the flywheel weld joints in question and issued Revision 2 of the design specification that included language specific to the flywheel materials. Westinghouse's approval to use alloy 600 type weld material 82/182 for the flywheel assembly on welds 37, 38, 39 and 61 was granted based on these prior discussions. Furthermore, the corresponding flywheel specific material language incorporated in Revision 2 of the design specification, which has since remained unchanged, was incorporated to provide for the acceptability of alloy 600 type weld material 82/182 for use in the flywheels.

- During the development of this response, EMD engaged Westinghouse in discussions on the NRC nonconformance associated with the alloy 600 type weld filler material 82/182 as it pertains to the flywheel assembly and the design specification. These discussions again confirmed the position by EMD and Westinghouse that the flywheel materials used comply with the design specification.

2) The corrective steps that have been taken and the results achieved:

Since EMD does not agree with this NRC finding, no corrective steps have been taken.

3) The corrective steps that will be taken to avoid further noncompliance:

Since EMD does not agree with this NRC finding, no corrective steps are planned.

4) The date when the corrective action will be completed:

Since EMD does not agree with this NRC finding, no corrective action is planned.

References:

1. Fabien Leonard, "Study of Stress Corrosion Cracking of Alloy 600 in High Temperature High Pressure Water", Ph. D Thesis, University of Manchester, 2010.

2. Gorman et al, "PWR Reactor Vessel Alloy 600 Issues", Chapter 44, Companion Guide to the ASME Boiler and Pressure Vessel Code, Volume 3, ASME, 2009

3. Brown and Mills, "Fracture Toughness, Tensile and Stress Corrosion Cracking Properties of Alloy 600, Alloy 690, and Their Welds in Water", Paper No. 90, NACE International Annual Conference and Exposition, 1996.

Attachment 2, Revision 1

Notice of Nonconformance 99901383/2016-201-02

B. Criterion III, of Appendix B to 10 CFR Part 50, states, in part, that, "Measures shall also be established for the selection and review for suitability of application of materials, parts, equipment, and processes that are essential to the safety-related functions of the structures, systems and components."

Criterion VII, "Control of Purchased, Material, Equipment, and Services," of Appendix B to 10 CFR Part 50 states, in part, that, "Measures shall be established to assure that purchased material, equipment, and services, whether purchased directly or through contractors or subcontractors, conform to the procurement documents. These measures shall include provisions, as appropriate, for source evaluation and selection, objective evidence of quality furnished by the contractor or subcontractor, inspection at the contractor or subcontractor source, and examination of products upon delivery."

EMD Product Assurance Instruction No. 224, "Commercial Grade Surveys," Revision 2, dated November 5, 2015, states, in part, that, "The Commercial Grade Survey Checklist shall be used to guide the evaluation process, document the observed control of critical characteristics, and provide adequate objective evidence to support the conclusions regarding the adequacy of the supplier's controls."

Contrary to the above, as of November 18, 2016, the NRC inspection team identified two examples where EMD failed to establish adequate measures for the selection and review for suitability of application of materials and processes that are essential to the safety-related functions of structures, systems, and components. Also, EMD failed to provide objective evidence of quality furnished by the contractor or subcontractor. Specifically, EMD failed to verify through the conduct of a commercial-grade survey or another acceptance method that certain critical characteristics identified in the technical evaluation of the impeller casting, impeller weld repair, and calibration services were adequately controlled. EMD's commercial-grade survey of Precision Castparts Corporation did not verify that they had imposed and verified the necessary controls on their commercial sub-suppliers for performing hot isostatic pressing activities and control and testing of weld filler material. In addition, EMD's commercial-grade survey of R.L. Holliday (RLH) did not verify that they had imposed and verified the necessary controls on their commercial sub-suppliers for the calibration of RLH's equipment. For both of these suppliers, EMD did not perform any additional verification or acceptance activities to ensure that the identified critical characteristics were adequately controlled and the components would perform their intended safety function.

The safety function of the Reactor Coolant Pump when power is removed is to provide coastdown flow to maintain adequate core cooling. The impeller is part of the safety-related rotor assembly which performs this function.

Response:

1) The basis for disputing the noncompliance:

- Curtiss-Wright Electro-Mechanical Corporation's (EMD) respectfully disagrees and contests the NRC finding. EMD's commercial grade dedication process meets the requirements of 10CFR50 Appendix B and 10CFR21. The suitability of EMD's commercial grade dedication process in question for the identified suppliers is as follows.

10CFR50 Appendix B

- The regulation cited with respect to the Notice of Nonconformance is Appendix B to 10 CFR Part 50. The criteria cited with respect to the Notice of Nonconformance are Criterion III (Design Control) and Criterion VII (Control of Purchased Material, Equipment, and Services).

- The extent of objective evidence required by Appendix B to 10 CFR Part 50, Criteria III, or Criteria VII; neither define nor specify the extent of objective evidence necessary during a commercial grade survey.

- Appendix B to 10 CFR Part 50 states, "...measures shall include provisions, as appropriate, for source evaluation and selection, objective evidence of quality furnished by the contractor or subcontractor, inspection at the contractor or subcontractor source, and examination of products upon delivery."

- Appendix B to 10 CFR Part 50 is not specific as to the extent of objective evidence required during a commercial grade survey. However, Criterion VII of the regulation does state in part, in reference to objective evidence, "...These measures shall include provisions, as appropriate, for source evaluation and selection, objective evidence of quality furnished by the contractor or subcontractor, inspection at the contractor or subcontractor source, and examination of products upon delivery". EMD, as the dedicating entity, determined that the objective evidence provided by the contractors (PCC and R.L. Holliday) and subcontractors in question, as reviewed by the survey team, was in fact appropriate and adequate to establish conformance to the procurement document.

IDPE41: Commercial Grade Dedication Procedure (Other Than RCP Seals)

- IDPE41 outlines the responsibilities and requirements for dedicating parts for use in safety-related applications.

- IDPE41 references and is written to the requirements of 10 CFR Part 21, the regulation that defines the requirements associated with the commercial grade dedication process. In addition to other industry documents, IDPE41 references EPRI NP-5652 (Guideline for the Utilization of Commercial Grade Items in Nuclear Safety Related Applications) and EPRI TR-102260 (Supplemental Guidance for the Application of EPRI Report NP-5652 on the Utilization of Commercial Grade Items).

- IDPE41 states that a Supplier Quality Engineer, "conduct survey of suppliers, and/or any required surveillance or in-process activities required to verify CCA (critical characteristics for acceptance), if applicable". The process for "survey of suppliers" is defined in EMD procedure PAI224 (Commercial Grade Surveys).

- EMD procedure IDPE41, in accordance with 10 CFR Part 21, controls the process for commercial grade dedication, which includes the acceptance methods necessary to verify that the critical characteristics for acceptance are met. Through the commercial grade surveys and additional acceptance methods as defined in 10 CFR Part 21, EMD determined that the critical characteristics, defined in accordance with IDPE41, were met.

10CFR21

- 10 CFR Part 21, the regulation that defines the requirements associated with the commercial grade dedication process, does not specifically state the extent of objective evidence that is necessary.

- 10 CFR Part 21 defines dedication as "(1) When applied to nuclear power plants licensed pursuant to 10 CFR Part 30, 40, 50, 60, dedication is an acceptance process undertaken to provide reasonable assurance that a commercial grade item to be used as a basic component will perform its intended safety function and, in this respect, is deemed equivalent to an item designed and manufactured under a 10 CFR Part 50, Appendix B, quality assurance program. This assurance is achieved by identifying the critical characteristics of the item and verifying their acceptability by inspections, tests, or analyses performed by the purchaser or third-party dedicating entity after delivery, supplemented as necessary by one or more of the following: commercial grade surveys; product inspections or witness at hold points at the manufacturer's facility, and analysis of historical records for acceptable performance. In all cases, the dedication process must be conducted in accordance with the applicable provisions of 10 CFR Part 50, Appendix B. The process is considered complete when the item is designated for use as a basic component."

- 10 CFR Part 21 defines dedicating entity as, "When applied to nuclear power plants licensed pursuant to 10 CFR Part 50, dedicating entity means the organization that performs the dedication process. Dedication may be performed by the manufacturer of the item, a third-party dedicating entity, or the licensee itself. The dedicating entity, pursuant to § 21.21(c) of this part, is responsible for identifying and evaluating deviations, reporting defects and failures to comply for the dedicated item, and maintaining auditable records of the dedication process."

- 10 CFR Part 21 defines critical characteristics as, "When applied to nuclear power plants licensed pursuant to 10 CFR Part 50, critical characteristics are those important design, material, and performance characteristics of a commercial grade item that, once verified, will provide reasonable assurance that the item will perform its intended safety function."

- EMD is both the purchaser and the dedicating entity.

- As the purchaser and dedicating entity, EMD identified critical characteristics and determined that by means of the verification processes employed, reasonable assurance had been provided that the item will perform its intended safety function. Specifically, the commercial grade survey and subsequently the objective evidence provided by the contractors (PCC and R.L. Holliday) and subcontractors during the commercial grade surveys in combination with additional acceptance methods provide reasonable assurance that the item will perform its intended safety function. EMD provided documented and auditable records to this effect during the NRC vendor inspection.

PAI224: Commercial Grade Surveys

- PAI224 states, "The Commercial Grade Survey Checklist shall be used to guide the evaluation process, document the observed control of critical characteristics, and provide adequate objective evidence to support the conclusions regarding the adequacy of the supplier's controls."

- The commercial grade surveys reviewed as part of the NRC's vendor inspection activities included commercial grade survey checklists, documented control of critical characteristics, and provided adequate objective evidence to support the conclusions regarding the adequacy of the supplier's controls.

- As the purchaser and dedicating entity, EMD determined that the contractors (PCC and R.L. Holliday) had provided sufficient and adequate objective evidence to determine that the suppliers' (PCC and R.L. Holliday) controls were adequate, in combination with additional acceptance methods used during the commercial grade dedication process to provide reasonable assurance that the item will perform its intended safety function.

- EMD met the requirements of PAI224.

Summary Conclusion:

- As the designer, purchaser, and dedicating entity, EMD determined through the commercial grade dedication process that the objective evidence of quality furnished by the contractors and subcontractors was adequate and sufficient to provide reasonable assurance that the item will perform its intended safety function. As a result, EMD is conforming to the procedures and regulations referenced herein. Therefore, EMD believes the Notice of Nonconformance as documented in NRC Inspection Report 99901383/2016-201 should not be considered nonconformance by the NRC.

2) The corrective steps that have been taken and the results achieved:

Since EMD does not agree with this NRC finding, no corrective steps have been taken.

3) The corrective steps that will be taken to avoid further noncompliance:

Since EMD does not agree with this NRC finding, no corrective steps are planned.

4) The date when the corrective action will be completed:

Since EMD does not agree with this NRC finding, no corrective action is planned.