CURTISS-WRIGHT

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November 27, 2017
QA-2017-028-2

U.S. Nuclear Regulatory Commission (NRC)
ATTN: Document Control Desk
Washington, DC 20555-0001

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

References:
1. Notices of Nonconformance 99901383/2016-201-01 and 9901383/2016-201-02
2. Curtiss-Wright Electro-Mechanical Corporation Letter QA-2017-019, dated August 31, 2017
3. NRC Letter, dated September 15, 2017, Subject: Curtiss-Wright Electro-Mechanical Division Response to the U.S. Nuclear Regulatory Commission Inspection Report 99901383/2016-201, and Notice of Nonconformance

Curtiss-Wright Electro-Mechanical Corporation (CW-EMD) acknowledges receipt of the NRC letter, dated September 15, 2017, Reference 3.

CW-EMD is committed to complying with the provisions of Appendix B, "Quality Assurance Criteria for Nuclear Power Plants and Fuel Reprocessing Plants," to Title 10 Code of Federal Regulations; and to Title 10 Code of Federal Regulations Part 21, "Reporting of Defects and Noncompliance". CW-EMD respectfully submits the Enclosures as additional information in support of our letter QA-2017-019, dated August 31, 2017, Reference 2, as requested by NRC's letter, dated September 15, 2017, Reference 3.

CW-EMD's response to questions pertaining to NON 99901383/2016-201-1 are addressed in Enclosures 1 through 5.

The response to the NRC question pertaining to NON 99901383/2016-201-2 is addressed in Enclosure 6.

Sincerely,

Stewart A. Shannon, PE
Senior Director, Product Assurance
Curtiss-Wright Electro-Mechanical Division

IE09
NRO

Enclosures:
1) Affidavit required by 10 CFR 2.390
2)Transmittal of EMD Technical Justification. Letter No: EMD-U600-0738, EMD-U601-0720, dated May 22, 2017
3) CW-EMD letter 17-APK-007, Technical Justification for Use of Alloy 600 Type Weld Filler Material on AP1000 Reactor Coolant Pump Flywheels (redacted)
4) Westinghouse PAR 4500265132-576-0 (pages 1 and 2 – redacted) dated 5/26/17
5) Westinghouse PAR 4500265135-551-0 (pages 1 and 2 – redacted) dated 5/26/17
6) Clarifications to CW-EMD Response to NON 99901383/2016-201-02

cc: Chief, Quality Assurance Vendor Inspection Branch – 2, Division of Construction Inspection and Operational Programs, Office of New Reactors

T. Herrity	U.S. NRC
B. Eckels	CW-EMD
R. Krchnavy	CW-EMD
R. Kiesow	CW-EMD
J. Gardiner	CW-EMD
M. Sherwin	CW-EMD

AFFIDAVIT OF MR. BRIAN W. ECKELS

COMMONWEALTH OF PENNSYLVANIA)
)
COUNTY OF ALLEGHENY)

I, Brian W. Eckels, being duly sworn, do hereby depose and say:

1. I am a citizen of the United States of America. I am a resident of North Huntingdon, Pennsylvania. My birth date is May 21, 1966.

2. I am presently employed by Curtiss-Wright Electro-Mechanical Corporation ("CW-EMD") in Cheswick, Pennsylvania. I am the Defense Business Senior General Manager and Site Leader of the Electro-Mechanical Division ("EMD"). I have held this position since August 17, 2012. I have personal knowledge of the facts set forth in this affidavit, and if called and sworn as a witness in a deposition or before any court, I could and would testify competently under oath to these facts.

3. CW-EMD requests that the Nuclear Regulatory Commission ("NRC") withhold the redacted portions of Enclosures 3-5 to the letter dated October 12, 2017 from Stewart Shannon to the NRC in accordance with the provisions of 10 CFR 2.390. Enclosures 3-5 to the October 12, 2017 letter are listed below.

Enclosure 3 - CW-EMD letter 17-APK-007, Technical Justification for Use of Alloy 600 Type Weld Filler Material on AP1000 Reactor Coolant Pump Flywheels (redacted), without cover letter
Enclosure 4 – Westinghouse PAR 4500265132-576-0 (pages 1 and 2) dated 5/26/17
Enclosure 5 - Westinghouse PAR 4500265135-551-0 (pages 1 and 2) dated 5/26/17

This request is made to protect CW-EMD's trade secret, proprietary and/or commercial information under 10 CFR 2.390(a)(4) that could be of great value to our competitors and may result in the loss of a competitive advantage. In addition, the request is made to protect contractual information as required by CW-EMD's contract with Westinghouse Electric Company, LLC. The public disclosure of the redacted information contained in the documents cited above is likely to cause substantial economic harm to the competitive advantage held by CW-EMD, and potentially violate contractual agreements with Westinghouse Electric Company, LLC.

4. The information contained in the documents described above have been held in confidence by CW-EMD in that it is trade secret, proprietary and/or commercial information as specified in Title 10 Code of Federal Regulations, Part 2.390(a)(4), and proprietary contractual information as specified by contracts with Westinghouse Electric Company, LLC. The top of the first page of the document and the top of each page containing such information is marked "Proprietary Information – Withhold From Public Disclosure Under 10 CFR 2.390" in accordance with 10 CFR 2.390(b)(1)(i)(A). The basis for requesting that the redacted portions of these documents be withheld from public disclosure is explicitly marked on the top of each affected page or adjacent to the proprietary information on the affected page in accordance with 10 CFR 2.390(b)(1)(i)(B). By handling this proprietary information in accordance with 10 CFR 2.390, the confidential nature of the information can be maintained and yet provide NRC with the information in a form that can be conveniently handled within the agency.

I declare under penalty of perjury under the laws of the United States of America that the foregoing is a true and correct statement of facts.

BW

Brian W. Eckels

Commonwealth of Pennsylvania)
) SS:
County of Allegheny)

On this 12th day of October, 2017, before me, the undersigned Notary Public, personally appeared Mr. Brian W. Eckels, known to me (or satisfactorily proven) to be the person whose name is subscribed to the Affidavit, and acknowledged that he executed same for the purposes therein contained.

In witness whereof, I hereunto set my hand and official seal.

COMMONWEALTH OF PENNSYLVANIA
NOTARIAL SEAL
Susan M. Hillery, Notary Public
Harmar Twp., Allegheny County
My Commission Expires March 29, 2020
MEMBER, PENNSYLVANIA ASSOCIATION OF NOTARIES

Susan M. Hillery
Notary Public

CURTISS-WRIGHT

EMD
EMS Division
1000 Wright Way
Cheswick, PA 15024
T: 724.275.5000

Letter No: EMD-U600-0738
EMD-U601-0720

May 22, 2017

Westinghouse Electric Company
Cranberry Woods Headquarters
1000 Westinghouse Drive
Cranberry Township, PA 16066

Subject: Transmittal of EMD Technical Justification Letter 17-APK-007

Reference: (a) Westinghouse Purchase Order 4500265135 (EMD Project U600)
(b) Westinghouse Purchase Order 4500265132 (EMD Project U601)

Attachment: (1) 17-APK-007: Technical Justification for Use of Alloy 600 Type Weld Filler Material on AP1000 Reactor Coolant Pump Flywheels

Dear Mr. Jones:

This letter is sent to transmit the Attachment (1) technical justification for the use of Alloy 600 type weld filler material on the Domestic AP1000 Reactor Coolant Pumps supplied under the reference (a) and (b) purchase orders.

Please contact the undersigned with any questions.

Sincerely,

Rachel E. Bell

Rachel Bell
Contract Administrator
EMD
Curtiss-Wright
T: 724-275-5346

cc:

EMD:	R. Krchnavy, R. Kiesow, R. Houston, R. Persia, M. Seymour, T. Dunn
WEC:	K. Schreurs, A. Tamilia, W. Moore

[redacted]

CURTISS-WRIGHT

EMD
Curtiss-Wright
1000 Wright Way • Cheswick, PA 15024
Phone: 724.275.5000
www.emd.cwfc.com

17-APK-007

May 22, 2017

To: K. Schreurs

Cc: R. Krchnavy
R. Persia
S. Seymour
B. Houston

Subject: Technical Justification for Use of Alloy 600 Type Weld Filler Material on AP1000 Reactor Coolant Pump Flywheels

1.0 Introduction

The purpose of this letter is to summarize and document the engineering evaluation and technical justification for the use of Alloy 600 type Filler Metal 82 and Welding Electrode 182 on the fabrication of the AP1000 Reactor Coolant Pump (RCP) flywheel assembly. Recognizing the critical nuclear safety function of the flywheel in the AP1000 RCP design, Curtiss-Wright Electro Mechanical Division (CW-EMD) held numerous discussions with Westinghouse Electric Corporation (Westinghouse) during the AP1000 RCP design phase on the flywheel design. These discussions included submittals of documents from CW-EMD to Westinghouse on the flywheel fabrication and weld procedures for approval. These exchanges spanned the years 2005 through 2010, and consisted of various forms of formal and informal communication that included emails, telephone calls, meetings, and submittals of letters and documents for approval such as weld procedures. These exchanges culminated with agreement by both parties on the use of the materials selected as exemplified by Reference 1 which identifies the weld procedures and location of weld joints on the flywheel where weld filler metals with nickel alloy material were to be used by CW-EMD and Reference 2 which provided Westinghouse acceptance of the justification of their use and subsequent approval of the associated weld procedures.

[redacted]

The function of the AP1000 flywheel assembly is to provide rotating inertia to deliver coastdown flow to maintain adequate cooling in the event of loss of power to the RCP. Section 5.1.3 of the Reference 3 AP1000 RCP Design Specification identifies requirements for the flywheel design. Section 7.1d of Reference 3 invokes Section 4.2.5 of the supplemental specification in Reference 2. Section 4.2.5 of Reference 4 in part 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." The information enclosed herein serves as the formal engineering evaluation and technical justification for the use of Alloy 600 type Filler Metal 82 and Welding Electrode 182 on select weld joints on the AP1000 flywheel assembly to meet the requirements in Reference 4.

2.0 Background

2.1 Flywheel Weldments

The weldments on the AP1000 flywheel assembly are identified in Reference 5. A sketch of the flywheel with base and weld materials defined in Figure 1 identifies the specific weldments on the AP1000 flywheel assembly that utilize Alloy 600 type weld Filler Metal 82 (ERNiCr-3) and Welding Electrode 182 (ENiCrFe-3). The particular weldments in question include:

- Weld 37 - the buttering of the Type 403 SST inner hub
- Weld 38 - the buttering of the Type 403 SST inner hub leak test hole
- Weld 39 - the weld of the end plate to the inner hub
- Weld 61 - the weld of the flywheel leak test plug

Other weldments on the AP1000 flywheel assembly identified in Reference 5 utilize Alloy 625 type Filler Metal 625 (ERNiCrMo-3) or Welding Electrode 112 (ENiCrMo-3). The use of these Alloy 625 type filler materials does not require explicit engineering evaluation or technical justification and therefore these weldments are not specifically addressed in this report. These weldments include:

- Weld 40 - the weld of the flywheel shell to the end plate
- Weld 41 - the weld of the end plate ring to the end plate in the flywheel end plate fabrication
- Weld 42 - the longitudinal weld of the flywheel shell
- Weld 62 - the seam weld in the flywheel end plate ring fabrication

[redacted]

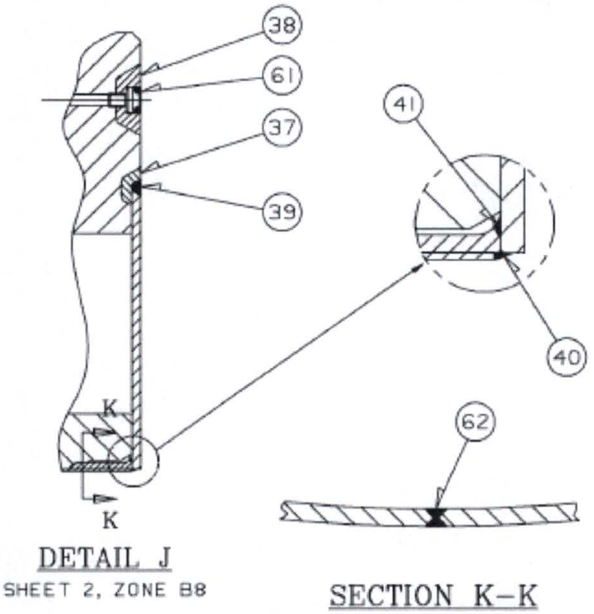


Figure 2: Flywheel weld joints identified on AP1000 weld map (Reference 5).

2.2 Operating Environment

The flywheel inner hub and the flywheel retainer ring are classified as Class 3 safety related components because the AP1000 RCP flywheel assembly provides rotating inertia to meet coastdown requirements specified in Reference 1. [redacted]

[redacted] Therefore, given the low stress state and brief time period that the weldments on the topside of the upper flywheel are exposed to stress corrosion crack initiation, a crack initiation evaluation is not numerically significant and stress corrosion crack initiation and growth at these weld locations is not considered a failure mode. Additional consideration of stress corrosion cracking is provided in Section 3.3.

3.0 Technical Justification

[redacted]

[redacted]

3.2 Use of Alternate Materials

Use of an alternate material to the ERNiCr-3 weld filler used on the flywheel inner hub, such as ERNiCrMo-3 (the counterpart of Alloy 625 base metal), can be problematic. The initial work to better understand the welding and solidification metallurgy of Alloy 625 was presented by M.J. Cieslak, (Reference 7). It was determined that with gas tungsten arc (GTA) welds of Alloy 625, the weld microstructure and solidification cracking were a function of the composition of the alloy. Specifically, carbon (C), silicon (Si), and niobium (Nb) increased the melting/solidification temperature range. Furthermore, γ/MC (NbC), γ/Laves, and γ/M_6C carbide eutectic-type secondary phases formed at the terminal stages of solidification. It was determined that additions of carbon and silicon increased the susceptibility of the Alloy 625 to hot crack in Nb bearing 625 as a result of these phases forming. This solidification behavior is specific to the Alloy 625 material and not to Alloy 600 or its weld filler equivalent ERNiCr-3.

An additional reference by DuPont (Reference 8) cites similar results to those of Cieslak but where Alloy 625 has been deposited onto 2.25Cr-1Mo base material. This work highlights the solidification reaction and microsegregation of major alloying elements. Solidification cracks were due to the wide solidification temperature range and formation of interdendritic γ and Laves phases.

In light of the work done by Cieslak, the hot cracking of the Alloy 625 buttering on the 400 series stainless steel would be exacerbated with the increase of C and Si from the 400 stainless steel hub material. Work by Patterson and Milewski (Reference 9) on welding Alloy 625 to 304L stainless steel, autogenously with the GTA welding process, showed increased susceptibility of hot cracking. It was found that cracking susceptibility was due to segregation of S, P, and Nb to an interdendritic phase which had cracked. The cracking occured in the 304L enriched weld zone as compared to an Alloy 625 rich weldment which would be less susceptible to cracking. This reference can be used to substantiate a similar cracking phenomenon that could occur in the 400 series SST weld with Alloy 625.

Finally, in order to ensure that any untempered martensite was tempered, the buttered 400 series SST material must undergo a heat treatment of 1350°F. The Alloy 625 filler material is age hardenable. The concern is that the buttered portion will age harden during the heat treatment cycle and therefore increase the strength of the buttered zone, which will potentially increase the propensity for cracking.

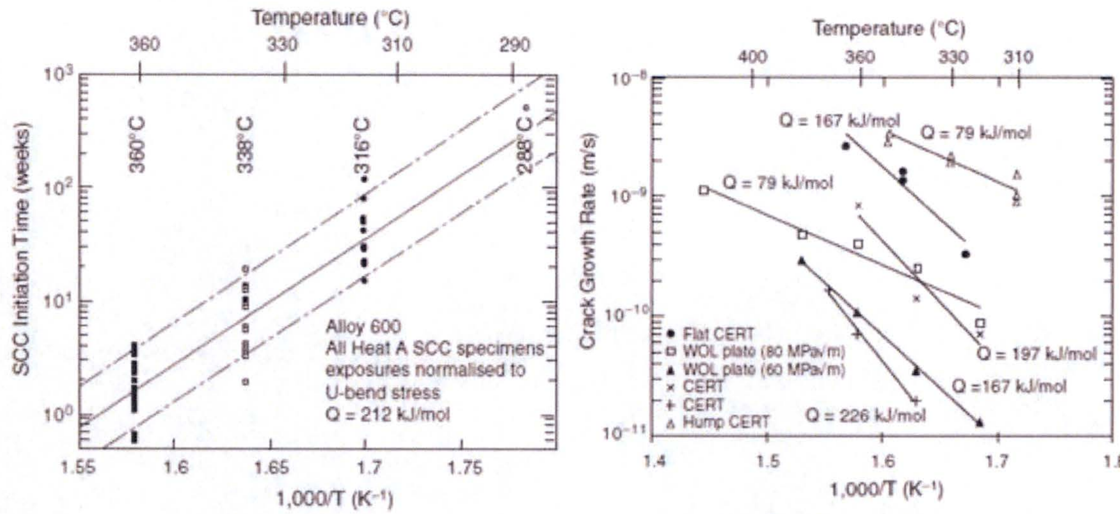
All of the cited research identified supports the rationale why CW-EMD developed and qualified the use of ERNiCr-3 weld filler material to butter the 400 series martensite SST base material. Buttering with the ERNiCr-3 weld filler material on the martensitic SST flywheel inner hub provides a consistent nickel, chromium, iron, carbon traditional microstructure that requires a post weld heat treatment to temper any untampered martensite formed in the heat affected zone. This heat treatment does not deleteriously affect or impact the microstructure of the buttered ERNiCr-3, which has the potential to occur with the use of an alternate material.

3.3 Stress Corrosion Cracking

CW-EMD understands that a number of PWR plant components have experienced instances of primary water stress corrosion cracking (PWSCC) in Alloy 600 base metal and related weld metals such as ENiCrFe-3. These have included steam generator tubing, reactor vessel nozzle welds, and control rod drive mechanism (CRDM) nozzles, where some of the most highly affected primary water system components have been those at hot leg temperatures in the vicinity of 600°F. It has been reported in the technical literature (References 10 and 11) that PWSCC has not been observed below 250°C (482°F), indicating 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. The maximum temperature experienced by the flywheels under steady state operating conditions in the RCP is 260°F, occurring at the top of the upper flywheel, which is below the 482°F threshold temperature for PWSCC susceptibility.

Early testing of PWSCC in Alloy 600 concentrated on the crack initiation of the Alloy 600 base metal with some crack growth rate testing also conducted. Two examples of published test data are shown in Figure 3 and 4. All of the data in these studies and most others are at temperatures well above that associated with the AP1000 RCP flywheel. The data in the two figures are shown in Arrhenius plots in which the abscissa is the inverse of absolute temperature. Recognizing that extrapolating the data trends to lower temperatures is an approximation, but the result of such an extrapolation is still instructive. If the mean crack initiation time line in Figure 3 is extrapolated to 260°F, the predicted time to crack initiation is 4000 years. Extrapolating to the same temperature with the mean data line in Figure 4 produces a predicted crack initiation time of 11,000 years. These data strongly indicate that stress corrosion crack initiation is not expected in Alloy 600 flywheel material over the 60 year design life of the AP1000 RCP.



(a) Initiation time

(b) Crack growth rate

Figure 3: Arrhenius plot of stress corrosion crack initiation time and crack growth rate of Alloy 600 as a function of temperature from References 12 as reported in Reference 13.

The crack growth rate data for Alloy 600 in Figure 3 can also be extrapolated to 260°F. The highest growth rate at 260°F predicted from any of the data lines in the figure is 5×10^{-13} m /sec, or 6.21×10^{-4} in /yr, equivalent to 0.037 inch of crack growth in 60 years. Reference 15 discusses more recent data on the stress corrosion crack growth rate of the type 82/182 weld materials associated with Alloy 600 base material. An equation for crack growth rate as a function of stress intensity factor K and temperature, as well as other variables, is provided. At a temperature of 260°F, and an estimated upper bound stress intensity factor for the flywheel welds of 20 ksi$\sqrt{\text{in}}$ at steady-state conditions, the predicted crack growth rate is 6.20×10^{-7} in /yr, yielding a negligible amount of crack growth in 60 years. These sources indicate that an insignificant amount of stress corrosion crack growth is expected in the Alloy 600 type weld materials in the AP1000 RCP flywheel.

An exception to the above behavior may occur with the sensitized material condition and water contaminants such as certain sulfur compounds, where PWSCC can occur at lower temperatures. For the AP1000 flywheels, there are no thermal treatment conditions that would cause sensitization, so this concern is not present, and the PWR water chemistry requirements prohibit the levels of contaminants where PWSCC has been observed.

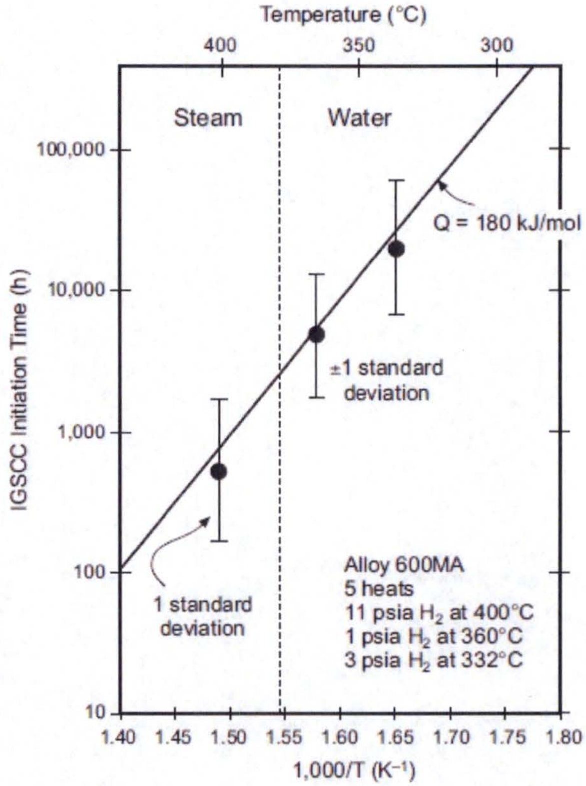


Figure 4: Arrehenius plot of stress corrosion crack initiation time of five heats of Alloy 600 as a function of temperature from Reference 14 as reported in Reference 13.

3.4 Low Temperature Crack Propagation

CW-EMD also evaluated the potential effect of the Low Temperature Crack Propagation (LTCP) phenomenon, despite the fact that it has been observed in the laboratory but not known to have occurred 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. The stress intensity factor (K) levels that can develop in the subject welds in service are thus important. Figure 5 is a plot of stress intensity factor as a function of crack depth in the AP1000 flywheel end plate to hub weld. The analysis assumes a semi-circular flaw at the outside surface of the weld and oriented across the minimum weld thickness of approximately 0.15 inch. The stress is assumed to have a value of 25.26 ksi and be uniform across the weld thickness and oriented perpendicular to the flaw plane. This stress is the maximum principal stress across the weld under the worst case transient of Recovery from Loss of Cooling Water. It is approximately twice the value of the corresponding maximum principal stress at steady-state conditions. The plot illustrates that the highest stress intensity factor is about 16 ksi√in when the flaw has extended across a large fraction of the weld thickness. This is a relatively low value of stress intensity factor and is compared with the LTCP toughness levels below.

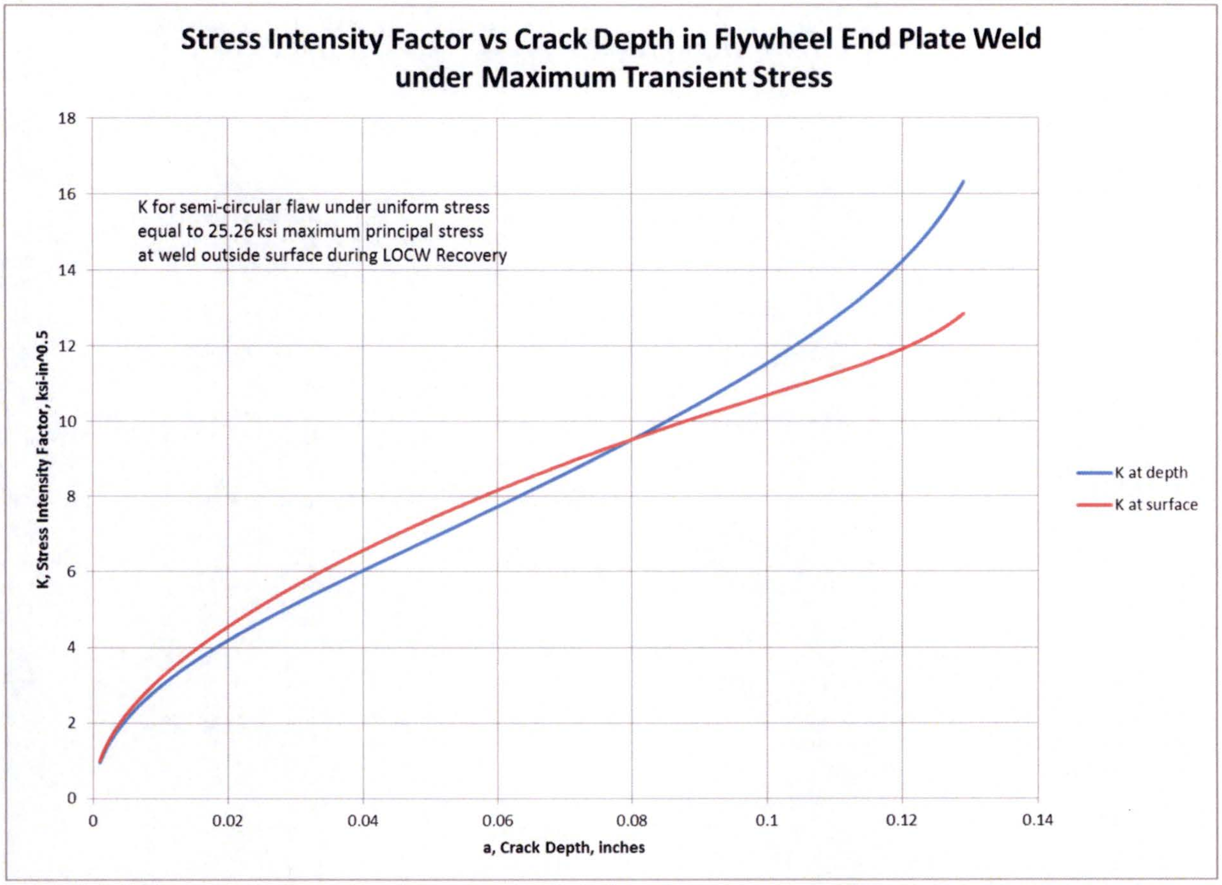


Figure 5: Stress intensity factor K as a function of crack depth in flywheel end plate to hub weld under maximum transient stress.

Table 1 contains a summary of LTCP data based on the results in References 16 through 22. The data cover a wide range of hydrogen concentration which has a strong effect on LTCP toughness. The hydrogen concentration range of approximately 20 to 80 cm^3 / kg H_2O covers operating and shutdown conditions in the reactor coolant system. Over the hydrogen concentration range of 15 to 100 cm^3 / kg H_2O in Table 1, the minimum toughness is 40 kJ/m^2, equivalent to approximately 79 ksi√in. The maximum estimated stress intensity of 16 ksi√in in the weld under operating conditions is well below this LTCP toughness level. Thus LTCP cracking will not occur in the subject flywheel welds. Much higher stresses or hydrogen concentration levels would be required for LTCP to be a concern.

[redacted]

Table 1: Summary of Low Temperature Crack Propagation (LTCP) test results for Alloy 82 and 182 weld filler materials in water with different hydrogen concentrations.

Source	Material	Test Temp	Jq (kJ/m^2) Toughness Values at Hydrogen Content (cm^3 H_2/KgH_20)					
		°C	3-5	15	30	50	100	150
Ahonen	182	54			77 to 100, 175		40 to 70, 100	
Mills & Brown	82H	54		52 to 96, 182		41 to 102, 214		40 to 80
Mills & Brown	82H	93						
Mills & Brown	82H	121						80
Mills & Brown	82H	149						214,269
Mills & Brown		338						460 to 680
Herms	182	50	57.7					
Herms	182	80	80 to 126					
Herms	182	150	491					

4.0 Conclusion

CW-EMD recognizes the nuclear safety function of the flywheel assembly and its critical function in the AP1000 Reactor Coolant Pump. With respect to the use of Alloy 600 type filler metal 82 (ERNiCr-3) and welding electrode 182 (ENiCrFe-3) filler materials in the flywheel fabrication, CW-EMD performed an engineering evaluation that considered best practices, use of alternate materials, and the effect of the flywheel operating environment on stress corrosion cracking and low temperature crack propagation.

The material selections for the flywheel assembly, including the use of the ERNiCr-3 and ENiCrFe-3 weld filler materials, are based on sound engineering judgement and analysis. Additional considerations also include that CW-EMD has significant experience successfully using these materials in similar applications, that post-weld heat treatment of alternative weld filler metals could result in an inferior product, and that the operating environment of the flywheels is not conducive to stress corrosion cracking nor low temperature crack propagation.

CW-EMD has been deliberate in the design and fabrication of the AP1000 RCP flywheel to ensure that it is technically acceptable and will meet its critical function for the 60-year design basis of the RCP. Throughout the flywheel design process, CW-EMD was in communication

with Westinghouse, including discussions on material selections specific to weld filler materials. CW-EMD proceeded with the implementation of the AP1000 flywheel design on the basis of Westinghouse approval of weld procedures specific to the use of Alloy 600 type weld filler material for select weld joints on the flywheel assembly. The information herein provides detail of the engineering evaluation and technical justification that demonstrates suitability of the materials employed in the flywheel design for a 60 year design basis as well as meeting compliance with all requirements of the Westinghouse AP1000 Design Specification.

5.0 References

1. Curtiss-Wright EMD Letter WEM/DCP0416, "Use of Filler Metals with Nickel Alloy Material in AP1000 RCPs", March 4, 2009.
2. Westinghouse Letter DCP_WEM_000491, "Response to Curtiss-Wright EMD Letter WEM/DCP0447, "Revision to EMD Documentation on Use of Alloy 600 in AP1000 RCP", May 22, 2009.
3. APP-MP01-M2-001, Revision 5, "AP1000 Reactor Coolant Pump Design Specification" January 15, 2016.
4. APP-GW-VLR-010, Revision 1, "AP1000 Supplemental Fabrication and Inspection Requirements," Revision 1, May 11, 2010.
5. Drawing No. 6D71580, "Weld Map AP1000 RCP", Revision 4, January 6, 2017.
6. 13-APK-033, "Use of Alloy 82 Weld Filler Material (WEM-DCP-000677), April 10, 2013.
7. "The Welding and Solidification Metallurgy of Alloy 625", M.J. Cieslak, Welding Research Supplement, February, 1991, pp.49-s-56-s.
8. "Solidification of Alloy 625 Weld Overlay", J.N. DuPont, Metallurgical and Materials Transactions A, Volume 27A, November 1996, pp. 3612-3620.
9. "GTA Weld Cracking –Alloy 625 to 304L", R.A. Patterson and J.O. Milewski, Welding Research Supplement, August, 1985, pp. 227-s-231-s.
10. NUREG/CR-6721, "Effects of Alloy Chemistry, Cold Work, and Water Chemistry on Corrosion Fatigue and Stress Corrosion Cracking of Nickel Alloys and Welds", O.K. Chopra, W.K. Soppet, and W.J. Shack, ANL-01-07, 2001.
11. "Stress Corrosion Cracking in Light Water Reactors: Good Practices and Lessons Learned", IAEA Nuclear Energy Series No. NP-T-3.13, 2011.
12. T. B. Casagne, P. Combrade, M. A. Foucault and A. Gelpi, "The Influence of Mechanical and Environmental Parameters on the Crack Growth Behaviour of Alloy 600 in PWR Primary Water", 12th Scandinavian Corrosion Congress & Eurocar '92, pages 55 – 67, Espoo, Finland, May 1992.
13. F. Leonard, "Study of Stress Corrosion Cracking of Alloy 600 in High Temperature High Pressure Water", Ph.D. Thesis, University of Manchester, 2010.

14. G. Economy, R. J. Jacko and F. W. Pement, "IGSCC Behavior of Alloy 600 Steam Generator Tubing in Water or Steam Tests above 360 °C", Corrosion, Volume 43, pages 727 – 734, December 1987.

15. J. Gorman, S. Hunt, P. Riccardella and G.A. White, "PWR Reactor Vessel Alloy 600 Issues", Companion Guide to the ASME Code, Third Edition, Volume 3, pages 63 – 87, 2009.

16. "Effect of microstructure on low temperature hydrogen induced cracking behavior of nickel-based alloy weld metals" Ahonen, Matias, Thesis Aalto University Espoo, Finland 2015 also VTT Science 105 VTT Finland.

17. "Low Temperature Crack Propagation (LTCP) Susceptibility of Nickel-based Alloy 182, 152 and 52 Weld Metals in PWR Primary Water" Ahonen, M., Ehrnsten, U., Todoschenki, O., and Hanninen, H. in "16th International Conference on Environmental Degradation of Material in Nuclear Power Systems – Water Reactors", Asheville NC (2013) USA Omnipress CD.

18. "Fracture Behavior of Nickel Base Alloys in Water" Mills, W.J. and Brown, C. M., in "9th International Conference on Environmental Degradation of Material in Nuclear Power Systems – Water Reactors", TMS (1999).

19. "Load Path Effects on the Fracture Toughness of Alloy 82H and 52 Welds in Low Temperature Water", Brown, C.M., and Mills, W.J., "12th International Conference on Environmental Degradation of Material in Nuclear Power Systems – Water Reactors", TMS (2005).

20. "Effect of Defect Acuity on the Fracture Toughness of Alloy 80H and 52 Welds in Low Temperature Water ", Brown, C.M., and Mills, W.J., "13th International Conference on Environmental Degradation of Material in Nuclear Power Systems – Water Reactors", CNS-CSN (2007).

21. "LTCP of Alloy 182/152 tested in PWR Primary Water" Herms, E., Raquet, O., De Curieres, I., and Joly, P. in in "14th International Conference on Environmental Degradation of Material in Nuclear Power Systems – Water Reactors", Asheville NC (2009) USA Omnipress CD.

22. "Low Temperature Crack Propagation Evaluation in Pressurized Water Reactor Service", Demma, A., McIlree, A., and Herrera, M., in., "12th International Conference on Environmental Degradation of Material in Nuclear Power Systems – Water Reactors", TMS (2005).

Prepared by:

Robert O. Kiesow, Ph.D.
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Curtiss-Wright Corporation, EMD

Reviewed by:

Ross R. Klein
Manager, Stress and Thermal Analysis
Curtiss-Wright Corporation, EMD

WESTINGHOUSE

PROCUREMENT ADVISORY RELEASE

PAR NO	PAGE	LTR IN NO	ISSUE DATE
4500265132-576-0	1 of 14		5/26/2017

ATTACHMENT	LTR IN NO	RESUBMITTAL DATE
4500265132-576-0.pdf	EMD-U601-0721	N/A

TO:

Curtiss Wright Electro-Mechanical Corp

1000 Wright Way
Cheswick, PA, 15024

FROM:

Westinghouse Electric Company

New Plants & Major Projects

1000 Westinghouse Drive

Cranberry Township, PA 16066

The purpose of this PAR is to provide disposition of the following document.

TITLE: Technical Justification for Use of Alloy 600 Type Weld Filler Material on AP1000 Reactor Coolant Pump Flywheels

SUPPLIER'S DOCUMENT NO.: 17-APK-007

SUPPLIER'S DOCUMENT REVISION: 05/23/17

SUPPLIER'S JOB NO:

SUBMITTED FOR: Engineering and Quality

WESTINGHOUSE DISPOSITION: Approved

Supplier Instructions: When a resubmittal is required in accordance with comments below, Supplier may need to edit or mark up previously submitted documents. At a minimum, the resubmittal must include information from Supplier that clearly identifies the additional edits or mark-up and specifies how the comments below have been addressed.

If in the opinion of Supplier the instructions contained in the PAR will involve an increase in the Purchase Price, a delay in delivery of the Work or other change in the Work, Supplier shall not proceed with the affected Work, but shall immediately notify Westinghouse Global Nuclear Supply Chain at the above address.

Action taken by Westinghouse in regard to any Supplier submittal or resubmittal neither relieves Supplier of responsibility or to comply with any obligations under the Purchase Agreement, nor authorizes and increase in the Purchase Price or delay of the Work.

WESTINGHOUSE

PROCUREMENT ADVISORY RELEASE

PAR NO	**PAGE**		**ISSUE DATE**
4500265135-551-0	1 of 14		5/26/2017
ATTACHMENT		**LTR IN NO**	**RESUBMITTAL DATE**
4500265135-551-0.pdf		EMD-U600-0739	N/A

TO:

Curtiss Wright Electro-Mechanical Corp

1000 Wright Way
Cheswick, PA, 15024

FROM:

Westinghouse Electric Company

New Plants & Major Projects

1000 Westinghouse Drive

Cranberry Township, PA 16066

The purpose of this PAR is to provide disposition of the following document.

TITLE: Technical Justification for Use of Alloy 600 Type Weld Filler Material on AP1000 Reactor Coolant Pump Flywheels

SUPPLIER'S DOCUMENT NO.: 17-APK-007

SUPPLIER'S DOCUMENT REVISION: 05/23/17

SUPPLIER'S JOB NO:

SUBMITTED FOR: Engineering and Quality

WESTINGHOUSE DISPOSITION: Approved

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Clarification to CW-EMD Response to NON 99901383/2016-201-2

NRC letter dated September 15, 2017 (Reference 3) states the following with respect to NON 99901383/2016-201-2:

2. Your follow-up response to NON 99901383/2016-201-02 failed to address an area of concern to the NRC staff. Specifically, in pages 4-6 and 4-7, the response states, in part, that for [R.L. Holliday (RLH)] sub-supplier accreditation, RLH uses two sub-suppliers that are accredited to ISO/IEC 17025:2005 for the calibration of test electrical equipment and test block standards for non-destructive examination equipment. The response also states, in part, "Having successfully completed the NRC-endorsed American Association of Laboratory Accreditation (A2LA) evaluation process, Trescal and West Penn Testing Group hold accreditation to perform..." The NRC's position on the use of the International Laboratory Accreditation Cooperation (ILAC) process for procurement of calibration and testing services is that it may only be used by the dedicating entity in lieu of performing a commercial-grade survey as part of the commercial-grade dedication process provided certain conditions are met. As such, since RLH is not the dedicating entity, CW-EMD cannot take credit for RLH's use of the ILAC accreditation process to demonstrate that RLH provided adequate oversight of their suppliers. Describe what additional actions CW-EMD is planning to implement to ensure that RLH is providing adequate oversight of its sub-suppliers.

CW-EMD Response:

CW-EMD acknowledges and understands the NRC's position regarding the use of the ILAC process for procurement of calibration and testing services and that it may only be used by the dedicating entity in lieu of performing a commercial-grade survey as part of the commercial-grade dedication process provided certain conditions are met. Furthermore, CW-EMD acknowledges and understands that RLH is not a 10CFR50 App B supplier and therefore, is not able to perform commercial grade dedication activities.

The information regarding the NRC's endorsement of the ILAC process was included in the prior response (QA-2017-019, dated August 30, 2017) to provide insight into the reasoning and to provide additional information as one part of the overall objective evidence that the CW-EMD ASME NQA-1 Qualified Lead Auditor used to determine that the supplier controls used by RLH were sufficient and reasonable for the intended application. More specifically, RLH was utilizing suppliers that were accredited by an external agency (ILAC), which demonstrates a certain level of capability and proficiency with a full understanding that the accreditation could not be utilized in place of a commercial grade survey since RLH is a commercial supplier and does not have a 10CFR50 App B program.

CW-EMD plans to require via purchase order that RLH submit a sub-supplier list to CW-EMD for review and acceptance prior to conducting work in order to ensure that RLH is providing adequate oversight of its sub-suppliers.