MEASUREMENT AND CONTROL

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February 5, 2018

Attn: Document Control Desk
US Nuclear Regulatory Commission
Washington, DC 20555-0001

Subject: Final Report for Potential 10 CFR 21 Notification SOR Test Report 9058-102 Revision 2

References:

1. Nuclear Regulatory Commission Inspection Report of SOR Inc. No. 99900824/2017-01
2. SOR Test Report 9058-102 Revision 2

SOR is providing this report in accordance with 10CFR Part 21.21. This letter serves as a final report to our interim notification letter dated December 15, 2017.

(i) Name and address of individual informing the NRC:
Melanie Dirks
Director of Quality
SOR Inc.
14685 West 105th Street
Lenexa, KS 66215-2003

(ii) Identification of the activity which fails to comply or contains a defect:
SOR Qualification Test Report 9058-102 Revision 2

(iii) Identification of the firm supplying the basic component which fails to comply or contains a defect:
SOR Inc., 14685 West 105th Street, Lenexa, Kansas 66215.

(iv) Nature of the potential failure to comply and the safety hazard which is created or could be created by such defect or failure to comply:
As a result of the referenced NRC NON in regards to SOR Test Report 9058-102, SOR has undergone a thorough review of the subject report. As a result of this review, SOR has identified the following reportable deviations:

- The Test Report did not account for all M&TE uncertainties. The following are affected:
  - Qualified Life
  - LOCA profile
  - HELB1 profile
  - HELB2 profile
- During qualification testing, observed Repeatability in excess of 1% of Span was not adequately addressed for some models. The following will be affected:
  - Vacuum switches (post LOCA only)
  - Temperature switches
- The Test Report presents data that is intended to provide a means to calculate reductions in qualified life depending on the conditions of the end use. However, there is a risk that this information could be overlooked by the end user. Following are the potential contributing factors to qualified life:
  - Temperature rise due to electrical load on switch element
  - Temperature rise on direct mount temperature switches due to elevated process temperature

SCOPE

With regards to all references in this report to the SOR model string, see below:

Example of Typical SOR Model String

XXX XX – XX XXX – XX – XXX – XX XX XX NQ
1st 2nd 3rd 4th 5th 6th 7th 8th 9th Last

1st position = up to 3 characters
2nd position = 2 characters
3rd position = up to 2 characters
4th position = up to 3 characters
5th position = 2 characters
6th position = 3 characters
7th position = 2 characters
8th position = optional, may or may not have 2 alpha characters
9th position = optional, may or may not have 2 alpha characters
Last position = "NQ" or "NQX" designator

In addition to configured model numbers, the following non-standard models are affected:
9013545, 9013761, 9013932, 9014202, 9014230

SOR Models Not Affected by this Part 21 Notification

No Differential Pressure Switch models with 103, 131 or 141 in Position 1
No Pressure, Vacuum or Temperature switches affected with models strings ending in X6, X7, X12 and X13.

Details of the deviations are given below:

QUALIFIED LIFE

Due to unaccounted for inaccuracies of the temperate indicator used to monitor thermal aging, the qualified life will be revised from 20 years at a service temperature of 120°F to **20 years at a service temperature of 119.257°F**. This is generically based on the lowest activation energy of 1.05 eV for the phenolic used in the "Y" and "W" switch elements (3rd position in model designation) with an "NQ" or NQX" at the end of the model. Non-standard models 9013545 and 9013761 are also affected. The "B" and "BB" switch elements are unaffected due to the high activation energy of these switches.

LOCA, HELB1, & HELB2 PROFILES

NTS report 60162-93N (Appendix B of 9058-102) verified that as a minimum, the LOCA, HELB1, and HELB2 profiles (pressure and temperature) identified in the test plan were met during testing. However, actual values of autoclave pressure and temperature were not in all cases reported and that data is no longer available. Therefore, for conservatism, it is necessary to correct the profiles to take into account M&TE uncertainties. See below for the corrected profiles. All pressure, vacuum, and temperature switches which will be used in a LOCA or HELB environment and with model numbers ending in "NQ" or "NQX" should be evaluated taking into consideration these corrected profiles.

LOCA Autoclave Profile (corrected for uncertainties)						
Time			Temperature (°F)		Pressure (psi)	
Minimum	Corrected Minimum	Units	Minimum	Corrected Minimum	Minimum	Corrected Minimum
0:00:00	**0:00:00**	(hrs : min : sec)	115	**111**	0	**0**
0:05:15	**0:05:15**		340	**336**	70	**69**
3:00:00	**2:59:54**		340	**336**	70	**69**
5:00:00	**4:59:50**		95	**91**	0	**0**
5:01:20	**5:01:10**		280	**276**	62	**<61**
5:02:00	**5:01:50**		280	**276**	62	**61**
5:02:30	**5:02:20**		340	**336**	70	**<69**
5:03:15	**5:03:05**		340	**336**	70	**69**
8:00:00	**7:59:44**		320	**316**	40	**39**
11:00:00	**10:59:38**		300	**296**	40	**39**
15:00:00	**14:59:30**		250	**246**	25	**24**
4	**3.998**	(days)	250	**246**	10	**9**
13.23	**13.223**		250	**246**	10	**9**

HELB 1 Autoclave Profile (corrected for uncertainties)					
Time (hr:min:sec)		Temperature (°F)		Pressure (psi)	
Minimum	Corrected Minimum	Minimum	Corrected Minimum	Minimum	Corrected Minimum
0:00:00	**0:00:00**	115	**111**	0	**0**
0:00:20	**0:00:20**	165	**161**	0	**0**
3:00:20	**3:00:14**	165	**161**	0	**0**
3:00:50	**3:00:44**	227	**223**	7	**6**
9:00:50	**9:00:32**	227	**223**	7	**6**
>9:00:50	**>9:00:32**	214	**210**	1.5	**0.5**
15:00:50	**15:00:20**	214	**210**	1.5	**0.5**
>15:00:50	**>15:00:20**	207	**203**	0	**0**
92:36:50	**92:33:45**	207	**203**	0	**0**

HELB 2 Autoclave Profile (corrected for uncertainties)					
Time (hr:min:sec)		Temperature (°F)		Pressure (psi)	
Minimum	Corrected Minimum	Minimum	Corrected Minimum	Minimum	Corrected Minimum
0:00:00	0:00:00	115	**111**	0	**0**
0:00:10	0:00:10	350	**346**	40	**39**
2:00:00	1:59:56	350	**346**	40	**39**
<3:48:00	<3:47:52	275	**271**	30	**29**
29:00:00	28:59:02	275	**271**	30	**29**

VACUUM SWITCH REPEATABILITY

The standard SOR specification for repeatability on Vacuum Switches is +/-1% of Span. It is implied that this specification applies throughout the lifetime of the switch. However, qualification testing demonstrated that the repeatability of the Vacuum Switch is in excess of 1% after LOCA testing. While the repeatability is noted in the test report, it was not identified as an anomaly and therefore there was no disposition. For conservatism, it should be noted that **post-LOCA repeatability could be as high as 1.5%**. This only applies to models beginning with "54" (1st position in model number), with "TA" or "TX" housing (2nd position in model number), and ending with "NQ" or "NQX".

TEMPERATURE SWITCH REPEATABILITY

The standard SOR specification for repeatability on Temperature Switches is +/-1% of Span. It is implied that this specification applies throughout the lifetime of the switch. However, qualification testing demonstrated that the repeatability for Temperature Switches is in excess of 1% at numerous times throughout the test program. While the repeatability was previously noted in the test report, it was not identified as an anomaly and therefore there was no disposition. For conservatism, it should be noted that **repeatability could be as high as 1.5%**. This only applies to models beginning with "201", "203", "205", "207", "209", or "20X" (1st location in model number), and ending with "NQ" or "NQX". It also applies to non-standard models 9013932, 9014202, and 9014230.

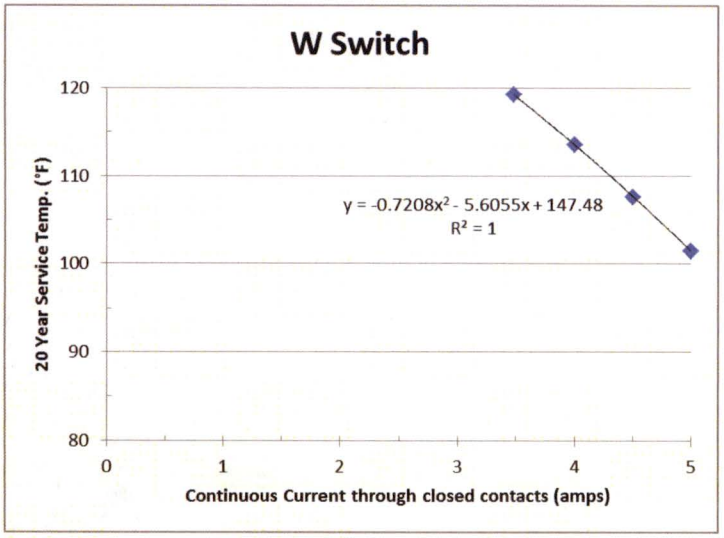
EFFECT OF ELECTRICAL LOAD ON QUALIFIED LIFE

This issue is addressed in SOR Test Report 9058-102, Section 9. If this was not previously been taken into account by the end user, it should be evaluated for every application. SOR will be adding the following supplemental information to Revision 3 of Test Report 9058-102 as an aid to help determine effects of electrical load on qualified life.

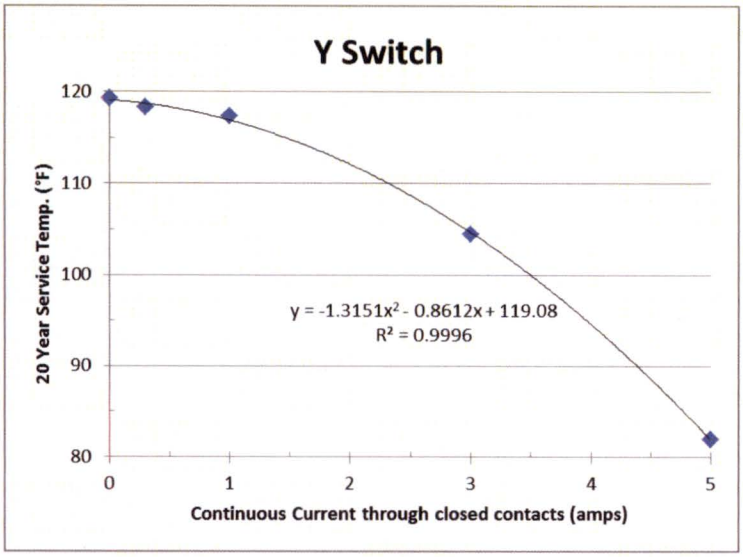
The SOR pressure, vacuum, and temperature switches are mechanical "On-Off" devices that do not require power to operate. Heat rise will only occur within the devices if the switch element contacts are closed and if there is enough current running through the closed contacts to create a rise in temperature in the current carrying wires and switch terminals. If there is enough temperature rise, this could reduce the qualified life of the switch. The following assumes worst case where the ambient temperature is at 119.257°F continuously, the contacts are closed at all times, and there is current running through the closed contacts continuously throughout the life of the switch.

For switches with a **"B" or "BB" switch element** (3rd position in the model string) **there is no effect** on qualified life under any load conditions due to the high activation energy of the phenolic in the switch element.

For switches with a **"W" switch element** (3rd position in the model string) and "NQ" or "NQX" at the end of the model string, the effect on qualified life would be as noted below. Non-standard models 9013545 and 9013761 are also affected. This is based on an activation energy of 1.32 eV.



For switches with a **"Y" switch element** (3rd position in the model string) and "NQ" or "NQX" at the end of the model string, the effect on qualified life would be as noted below. This is based on an activation energy of 1.05 eV.



EFFECT OF PROCESS TEMPERATURE ON THE QUALIFIED LIFE OF DIRECT MOUNT TEMPERATURE SWITCHES

This issue is addressed in SOR Test Report 9058-102, Section 8. If this has not previously been taken into account by the end user, it should be evaluated for every application. SOR will be adding the following supplemental information to Revision 3 of Test Report 9058-102 as an aid to help determine effects of process temperature on the qualified life of direct mount temperature switches.

This issue applies only to SOR direct mount temperature switches which are designated by **"201" or "20X"** (where "20X" = a non-standard direct mount temperature sensor) in the 1st position of the model string and an "NQ" or "NQX" at the end of the model string. It also applies to non-standard models **9013932 and 9014230**.

The graphs shown below can be used as an aide to determine the effect of elevated process temperature on qualified life for the age sensitive materials. These graphs are based on the testing that was performed in 9058-102, Section 8. The effect on qualified life for a particular material may or may not be relevant depending on the qualification requirements. For this reason, 9058-102, Section 8 defines the purpose for each of the materials shown in the graphs below.

Assuming worst case where an application requires full qualification (seismic and HELB), then the weak links and their effect on life can be summarized as follows;

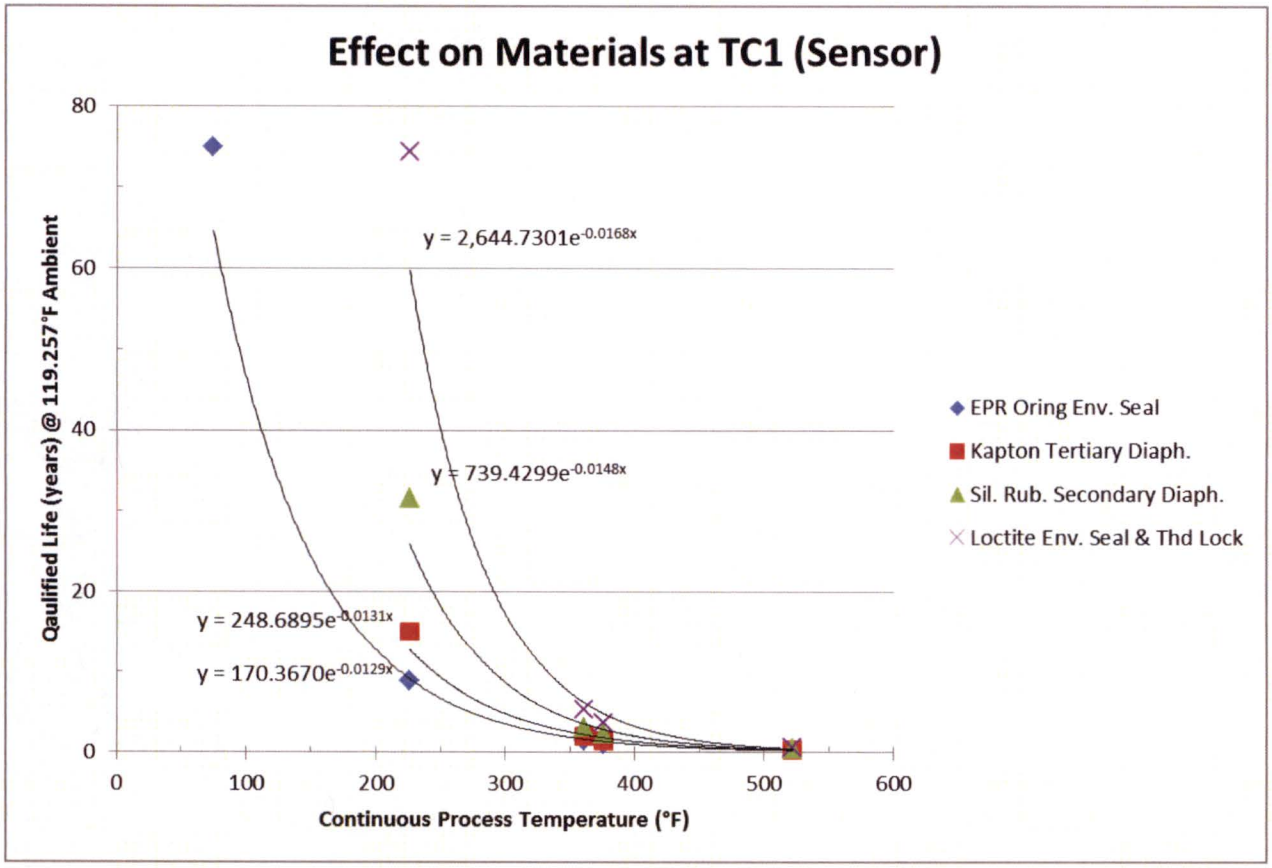
"W" or "Y" Switch Element

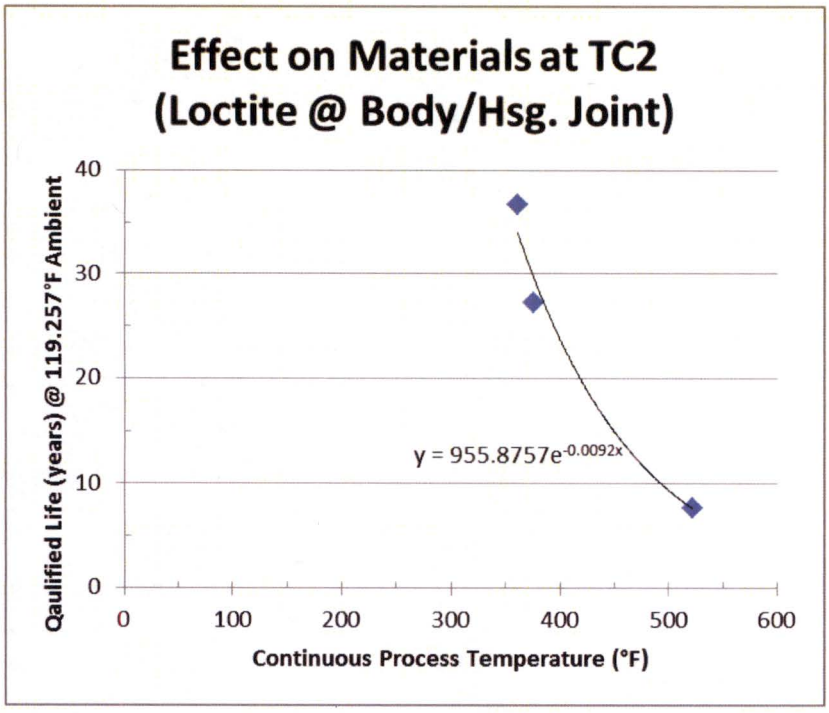
Assume that the switch contains a "W" or "Y" switch element (3rd position in the model string). Then the qualified life could be calculated by the formula $y=32.1569\ e^{(-0.0055x)}$ where "y" is the qualified life in years (assuming 119.257°F ambient), and "x" is the process temperature in degrees Fahrenheit (assuming continuous exposure to this temperature). This formula represents the weak link up to a process temperature of 225.3°F at which point the weak link becomes the EPR O-ring environmental seal between the sensor and the body. Then the qualified life could be calculated by the formula $y=170.3670\ e^{(-0.0129x)}$. This formula represents the weak link up to a process temperature of 520°F which is the highest rated over-range temperature available in an SOR nuclear qualified temperature switch.

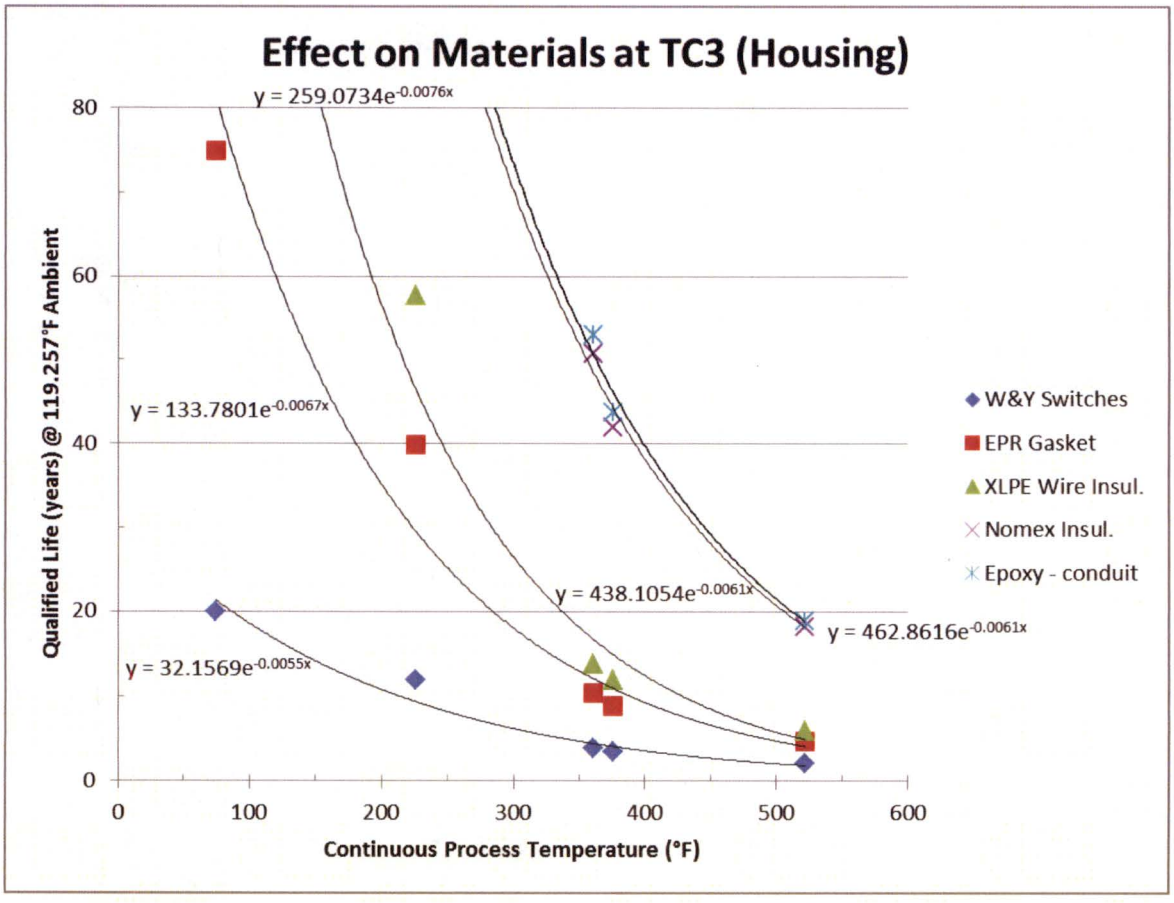
"B" or "BB" Switch Element

Assume that the switch contains a "B" or "BB" switch element (3rd position in the model string). Due to the high activation energy of the "B" and "BB" switch elements, then the first and only weak link is the EPR O-ring used as an environmental seal between the sensor and the body. The qualified life would be calculated by the formula $y=170.3670\ e^{(-0.0129x)}$ where "y" is the qualified life in years (assuming 119.257°F ambient), and "x" is the process temperature in degrees Fahrenheit (assuming continuous exposure to this temperature). This formula represents the weak link up to a process temperature of 520°F which is the highest rated over-range temperature available in an SOR nuclear qualified temperature switch.

The graphs below are based on temperature measurements at 3 locations on the direct mount temperature switch; TC1, TC2, and TC3. Reference 9058-102, Section 8 for more details.







(v) The date on which the information of such failure to comply was obtained:
February 2, 2018

(vi) In the case of a basic component which contains a defect or fails to comply, the number and location of these components in use at, supplied for, or may be supplied for, manufactured or being manufactured for one or more facilities or activities subject to the regulations in this part.

SOR does not have the capability to perform further evaluations to determine if a safety hazard exists as the specific customer application is unknown. The end user must confirm for each application that the corrected qualification values in this notification meet their requirements.

The following customers are potentially affected by this deviation based on the nuclear qualified models procured. The affected models were shipped after July 1993.

In accordance with the requirements of 10 CFR Part 21.21, the customers listed in the tables on the following pages are in the process of being notified by email and/or postal letter regarding this issue to allow them to evaluate this deviation and its potential safety hazard.

Company	Plant
Ameren	Callaway
American Electric Power (AEP)	Donald C. Cook
Arizona Public Service Company (APS)	Palo Verde
Bruce Power	Bruce, Ontario, Canada
COIMSA	CFE, Mexico
Comision Federal De Electricdad (CFE)	Laguna Verde, Mexico
Dominion	Millstone
Doosan	KHNP - Shin-Hanul, Korea
Dremel, Inc.	Asco, Spain
DTE Energy	Fermi 2
Duke Energy	Catawba Oconee McGuire Brunswick Shearon Harris H. B. Robinson Crystal River
Electrabel NV/SA	Doel, Belgium Tihange, Belgium
Energy Northwest	Columbia
Enertech	
Entergy Operations, Inc.	Pilgrim Waterford 3 Indian Point 2 & 3 River Bend Vermont Yankee James A. Fitzpatrick Palisades Grand Gulf
Ergytech	Asco, Spain Laguna Verde, Mexico
Exelon	Braidwood Byron Calvert Cliffs Clinton Dresden LaSalle Limerick Nine Mile Point Oyster Creek Peach Bottoms Quad Cities Three Mile Island
Fairbanks Morse	Beaver Valley Peach Bottom
First Energy Nuclear Operating Company	Davis- Besse Perry

Company	Plant
Florida Power & Light	St. Lucie Turkey Point
Fluids Control	Taiwan Power Company, Taiwan
GE-Hitachi Nuclear Energy Americas	Kernkraftwerk Leibstadt AG, Switzerland Limerick Brunswick Perry Susquehanna Takai 2, Japan TPC – Kuosheng, Taiwan Hatch KHNP – Shin-Kori 3 & 4, Korea
GE-Hitachi Nuclear Energy Canada	Bruce, Ontario, Canada Pickering, Ontario, Canada Darlington, Ontario, Canada
Hydro-Quebec	Gentilly II, Quebec, Canada
I&C Solutions	Los Alamos National Laboratory
Iberfluid	Asco, Spain Vandellos, Spain Confrentes, Spain Santa Anna De Garona, Spain
IMI CCI	KHNP – Shin-Kori 1 & 2, Korea KHNP – Shin-Wolsong 1 & 2, Korea
ISI Industrie Services International	Iberdola, Spain La Central Nuclear De Confrentes, Spain
Konan	KHNP, Korea
Korea Hydro & Nuclear Power Company (KHNP)	Ulchin 3, 4, 5 & 6, Korea Wolsong 1, 2, 3 & 4, Korea Yonggwang 3, 4, 5 & 6, Korea Kori 1 & 2, Korea Shin-Kori 3 & 4, Korea
National Technical Systems (NTS)	Millstone
Nebraska Public Power District (NPPD)	Cooper
NextEra Energy	Duane Arnold Energy Center
Nihon Koso	Bosch Rexroth, Japan
Nuklearna Elektrarna Krsko (NEK)	Krsko, NPP, Slovenia
Nutherm	Calvert Cliffs
Omaha Public Power District (OPPD)	Ft. Calhoun
Ontario Power Generation	Darlington, Ontario, Canada Pickering, Ontario, Canada
Parragon Energy Solutions	TVA Watts Bar
Petroprema	Electrabel, Belgium
PSEG Nuclear LLC	Salem
SLD	China

Company	Plant
South Carolina Electric & Gas Company (SCE&G)	Virgil C. Summer
Southern California Edison	San Onofre (SONGS)
Southern Nuclear Operating Company	Edwin I. Hatch Alvin W. Vogtle Joseph M. Farley
STP Nuclear Operating Company	South Texas Project
Talen Energy	Susquehanna
Tennessee Valley Authority	Watts Bar Sequoyah Browns Ferry
Third Qinshan Nuclear	Qinshan, China
Weir Valves & Controls (UK) Ltd.	Shin-Hanul, Korea Barakah, UAE
Westinghouse Electric (Combustion Engineering)	Yonggwang 3, 4, 5 & 6, Korea Kedo 1 & 2, Korea Ulchin, 3, 4, 5 & 6, Korea Shin-Wolsong 1 & 2, Korea Shin-Kori, 1, 2 & 3, Korea Barakah 1-4, UAE
Wolf Creek Nuclear Operating Corp.	Wolf Creek
Xcel	Prairie Island Monticello

(vii) The corrective action which has been, is being, or will be taken; the name and individual or organization responsible for the action; and length of time that has been or will be taken to complete the action.

SOR has conducted or is conducting the following corrective actions:

- Provided details in this report regarding the NQ models strings and non-standard models potentially affected
- Identified the contact list of customers potentially affected by this deviation within this notification
- Notifying the utilities as indicated with a copy of this notification attached targeting completion by February 8, 2018
- Revise and update test report 9058-102 to revision 3 targeting completion and availability by February 28, 2018

(viii) Any advice related to the defect or failure to comply about the facility, activity, or basic component that has been, is being, or will be given to the purchasers or licensees.

See Item (iv) above. The end user must confirm for each application that the corrected qualification values in this notification meet their requirements.

(ix) In the case of an early site permit, the entities to whom an early site permit was transferred:

Not Applicable to this Part 21.

Should you have any additional questions regarding this matter, please contact:

For general inquiries:

Linda Coutts
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For technical inquiries:

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Sincerely,
SOR, Inc.

Melanie Dirks
Director of Quality
Email: mdirks@sorinc.com