



UNITED STATES
NUCLEAR REGULATORY COMMISSION
WASHINGTON, D.C. 20555-0001

July 21, 2017

Mr. Daniel G. Stoddard
Senior Vice President and Chief Nuclear Officer
Innsbrook Technical Center
5000 Dominion Blvd.
Glen Allen, VA 23060

SUBJECT: NORTH ANNA POWER STATION, UNITS 1 AND 2 - PROPOSED INSERVICE
INSPECTION ALTERNATIVES N1-I4-NDE-008 AND N2-I4-NDE-003 (CAC
NOS. MF8171 AND MF8172)

Dear Mr. Stoddard:

By letter dated July 27, 2016, as supplemented by letter dated November 22, 2016 (Agencywide Documents Access and Management System Accession Nos. ML16215A192 and ML16333A007, respectively), Virginia Electric and Power Company (Dominion, the licensee), submitted requests to the U.S. Nuclear Regulatory Commission (NRC) for the use of proposed alternatives to certain inservice inspection (ISI) interval requirements of the American Society of Mechanical Engineers Boiler and Pressure Vessel Code (ASME Code), Section XI, Paragraph IWB-2412, "Inspection Program B," for North Anna Power Station (NAPS), Units 1 and 2. Inspection Program B requires volumetric examination of essentially 100 percent of reactor pressure-retaining welds identified in Table IWB-2500-1 once each 10-year interval.

Specifically, pursuant to Title 10 of the *Code of Federal Regulations* (10 CFR), Part 50.55a(z)(1), the licensee requested approval for the use of proposed alternatives N1-I4-NDE-008 and N2-I4-NDE-003, to extend the inspection interval for certain reactor vessel pressure retaining welds from 10 years to 20 years on the basis that the alternatives provide an acceptable level of quality and safety.

The NRC staff has reviewed the subject request and concludes, as set forth in the enclosed safety evaluation, that the proposed alternatives will provide an acceptable level of quality and safety. Pursuant to 10 CFR 50.55a(z)(1), the staff authorizes the use of the proposed alternatives extending the fourth ISI intervals for the examination of the specified welds until April 30, 2029 for NAPS, Unit 1, and December 13, 2030 for NAPS, Unit 2, respectively. The required examinations of the subject components shall be conducted prior to the end of the extended fourth 10-year ISI intervals, in accordance with the appropriate ASME Code requirements associated with the those intervals.

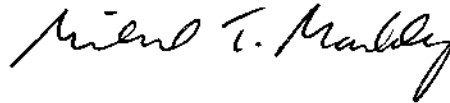
All other ASME Code requirements for which alternatives or relief was not specifically requested and approved in the subject request remain applicable.

D. Stoddard

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If you have any questions, please contact the Project Manager, Randy Hall, at 301-415-4032 or via e-mail at Randy.Hall@nrc.gov.

Sincerely,

A handwritten signature in black ink, appearing to read "Michael T. Markley". The signature is written in a cursive style with a large, sweeping initial "M".

Michael T. Markley, Chief
Plant Licensing Branch II-1
Division of Operating Reactor Licensing
Office of Nuclear Reactor Regulation

Docket Nos. 50-338 and 50-339

Enclosure:
Safety Evaluation

cc w/encl: Distribution via Listserv



UNITED STATES
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SAFETY EVALUATION BY THE OFFICE OF NUCLEAR REACTOR REGULATION
REQUEST FOR ALTERNATIVES TO IMPLEMENT EXTENDED REACTOR VESSEL
FOURTH INSERVICE INSPECTION INTERVALS
VIRGINIA ELECTRIC AND POWER COMPANY
NORTH ANNA POWER STATION, UNITS 1 AND 2
DOCKET NOS. 50-338 AND 50-339

1.0 INTRODUCTION

By letter dated July 27, 2016, as supplemented by letter dated November 22, 2016 (Agencywide Documents Access and Management System (ADAMS) Accession No. ML16215A192 and ML16333A007 respectively), Virginia Electric and Power Company (Dominion, the licensee), submitted requests N1-I4-NDE-008 and N2-I4-NDE-003 which proposed alternatives to the inservice inspection (ISI) interval requirements of the American Society of Mechanical Engineers Boiler and Pressure Vessel Code (ASME Code), Section XI, Paragraph IWB-2412, "Inspection Program B," for the North Anna Power Station (NAPS), Units 1 and 2. Inspection Program B requires volumetric examination once each 10-year interval of essentially 100 percent of reactor vessel pressure-retaining welds identified in Table IWB-2500-1, Examination Categories B-A, "Pressure Retaining Welds in Reactor Vessel," and B-D, "Full Penetration Welded Nozzles in Vessels."

Pursuant to Title 10 of the *Code of Federal Regulations* (10 CFR), Part 50.55a(z)(1), the licensee requested the use of the proposed alternatives to extend certain required examinations of the NAPS, Units 1 and 2 reactor vessel pressure-retaining welds from 10 years to 20 years for their respective fourth ISI inspection intervals, on the basis that the alternatives provide an acceptable level of quality and safety. The current fourth 10-year ISI intervals for NAPS, Units 1 and 2, are scheduled to end on April 30, 2019, and December 13, 2020, respectively. The licensee's proposed alternatives would allow for the deferral of the subject examinations for up to an additional 10 years, no later than April 30, 2029, and December 13, 2030, respectively.

2.0 REGULATORY EVALUATION

2.1 Regulations and Guidance

Systems and components of boiling and pressurized water-cooled nuclear power reactors must meet the ISI requirements of the ASME BPV Code as specified in 10 CFR 50.55a(g). The ISI of ASME Code Class 1, 2, and 3 components is performed in accordance with Section XI of the ASME Code and applicable addenda as a way to detect anomaly and degradation indications so that structural integrity of these components can be maintained. Pursuant to

10 CFR 50.55a(g)(4), components (including supports) that are classified as ASME Code Class 1, Class 2, and Class 3 must meet the requirements, except design and access provisions and preservice examination requirements, set forth in Section XI of editions and addenda of the ASME Code, that become effective subsequent to editions specified in paragraphs (g)(2) and (3) of this section, to the extent practical within the limitations of design, geometry, and materials of construction of the components. The regulations require that inservice examination of components and system pressure tests conducted during the successive 120-month inspection intervals (following the initial 120-month inspection interval) must comply with the requirements in the latest edition and addenda of the ASME Code, which was incorporated by reference in 10 CFR 50.55a(a), 12 months before the start of the 120-month interval [or the optional ASME Code Cases listed in U.S. Nuclear Regulatory Commission (NRC) Regulatory Guide (RG) 1.147, Revision (Rev.) 17, subject to the conditions listed in 10 CFR 50.55a(b)].

For the fourth 10-year ISI intervals at NAPS, Units 1 and 2, the Code of record for the inspection of ASME Code Class 1, 2, and 3 components is the 2004 Edition of the ASME Code, Section XI, with no addenda. Paragraph 10 CFR 50.55a(z) states that alternatives to the requirements of paragraphs (b) through (h) of 10 CFR 50.55a or portions thereof may be used, when authorized by the Director, Office of Nuclear Reactor Regulation. A proposed alternative must be submitted and authorized prior to implementation. The applicant or licensee must demonstrate that: (1) the proposed alternative would provide an acceptable level of quality and safety; or (2) compliance with the specified requirements of this section would result in hardship or unusual difficulty without a compensating increase in the level of quality and safety.

RG 1.99, Rev. 2, "Radiation Embrittlement of Reactor Vessel Materials," (ADAMS Accession No. ML003740284) describes methods acceptable to the staff for calculating the effects of neutron radiation embrittlement of the low-alloy steels currently used for light-water-cooled reactor pressure vessels (RPVs).

RG 1.174, Rev. 1, "An Approach for Using Probabilistic Risk Assessment in Risk-Informed Decisions on Plant-Specific Changes to the Licensing Basis," (ADAMS Accession No. ML023240437) describes a risk-informed approach, acceptable to the NRC, for assessing the nature and impact of proposed licensing basis changes by considering engineering issues and applying risk insights.

2.2 Background

The ISI of Categories B-A and B-D components consists of visual and ultrasonic examinations intended to discover whether new flaws have initiated, whether pre-existing flaws have extended, and whether pre-existing flaws may have been missed in prior examinations. These examinations are required to be performed at regular intervals, as defined in Section XI of the ASME Code.

2.3 Summary of WCAP-16168-NP-A, Rev. 2

By letter dated May 8, 2008 (ADAMS Accession No. ML081060045), the NRC staff issued a final safety evaluation (SE) which found that topical report WCAP-16168-NP, Revision 2 (the WCAP), "Risk-Informed Extension of the Reactor Vessel In-Service Inspection Interval," is acceptable for referencing in licensing applications for pressurized water reactors (PWRs) designed by Westinghouse Electric Company (Westinghouse), Combustion Engineering, Inc., and Babcock and Wilcox, Inc. (B&W).

In June 2008, the Pressurized Water Reactor Owners Group (PWROG) issued the NRC-approved report, incorporating the staff SE, as WCAP-16168-NP-A, Rev. 2. This WCAP was developed to support a risk-informed assessment of extensions to the ISI intervals for ASME Code, Section XI, Examination Category B-A and B-D components, from 10 to 20 years using data from three different PWR plants (referred to as the pilot plants) representing each of the vendors.

The analyses in the WCAP used probabilistic fracture mechanics tools and inputs from the work described in NUREG-1806, "Technical Basis for Revision of the Pressurized Thermal Shock (PTS) Screening Limit in the PTS Rule (10 CFR 50.61): Summary Report" (ADAMS Accession No. ML061580318) and NUREG-1874, "Recommended Screening Limits for Pressurized Thermal Shock (PTS)," March 1, 2007 (ADAMS Accession No. ML070860156). The PWROG analyses incorporated the effects of fatigue crack growth and ISI data. Design basis transient data was used as an input for the fatigue crack growth evaluation. The effects of ISI data were modeled consistently with the previously-approved probabilistic fracture mechanics codes contained in WCAP-14572, Revision 1-NP-A, "Westinghouse Owners Group Application of Risk-Informed Methods to Piping Inservice Inspection Topical Report," (ADAMS Accession Nos. ML012630349 and ML012630327) and Supplement 1, "Westinghouse Structural Reliability and Risk Assessment (SRRA) Model for Piping Risk Informed Inservice Inspection (ADAMS Accession No. ML012630313). These effects were inputs into the evaluations performed with the "Fracture Analysis of Vessels - Oak Ridge (FAVOR)" computer code. All other inputs were identical to those used in the PTS risk re-evaluation underlying 10 CFR 50.61a, "Alternative Fracture Toughness Requirements for Protection against Pressurized Thermal Shock Events."

The PWROG concluded, as a result of these studies, that the ASME Code, Section XI, 10-year ISI interval for Examination Category B-A and B-D components in PWR RPVs can be safely extended from 10 to 20 years. This conclusion, based on the results from the pilot plant analyses, was considered to apply to any plant designed by the three PWR vendors represented in the pilot plant study, as long as certain critical plant-specific criteria (defined in Appendix A of the WCAP) are bounded by the analysis for the applicable pilot plant.

2.4 Summary of NRC Safety Evaluation for WCAP-16168-NP-A, Rev. 2

The NRC staff issued a second SE, dated July 26, 2011 (ADAMS Accession No. ML111600303) superseding the initial SE in the WCAP, which addressed the PWROG's request for clarification of the information needed in applications utilizing the WCAP. In this SE, the staff concluded that the methodology presented in the WCAP is consistent with the guidance provided in RG 1.174, Rev. 1, and is acceptable for referencing in requests to implement alternatives to ASME Code inspection requirements for PWR plants in accordance with the limitations and conditions specified in the SE. In addition to showing that the subject plant parameters and inspection history are bounded by the critical parameters identified for the pilot plants in Appendix A in the WCAP, licensees that submit a request for an alternative based on the WCAP need to submit certain plant-specific information, including:

1. Licensees must demonstrate that the embrittlement of their RPV is within the envelope used in the supporting analyses. Licensees must provide the 95th percentile [total through-wall cracking frequency ($TWCF_{TOTAL}$)] and its supporting material properties at the end of the period in which the relief is requested to extend the ISI from 10 to 20 years. The 95th percentile $TWCF_{TOTAL}$ must be calculated using the methodology in NUREG-1874. The RT_{MAX-X} and the shift in the Charpy transition temperature produced by irradiation defined at the 30 ft-lb energy level, ΔT_{30} , must

be calculated using the methodology documented in the latest revision of RG 1.99, "Radiation Embrittlement of Reactor Vessel Materials," or other NRC-approved methodology. [RT_{MAX-X} is the material property which characterizes the reactor vessel's resistance to fracture initiating from flaws in plates (RT_{MAX-PL}), forgings (RT_{MAX-FO}), axial welds and circumferential welds ($RT_{MAX-AW/CW}$)].

2. Licensees must report whether the frequency of the limiting design basis transients during prior plant operation are less than the frequency of the design basis transients identified in the PWROG fatigue analysis that are considered to significantly contribute to fatigue crack growth.
3. Licensees must report the results of prior ISI of RPV welds and the proposed schedule for the next 20-year ISI interval. The 20-year inspection interval is a maximum interval. In its request for an alternative, each licensee shall identify the years in which future inspections will be performed. The dates provided must be within plus or minus one refueling cycle of the dates identified in the implementation plan provided to the NRC in PWROG letter OG-10-238 [(ADAMS Accession Number ML11153A033)].
4. Licensees with B&W plants must (a) verify that the fatigue crack growth of 12 heat-up/cool-down transients per year that was used in the PWROG fatigue analysis bounds the fatigue crack growth for all of its design basis transients; and (b) identify the design bases transients that contribute to significant fatigue crack growth.
5. Licensees with RPVs having forgings that are susceptible to underclad cracking and with RT_{MAX-FO} values exceeding 240 °F must submit a plant-specific evaluation to extend the inspection interval for ASME Code, Section XI, Category B-A and B-D RPV welds from 10 to a maximum of 20 years because the analyses performed in the [WCAP] are not applicable.
6. Licensees seeking second or additional interval extensions shall provide the information and analyses requested in Section (e) of 10 CFR 50.61a.

WCAP-16168-NP-A, Rev. 3, which contains this SE for the WCAP, was issued in October 2011 (ADAMS Accession Number ML11306A084, referred to as the WCAP-A in the rest of this SE).

3.0 TECHNICAL EVALUATION

3.1 Licensee's Proposed Alternatives

3.1.1 Description of Proposed Alternatives

The licensee proposes to extend the fourth inspection intervals from 10 to 20 years for certain reactor pressure vessel welds, to allow the ASME Code required Categories B-A and B-D examinations to be deferred for NAPS, Unit 1 until the fall of 2028, and for NAPS, Unit 2 until the fall of 2029. These proposed ISI dates are not consistent with the schedule proposed in PWROG Letter OG-10-238, the latest NRC staff-reviewed implementation plan for the PWROG plants. This deviation from the implementation plan is discussed in Section 3.2 of this SE.

3.1.2 Components for Which Relief is Requested

The affected components are the NAPS, Unit 1 and NAPS, Unit 2 RPVs. The following examination categories and item numbers from IWB-2500 and Table IWB-2500-1 of the ASME Code, Section XI, are addressed in this request:

Examination Category	Item Number	Description
B-A	B1.10	Shell Welds
B-A	B1.11	Circumferential Shell Welds
B-A	B1.20	Head Welds
B-A	B1.21	Circumferential Head Welds
B-A	B1.22	Meridional Head Welds
B-A	B1.30	Shell-to-Flange Weld
B-A	B1.40	Head-to-Flange Weld
B-D	B3.90	Nozzle-to-Vessel Welds
B-D	B3.100	Nozzle Inside Radius Section

3.1.3 Basis for Proposed Alternative

The licensee stated that the methodology used to demonstrate the acceptability of extending the inspection interval for the Examination Category B-A and B-D RPV welds is based on that defined in the WCAP-A. This report focuses on risk assessments of materials within the beltline region of the RPV wall. Plant-specific parameters for NAPS are summarized in Tables 1-3 of Attachment 1 (for Unit 1) and Tables 1-3 of Attachment 2 (for Unit 2) to the licensee's letter dated July 27, 2016. The format of the information is patterned after that found in Appendix A of the WCAP-A. Deferral of the required volumetric examinations of the NAPS, Unit 1 and Unit 2 reactor vessel welds will result in a reduction in occupational radiation exposure and examination costs.

The licensee concluded that both NAPS units are bounded by the Westinghouse pilot plant analysis in the WCAP-A, thus the risk criteria in RG 1.174 are satisfied, and therefore, the use of this proposed alternative will provide an acceptable level of quality and safety. Accordingly, the licensee requested that the NRC authorize the requested alternatives N1-I4-NDE-008 and N2-I4-NDE-003, pursuant to 10 CFR 50.55a(z)(1).

3.1.4 Duration of Proposed Alternatives

The licensee's proposed alternatives N1-I4-NDE-008 and N2-I4-NDE-003 would extend the duration of the fourth 10-year ISI interval for the above ASME Code, Section XI, Examination Category B-A and B-D components until April 30, 2029 for NAPS, Unit 1, and until December 13, 2030 for NAPS, Unit 2, respectively. The licensee stated that it will perform the required examinations in the fall of 2028 for NAPS, Unit 1 and in the fall of 2029 for NAPS, Unit 2.

3.2 NRC Staff Technical Evaluation

The NRC reviewed the licensee's proposal to extend the NAPS, Units 1 and 2 ISI intervals in order to determine whether the licensee met the risk-informed criteria set forth in the WCAP-A

for a Westinghouse plant. By showing that NAPS, Units 1 and 2 are bounded by the Westinghouse pilot plant analysis with respect to the six criteria discussed in Section 2.4 of this SE, the licensee would have a sufficient technical basis for extending the ISI in accordance with the provisions of the WCAP-A. Both NAPS units have a single layer cladding and are bounded by the Westinghouse pilot plant basis.

Table 3 of Attachments 1 and 2 provided the TWCF of the limiting forging and circumferential welds of NAPS, Units 1 and 2, along with the parameters necessary to perform the calculations. The licensee utilized the methodology provided in RG 1.99, Rev. 2 to calculate the ΔT_{30} . The licensee reported a $TWCF_{95-TOTAL}$ of 1.56×10^{-11} per year for Unit 1 and 1.97×10^{-10} per year for Unit 2. The NRC staff performed independent calculations and confirmed the licensee's reported values are correct. These $TWCF_{95-TOTAL}$ values are below the Westinghouse pilot plant bounding value of 1.76×10^{-8} per year; therefore, the staff finds the $TWCF_{95-TOTAL}$ values for NAPS, Units 1 and 2 acceptable, and the first criterion from WCAP-A, as stated in Section 2.4 is met.

With regard to the frequency and severity of design basis transients, the licensee was required to show that the number of heatup/cooldown transients for NAPS, Units 1 and 2 are bounded by that of the Westinghouse pilot plant basis (7 heatup/cooldown cycles per year). By letter dated November 22, 2016, the licensee stated that data as of November 3, 2016, indicate that Unit 1 has had a total of 58 heatups and 57 cooldowns of the reactor coolant system (RCS), and Unit 2 has had a total of 54 heatups and 53 cooldowns of the RCS. These values are well below the 7 heatup/cooldown cycle per year threshold; therefore, the staff agrees that the frequency of the limiting design basis transients during prior plant operation is less than the frequency of the Westinghouse design basis transients identified in the PWROG fatigue analysis, and the second criterion cited in Section 2.4 is met.

The licensee stated that three complete 10-year ISIs have been performed on both NAPS, Unit 1 and NAPS, Unit 2 to date. During the most recently completed ISI of NAPS, Unit 1, four subsurface indications were discovered in the intermediate shell to lower shell circumferential weld seam, identified as item 5 in Table 3 of Attachment 1 to the licensee's submittal. The licensee stated that all four indications were found to be acceptable per Table IWB-3510-1 of the ASME Code, Section XI, and none of the indications lie within the inner $1/10^{\text{th}}$ or 1 inch of the reactor vessel thickness; therefore the indications are acceptable per the requirements of 10 CFR 50.61a. The most recently completed ISI of NAPS, Unit 2 identified nineteen subsurface indications in the bellline region. Specifically, the nineteen subsurface indications were located in the intermediate shell to lower shell circumferential weld seam, which is identified as item 5 in Table 3 of Attachment 2 to the licensee's submittal. These indications were also found acceptable per Table IWB-3510-1 of the ASME Code, Section XI and none of the indications lie within the inner $1/10^{\text{th}}$ or 1 inch of the reactor vessel thickness; therefore the indications are acceptable per the requirements of 10 CFR 50.61a.

The NAPS, Unit 1 fourth ISI of the reactor vessel full penetration pressure-retaining Examination Category B-A and B-D welds is currently scheduled to be performed during the spring 2018 refueling outage, preceding the end of the fourth 10-year ISI interval, scheduled for April 30, 2019. The licensee proposed to perform the fourth volumetric examinations during the fifth ISI interval for NAPS, Unit 1 in the fall of 2028, prior to the end of that interval on April 30, 2029. The NAPS, Unit 2 fourth ISI of the reactor vessel full penetration pressure-retaining Examination Category B-A and B-D welds is currently scheduled to be performed during the fall 2020 refueling outage, preceding the end of the fourth 10-year ISI interval, scheduled for December 13, 2020. The licensee proposed to perform the fourth volumetric examinations

during the fifth ISI interval for NAPS, Unit 2 in the fall of 2029, prior to the end of that interval on December 13, 2030. The proposed dates are not consistent with the PWROG letter OG-10-238 because that letter reflects no implementation of the extended ISI interval. However, the proposed dates are consistent with a 10-year ISI interval extension, therefore, the staff finds the dates acceptable. Furthermore, it must be noted that the application of WCAP-A allows for an extension of the current ISI interval from 10 to 20 years, not a deferral of the required volumetric examinations to the next ISI interval. Even though the dates proposed by the licensee are acceptable, the examinations should be conducted in accordance with the ASME Section XI requirements that are applicable during the fourth 10-year ISI interval. The staff finds that the licensee has satisfactorily addressed the third criterion of WCAP-A, as cited in Section 2.4.

NAPS, Units 1 and 2 are both Westinghouse plants, therefore, the 4th criterion related to the bounding fatigue crack growth for all design basis transients and identification of design basis transients that contribute to significant fatigue crack growth in B&W plants is not applicable.

The 5th criterion stated in Section 2.4 requires that plants with forgings that are susceptible to underclad cracking and with RT_{MAX-FO} values exceeding 240 °F must submit a plant-specific evaluation to extend the inspection interval because the analyses performed in the WCAP-A are not applicable. Since the RT_{MAX-FO} values calculated for NAPS, Units 1 and 2 do not exceed 240 °F, this criterion is not applicable.

Lastly, the licensee is not currently seeking additional interval extensions, so the 6th and final criterion is not applicable.

In summary, the licensee's submittal demonstrated that the RPVs for NAPS, Units 1 and 2 are bounded by the Westinghouse limitations set forth in the WCAP-A and the associated SE from the NRC staff. The licensee adequately confirmed that the NAPS, Unit 1 and Unit 2 RPVs meet all of the applicable criteria set forth in the WCAP-A.

4.0 CONCLUSION

The NRC staff has completed its review of proposed alternatives N1-I4-NDE-008 and N2-I4-NDE-003 for NAPS, 1 and 2, respectively. The staff concludes that extending the fourth ISI interval for the specified Categories B-A and B-D components from 10 to 20 years will result in no appreciable increase in risk. This conclusion is based on the fact that the NAPS, Units 1 and 2 RPV plant-specific information is bounded by the data in the WCAP-A, and that the request meets all of the conditions and limitations set forth in the NRC staff's January 26, 2011, safety evaluation of the WCAP-A. Therefore, extension of the fourth ISI intervals from 10 to 20 years for the subject components for NAPS Units 1 and 2 will provide an acceptable level of quality and safety. Pursuant to 10 CFR 50.55a(z)(1), the staff authorizes the use of the proposed alternatives extending the fourth ISI intervals for the examination of the specified welds until April 30, 2029 for NAPS Unit 1, and December 13, 2030 for NAPS Unit 2, respectively. The examinations of the Category B-A and B-D components for NAPS Units 1 and 2 shall be conducted prior to the end of the extended fourth 10-year ISI intervals, in accordance with the appropriate ASME Code requirements associated with the those intervals.

All other requirements of the ASME Code, Section XI, not specifically included in the request for the proposed alternatives, remain in effect.

Principal Contributor: Austin Young

SUBJECT: NORTH ANNA POWER STATION, UNITS 1 AND 2 - PROPOSED INSERVICE INSPECTION ALTERNATIVES N1-I4-NDE-008 AND N2-I4-NDE-003 (CAC NOS. MF8171 AND MF8172) DATED JULY 21, 2017

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