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ROOT CAUSE ANALYSES

OF

AUTOMATIC SWITCH COMPANY (ASCO) MODEL L206-832-3RVF SOLENOID OPERATED VALVES ASSOCIATED WITH THE 2-G16-F003 AND 2-G16-F004 FAILURE TO CLOSE EVENT

Dated July 28, 1991

Prepared By The BNP ASCO Task Force

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Executive Summary

On June 30, 1991 two ASCO solenoid valves failed to change state in a manner that resulted in two Primary Containment Isolation valves not closing. After proper reporting per plant procedures, a task force was established to determine the root cause of failure.

Based upon the information assimilated during this investigation, the root cause determination of the BSEP Unit 2 solenoid valve failures were primarily attributed to a gelling of the Dow Corning 550 Silicone Lubricant and some foreign particulate. The lubricant was used in the manufacturing process to facilitate the assembly of the solenoid valve core subcomponents and to reduce chatter caused by the 60 cycle hum. This lubricant migrated to the surface of the core subassembly and solidified following long periods of solenoid valve energization. When solidified, the lubricant formed an amber colored residue which was responsible for the core assembly adhering to the solenoid valve base sub assembly.

The failed solenoid valves have been replaced with the same ASCO L206-832-3RVF model. A Compensatory Action has been established to weekly cycle all ASCO Model L206-832 normally energized solenoid valves. This compensatory action is consistent with other utility corrective actions which have previously experienced this deficiency. The ASCO Task Force recommends that effected SOV's be replaced. **Replacement should be "staggered" whereby the redundant component SOV's would always be a recent replacement which would increase the safety and reliability of the system function. This additional defense through redundancy and diversity is a recommendation per AEOD Case Study Report "Solenoid Valve Problems At U.S. Light Water Reactors" to eliminate redundant failures.**

Additionally, the Root Cause Analyses Report provides recommendations for corrective actions (Section 4.0) to significantly reduce the occurrence of SOV failures.

ROOT CAUSE ANALYSES REPORT

1.0 Problem Description

Containment Isolation valves

The 2-G16-F003 and -F004 valves are located in the Drywell Floor Drain System piping and are components of the Primary Containment Isolation System (PCIS). The valves are three inch, 150 lb., Anchor Darling cast carbon steel gate valves. The valves are opened by an air actuated cylinder controlled by an Automatic Switch Company (ASCO) solenoid valve. The valves are closed by spring force upon loss of air pressure. Since the drain valves are open to the containment atmosphere, the redundant, automatic isolation valves are located outside the primary containment (i.e., Reactor Building).

Safety Function

The solenoid operated valves evaluated by this RCAR are the ASCO Model No. L206-832-3RVF associated with 2-G16-F003 and 2-G16-F004. Each SOV is located at Reactor Building Elev. 30 ft. Per BNP Safety Classifications, the solenoid operated valves safety function is considered "Active" and is "required to close the Drywell Floor Drain Isolation Valve on a Group 2 Isolation Signal for primary containment isolation". FSAR Accident Sections 15.2.6, 15.4.6, 15.6.4, and 15.6.6 and Technical Specifications Sections 3.6.3, 4.6.3, and B3/4.6.3 apply to these solenoid operated valves.

A (maximum) normal ambient temperature of 104 °F has been assumed for this area for equipment qualification purposes. This value is documented in Section 3.3 of the Reactor Building Environmental Report (RBER), UE&C Report No. 9527-058-S-MS-001 (Rev.3). This equipment is required to perform an active safety function following any High Energy Line Breaks (HELB) postulated to occur inside the Reactor Building. Additionally, the SOVs must remain operable through temperature fluctuations resulting from a LOCA in the Primary Containment. UE&C Report RBER, Figure 4-2, shows a 133 °F peak temperature occurring in this area over the postulated 30-day post-LOCA duration.

The Total Integrated Dose (TID), over the SOVs 40-year normal and 30-day HELB/LOCA service conditions, for this area is 1.0×10^{5} rads gamma.

Event Description, June 30, 1991

The following event description was summarized from the Shift Foreman and Control Room Operators log:

05:19
Outboard Drywell Floor Drain Isolation Valve (2-G16-F004) failed to close on demand.

05:26
1 hour phone report made to USNRC due to failure of 2-G16-F004.

12:55
Technical Specification (3.6.3) "Line Isolation" required the redundant valve in line (2-G16-F003) to be closed ensuring line isolation. The 2-G16-F003 switch was taken to "close" and the valve remained open (failed to change state). The switch was cycled 4 times and the valve closed at 12:55.

13:43
1 hour phone report made to USNRC due to failure of 2-G16-F003.

18:00
Stroke tested valves 2-G16-F019, 2-G16-F020, 2-C12-CV-F010, 2-C12-CV-F011, 2-C12-V139, and 2-C12-V140 satisfactorily

22:10
SOV replacement of 2-G16-SV-F004 and 2-G16-SV-F003 was completed.

23:00
Valves 2-G16-F004 and 2-G16-F003 were declared operable and returned to service.

Event Discussion

On June 30, 1991 at approximately 05:19, BSEP Unit 2 was operating at approximately 95% power following a power reduction to perform Main Turbine valve testing. A Control Operator was performing a weekly surveillance using an operating procedure to check the operation of the Manual (DC) and Auto (AC) Main Generator Voltage Regulator. After completing a step of the procedure which places the Voltage Regulator Mode Selector in the Manual position, the Control Operator observed a significant deflection of the transfer voltmeter (TVM). The TVM monitors the outputs of the Manual (DC) and Auto (AC) voltage regulators and is used to match the outputs of the two regulators so the generator voltage does not change when the regulator is transferred. The observed deflection of the TVM indicated that generator excitation had decreased upon transferring from Auto to the Manual mode. The Control Operator asked the Senior Control Operator if he had seen the TVM deflection and he replied that he had. The Control Operator looked again at the TVM and also observed that the generator megavars had decreased from 80 to 10. An alarm came in for a 250 volt Battery B ground followed by an alarm for 250 volt Battery A ground. The Control Operator began to receive alarms indicating a loss of Reactor Protection System Bus B and Emergency Bus 4 (E4 Bus). At approximately 05:19, the Bus 2C to Emergency Bus E4 master and slave breakers tripped due to actuation of 2 out of 3 E4 Bus degraded voltage relays. This initiated an auto start of the No. 4 Emergency Diesel Generator (EDG). One relay associated with the auto start logic for the No. 3 EDG actuated.

ECCS systems and Emergency Diesel Generators were operable and in standby.

Results of the loss of the E4 Bus included;

- Autostart of the associated Emergency Diesel Generator which re-energized the E4 Bus.
- Trip of the 2B Reactor Protection System (RPS) Motor Generator (MG) Set which resulted in the following:

  1/2 SCRAM-Division II

Primary Containment Isolation System:
GROUP 2 ISOLATION-Division II (Transverse Incore Probe and Drywell Floor and Equipment Drain valves) (2-G16-F004 failed to close)
GROUP 3 ISOLATION (Reactor Water Cleanup)
GROUP 6 ISOLATION (Containment Atmospheric Control)

At approximately 05:29, the Control Operator manually raised the Main Generator output voltage with the manual voltage regulator and transferred the voltage regulator to the automatic mode. Expected actuations resulting from a loss of the E4 Bus occurred as required except for the Drywell Floor Drain Outboard Isolation Valve (2-G16-F004) which failed to close on a GROUP 2 isolation signal. After verification of actuations, the 2B MG SET was restarted.

Due to the failure of 2-G16-F004, an eight hour active Limiting Condition of Operation (LCO) in accordance with Technical Specifications (T.S.) was initiated. This Technical Specification requires that with only one operable valve, the affected penetration line be isolated within eight hours by the use of one deactivated automatic valve secured in the isolated position. This required the closure of the Drywell Floor Drain Inboard Isolation Valve (2-G16-F003). At approximately 12:45, the Control Operator attempted to close 2-G16-F003 valve using the control switch. At 12:55, after four attempts, the valve closed. Although, the penetration line was already isolated, problems encountered in the closing of 2-G16-F003 required declaring the valve inoperable. With the two primary containment isolation valves in series being inoperable, the unit was unable to perform an Operational Leakage Surveillance required per Technical Specification. After solenoid valve replacement on 2-G16-F003 and 2-G16-F004, the valves were declared operable and returned to service at approximately 22:10 and 23:00 respectively.

Adverse Condition Report 91-290 was issued to ensure event notification per 10CFR 50.72 (b) (1).

2.0 Scope of Root Cause Analyses/Evaluation

The scope of the root cause is directed at the ASCO solenoid valves (Model L206-832). This is based upon field verification during testing after the event of the SOVs failure (change state). This field verification ruled out any concern with the valve, valve actuator, or limit switch.

The following will be evaluated per this Root Cause Analysis Report:

- Root cause of failure.
- Was the equipment known to be deficient prior to the event?
- Did the equipment history indicate that the equipment had either been historically unreliable or if maintenance or modifications had been recently performed?
- Was any equipment vendor involvement prior to or after the event?
- The Pre-event status of surveillances, testing, and /or preventative maintenance.
- The extent to which the equipment was covered by existing corrective action programs and the implication of the failures with respect to program effectiveness.

L206-832-3RVF Description

The ASCO 3 way solenoid operated valve, Model No. L206-832-3RVF is primarily used as pilot operators on larger control valves. The following information is applicable to the BNP SOVs which failed:

Pipe Size:	1/4"
Orifice Size:	1/4"
Max. Continuous Ambient:	140 °F
Max. Operating Pressure:	150 PSI
Max. Fluid Temperature:	180 °F
CV Flow Factor:	.45
Solenoid enclosure:	Explosion/Water Proof
Body Material:	Brass
Watt Rating:	20 AC
Weight:	4 lbs (approximate shipping Weight)

3.0 Root Cause Analysis/Evaluation

Root Cause

Initial Valve Inspections and failure mode identification

2-G16-F003

A gelled Silicone lubricant was found to completely coat the top of the solenoid core. The lubricant was identified as Polymethyl Siloxane (i.e., consistent with Dow Corning 550 or one of the Neolube products) by infrared analysis. A few light scratches were found on the SOVs upper and lower stems. A patch of copper bearing material was found adhering to the upper stem in a region that passes through a brass bushing. A calculation was performed to demonstrate that if all of the core top was sealed by Dow Corning 550 that the resistant force from air pressure would cause the core to remain in its energized position after the solenoid coil deenergizes. After solenoid deenergization, the air pressure induced resistant force gradually disappeared as the sealing broke because of the relative thermal contraction between the core housing and the core. A calculation demonstrated that when the lubricant gels over a period of time (i.e., in a high temperature environment), it will prevent the air pressure resistant force (62.5 lbf-inch) from allowing the core to change position.

2-G16-F004

A gelled Silicone lubricant was found to coat about 50% of the top of the solenoid core. The lubricant was identified as Polymethyl Siloxane (i.e., consistent with Dow Corning 550 or one of the Neolube products) by infrared analysis. Many 5 to 30 Micron wide scratches were found on the lower stem. Additionally, a long thread machining burr was found between the upper seat bushing and the main valve body. This machining burr was still attached to the threaded region of the valves pressure port. A calculation was performed to demonstrate that if a portion (i.e., 50%) of the core outer radius was gelled by Dow Corning 550 that the resistant force from air pressure would not cause the core to remain in its energized position after the solenoid coil deenergizes. A calculation indicated an air pressure resistant force (-3.27 lbf-inch), from slight gelling of the lubricant in a high temperature environment, would not prevent the core from changing position. This low value was in the area of calculational uncertainty, therefore gelling will be considered as applicable and/or contributing to the failure mode. A calculation of the friction force on the lower disc guide stem due to the 5 to 30 micron scratches found on the lower disc guide was performed. The scratches (indication of high friction forces) indicated a presence of a high strength foreign material between the stem and the bushing interface. It was determined that the scratches could not have originated from the softer brass bushings and had to originate from a hard foreign material. The total friction force of the scratch marks was calculated to be 1.14 lbf. Since the core can move freely downward, the gravitational force of the core becomes the force to open the lower exhaust valve. This is due to the lower disc spring force being almost zero when the lower valve starts to be pushed open by the lever. A calculation of the resistance force (0.314 lbf-inch) results indicates the SOV would not change state. The binding of the lower core with the partial gelling of the lubricant is the most probable failure mode.

Outstanding Equipment Deficiencies Prior To The Event:

There were no existing deficiencies identified with the 2-G16-SV-F003 and 2-G16-SV-F004 prior to the event.

BNP ASCO SOV Failure History

Engineering has performed a review to determine the failure history of various model ASCO solenoid valves installed at BSEP Units 1 & 2. An EDBS data query was initially performed to identify the entire population of ASCO solenoid valves utilized at BSEP (2395 valves); this query identified valve model number, tag number, quality classification, and description. Further research was performed to identify the components which are identified as nuclear safety-related and could be encompassed by the failure mode determination for global plant impact. The following criteria was utilized to identify these components:

ASCO Solenoid Valve
Quality Class "A"
Coil - Normally Energized

The solenoid valves (approx. 628) which meet the above noted criteria were identified by review of Environmental Qualification (EQ) data, previous research included within EER 88-0076, and information supplied by various Systems Engineers.

Of the 628 solenoid valves which met the failure mode criteria, 548 of these valves are identified as the Scram Pilot Valves for the Control Rod Drive system (CRD); these valves are ASCO Model #HVA904052A. General Electric Company (GE) generated an operating experience report for failure history of these components (Ref. NEDE-22292); this review gathered data on 5490 valves installed at 23 different plants which had been operating as early as 1960. Relative to the number of valves considered, and reactor years of service (estimated at 198 years), less than 50 BUNA-N related valve failures were reported. Of this number, 10 failures were known to be attributed to core disk failure. Due to the research performed by GE, engineering determined further investigation of these model valves was not warranted; the subject solenoid valves are replaced on a regular scheduled basis to ensure the service life is not exceeded. Therefore, the CRD scram pilot solenoid valves were not included in the ASCO failure history investigation.

Due to the large number of solenoid valves identified (80), a sample lot of various model solenoid valves has been researched to determine the failure history of these components. The sample lot was limited to 25 percent of a subject model number and size. Where four or less valves were identified, the sample lot increased to 50 percent. The sample valves researched were randomly selected from the list of components which met the failure mode criteria. If a solenoid failure was attributed to a "sticking" problem, the sample lot was increased by one sample lot for the affected model number and size.

Once the sample lot was determined, a historical WR/JO review was performed, utilizing AMMS (Automated Maintenance Management System), to determine failure history. The AMMS query was performed for each component identified by researching the actual solenoid valve tag number, process valve tag number, and process valve actuator tag number (e.g., 2-G16-SV-F003, 2-G16-F003, and 2-G16-F003-AO); this extended research was performed to better ensure valve failures were captured. The AMMS query also included review of the General Inquiry Menu (active plus 3 year WR/JO history) and Archive Inquiry Menu (completed WR/JO >3 years); reviewing AMMS General Inquiry and Archive Inquiry will capture work orders performed since November 1985.

Engineering also performed a NPRDS query to capture identified solenoid valve failures prior to November 1985. Due to the methodology utilized by NPRDS, the query was performed to identify valve operator failures at BSEP Units 1 & 2. NPRDS does not list solenoid valves as a individual components but rather as a piece-part of the process valve operator. Engineering performed a review of the NPRDS data received and has included the identified solenoid valve failures in the sample lot. Below is a listing of sample solenoid valves researched including model number/size, tag number, and failure history:

Model Number	Tag Number	Failures
FT8345E11	2-CAC-CV-2890-SV4	N/A
HT8302B25RU	1-E41-F028-SV3	N/A
	2-E41-F028-SV3	N/A
HT8321A5	1-SW-V137-SV3	N/A
	2-SW-V123-SV3	N/A
HT8321A6	1-SW-PY-116	N/A
	1-SW-PY-136	Replaced due to corrosion
	2-SW-PY-118	Replaced due to corrosion
HT8345E11	2-CAC-CV-2889-SV4	Air leak - Solenoid body
L206-832-2RF	1-B32-SV-F019	N/A
	2-B32-SV-F019	Possible solenoid sticking Root cause indeterminate (1988)
L206-832-2RVF	1-B32-SV-F020	N/A
	2-B32-SV-F020	N/A

L206-832-3RVF	2-G16-SV-F003	Solenoid sticking (1986, 87, 88, & 91)
	2-G16-SV-F004	Solenoid sticking (1987, 88, & 91)
	2-G16-SV-F019	Solenoid sticking (1988)
	2-G16-SV-F020	Solenoid sticking (1988 & 90)
	1-G16-SV-F003	N/A
	1-G16-SV-F004	N/A
	1-G16-SV-F019	Sluggish stroke (1991)
	1-G16-SV-F020	Solenoid sticking (1990)
NPL8316A57V	1-CAC-SV-V5-1S	N/A
	2-CAC-SV-V6-1S	N/A
NPL8316A65V	1-C11-SV-F009A	N/A
	2-C12-SV-F009B	N/A
NPL8321A2V	2-SW-V129-SV3	N/A
NPL8321A6E	2-SW-V141-SV3	N/A
NP832093V	1-CAC-SV-4409-24	N/A
	2-CAC-SV-4410-24	N/A
NP8321A2E	1-SW-V124-SV3	N/A
NP8321A6V	1-SW-V136-SV3	N/A
WPHT832L[illegible]	1-SW-V123-SV3	N/A
	2-SW-V128-SV3	N/A
NPL8323A36E	1-B21-SV-F028A-1	Defective Coil
	1-B21-SV-F028B-1	N/A
	1-B21-SV-F028C-1	Valve body leak
	1-B21-SV-F028D-1	N/A
NPL8323A36V	1-B21-SV-F022A-1	Solenoid sticking (1985)
	1-B21-SV-F022B-1	N/A
	1-B21-SV-F022C-1	N/A
	1-B21-SV-F022D-1	N/A
	2-B21-SV-F022A-1	Defective coil
	2-B21-SV-F022B-1	Defective solenoid
	2-B21-SV-F022C-1	Defective coil
	2-B21-SV-F022D-1	Defective coil
	2-B21-SV-F028A-1	Solenoid sticking (1985)
	2-B21-SV-F028B-1	Defective coil
	2-B21-SV-F028C-1	Defective coil/Solenoid sticking (1985)
	2-B21-SV-F028D-1	N/A

A historic review of the BNP ASCO solenoid valve failures indicate the highest failure rate is occurring on the ASCO Model # L206-832 solenoid valves. Other solenoid valve models, from this historical search, do not indicate failure trends or common mode failures at a level where concern exists. The ASCO Model #8323A36E/V also reflects a high failure rate; this model valve is used for the Main Steam Isolation Valves (MSIVs). Review of the failure dates indicates that these failure types have not reoccurred since 1985; this change in the failure rate is due to a design change implemented for these components. Since the MSIVs have not experienced solenoid valve failures in recent years, the design change implemented appears to have corrected the root cause problem; therefore, these model solenoid valves are not considered high failure rate valves per this investigation.

Industry Failures

The history of industry SOV failures is extensive and has been considered in this root cause evaluation. This report is not intended to reveal all SOV failure data as presented in large funded research projects, but to show similarity to the lubricant (i.e., residue, FUSS [foreign unidentified sticky substance], amber colored sticky material, organic deposit, sticky deposit, sticky substance) involved and/or identified in numerous SOV failures. Additionally, most failure analyses had concerns with the degradation of the Ethylene Propylene Diene Monomer (EPDM) elastomers which tended to focus on the elastomers in the final root cause determination.

Franklin Research Center (NUREG CR/5141)
A research program was conducted for the Division Of Engineering Office Of Nuclear Research on the aging of solenoid operated valves.

During this test program, ASCO SOVs failed to transfer (change state) when approximately one fourth of the accelerated thermal aging had been completed and it was time to perform the first increment of 500 operational cycles. Examinations of all six new ASCO SOVs undergoing accelerated thermal aging revealed an organic deposit at the top of the core assembly. The deposit appeared to have acted as a sticky substance that prevented transfer. Additionally test specimens from the Fort Calhoun Plant were found to have the sticky deposit. A detailed analysis (e.g., using IR techniques) of the sticky substance was not possible within the budgetary restraints of the test program. The material is used in the manufacturers assembly process of the solenoid valves.

Grand Gulf
1985-MSIV Failures related to solenoid valve problems were related to foreign substance. ASCO felt certain that the valve failures resulted from high temperature sticking of the lower core to plug nut interfaces resulting from a foreign substance or combination of substances collected at this interface. There was not enough residue for definitive identification of the nature of the foreign substance.

Kewaunee LER 88-007
Two redundant containment isolation valves failed to transfer (change state) position due to a manufacturer's use of a lubricant, resulting in degradation of containment integrity. The ASCO failure was attributed to a lubricant P-80. However, significant amounts of Dow Corning 550 Silicone Lubricant were present. The P-80 lubricant has been removed from the ASCO manufacturing process. After the testing, there were concerns raised about ASCO air systems used to test valves, lapping compounds, cleaning compounds, and other possibilities of ASCO introducing contaminants during assembly.

Perry (CEI)
October 29, 1987-Three of eight MSIVs failed to close due to solenoid valve failures. November 3, 1987-Two of eight MSIVs failed to close due to solenoid valve problems. November 29, 1987-One of eight MSIVs failed to close due to solenoid valve problems.

Thermal endurance testing performed by Farwell & Hendricks for CEI concluded that EPDM elastomers and lubricants were the cause of failure to shift. During the testing, a foreign substance described as an amber colored sticky residue was identified. This material was similar in composition to the lubricant applied to the valve internals (i.e., Silicone lubricant).

LaSalle (Com. Ed.)
December 17, 1987 - The failure analyses by LaSalle demonstrated that the cohesive/adhesive force caused by a foreign sticky substance between the plug nut and the core assembly was significant and could have caused the failure. After the core assembly was held vertically, the plug nut was pressed against the core assembly. The plug nut was then let go. The adhesive forces from the foreign substance between the two surfaces were able to support the weight of the plug nut to prevent it from falling.

River Bend
September 30, 1988- Two MSIVs failed to close due to solenoid valve failure to shift. The root cause was determined to be gelling of the lubricant (Dow Corning 550) (Reference LER-88-023).

General Electric
SIL No. 481 identified testing of the Dow Corning 550 Lubricant which dried and evaporated with time. General Electric could not contribute the failures of MSIVs to the lubricant. The solenoid valve failures were attributed to the elastomer materials.

San Onofre (SCE)
1987-San Onofre experienced five SOV failures of the ASCO Model L206-380-3RU to shift (Reference LER 87-016). In 1990, a root cause evaluation (Reference RCE-90-004) determined that the valve design did not recognize the potential of an adhesive film at the core top when the valve is used in a normally energized service application. The report identifies Dow Corning 550 to be the identified material which gelled.

DOW Corning 550 Evaluation

Failure Prevention Inc. (FPI) identified gelling of the silicone lubricant by the failure modes analysis report (Reference Attachment 1). Dow Corning Data published literature identifies that the 550 Silicone Lubricant gels at a temperature of 200 °C (392 °F) at 14-months.

Note: ASCO has not identified any age related temperature information concerning the Dow Corning 550 Silicone lubricant.

Further investigation into other BNP ASCO solenoid valves which could be potentially affected by gelling concerns was performed.

Using ASCO solenoid valve temperature heat rise data for normally energized solenoid valves at BNP, a heat rise vs BNP ambient temperature plot (Reference Attachment 2) was developed. This heat rise vs ambient temperature plot was used to identify any ASCO solenoid models which would potentially be most susceptible to the Dow Corning 550 lubricant gelling. Discussions with ASCO revealed that the ASCO published heat rise data is based on using a resistance calculation method plus 5 °C margin for the coil hot spot.

Evaluation of the heat rise data vs BSEP ambient temperatures (Reference Attachment 2) indicated extensive heat rise temperatures for the ASCO SOV model L206-832 vs other ASCO SOV models at BSEP Units 1 & 2.

The data supplied by FPI provided a temperature plot of the Dow Corning 550 Silicone lubricant for thermal capabilities. The data was analyzed for heat rise effects of the normally energized ASCO SOVs and the Dow Corning 550 Lubricant gelling. Using the Arrhenius Methodology, BNP plant specific temperatures (25 °C, 40 °C, and 65 °C) were graphed (Reference Attachment 3) for normally energized ASCO solenoid valve models. They were graphed to identify any other ASCO solenoid valves which would potentially have a gelling condition.

Evaluation of the Arrhenius data revealed significant reduction in life expectancy due to the extensive heat rise temperatures for the ASCO SOV model number L206-832 vs other ASCO SOV models at BSEP Units 1 & 2.

The area, where the lubricant gelling was identified (Top Core Sub Assembly) was in an area in which temperature would have been less than the coil hot spot used in the Arrhenius qualified life calculations. The Harris E & E Center provided actual temperatures of the Top Core Sub Assembly of a similar solenoid valve 2-G16-SV-F019 which is considerably lower than the temperatures used in the BNP calculations. The temperatures were 295 °F (146 °C) for the Top Core Sub Assembly at 122 VAC at an ambient of 105 °F (40 °C). The temperatures as expected were directly proportional to the voltage applied to the coil. These temperatures were considerably less than the FPI reported temperature of 400 °F (204 °C). These measurements were taken with thermocouples epoxied to various metal interfaces to prevent convective losses. Using the three Dow Corning data points a trend graph (Reference Attachment 4) was developed to extrapolate the data of the Dow Corning 550 Lubricant to various BSEP temperatures.

Currently, **evidence indicates that the Dow Corning 550 Silicone Lubricant gels at a temperature lower than that published by the manufacturer Dow Corning.** This potentially could be attributed to materials testing by Dow Corning on the 550 Silicone Lubricant in a circulating air environment. The ASCO application is in a non-circulating air environment until the valve is cycled. This could be a contributing factor in accelerating the aging process of the Dow Corning Silicone Lubricant. Additionally, the amount of lubricant tested at Dow Corning versus the amount of lubricant applied to the ASCO component (i.e., thin film) in the manufacturing process could potentially account for the accelerated gelling.

Note: During post event discussions, ASCO stated that their procedure for applying Dow Corning 550 Silicone Lubricant is non specific on how the lubricant is applied and/or the quantity to be used.

Equipment Vendor (ASCO) Involvement (Pre-Event)

There has been previous equipment vendor involvement associated with SOV failures at BNP (i.e., MSIV incident). Additionally, the equipment vendor has participated through the Nuclear Utilities Group On Equipment Qualification (NUGEQ). There has not been any vendor involvement associated with the L206-832 model or lubricant degradation, except transmission of heat rise data which has been incorporated into the BNP EQ Program. The SOV vendor has not provided any information associated with the Dow Corning 550 Silicone lubricant and age related failure mechanisms.

Equipment Vendor (ASCO) Involvement (Post-Event)

ASCO was invited to participate in the Root Cause Analysis at the site or Harris E & E Center. ASCO did not participate but indicated they would provide the root cause analysis if the failed components were provided. Phone question and answer sessions have been held with the SOV vendor.

Pre-Event Status Of Surveillances, Testing, And /Or Preventative Maintenance.

Surveillances and testing was performed in the time required by plant schedules up to the time of event. Testing performed (i.e., stroke testing) indicated no evidence of solenoid degradation prior to the failure.

The valves stroke time data for all drywell drain valves were reviewed and graphed from 1988 to the present time. Based upon this review, it was determined that the valve stroke times provided no indication of the imminent valve failure. It was noted that the 1-G16-F019 did indicate a slight increase in stroke time in the test prior to failure, however this increase was well within the normal data scatter for this valve. There was no increase in the stroke time data prior to the valve failure.

SOVs were functionally tested prior to installation by the maintenance group. This test involves connecting to the Service Air System and cycling the valve for proper operation.

Post-Event status of systems affected by ASCO SOV Lubricant Gelling Concerns.

The two SOVs involved in the failure have been replaced with the same ASCO Model Number L206-832-3RVF.

Instrument Air System was analyzed downstream of the filter for contaminants and air quality with the following results:

Sample Volume	1/2 Cubic Foot	
Hydrocarbons	< 1 ppm	
Dew Point	-45F	
Particulate	.5 micron	@ 5000 particles
	2 micron	@ 20-30 particles
	3 micron	@ 2
	Insignificant number larger	(170 micron @ 1)

Service Air System (air used for functional test) was analyzed for air quality with the following results:

Hydrocarbons < 1 ppm

The voltage measurements at the failed solenoid valves were as follows:

2-G16-SV-F003 116.63 Vac 2-G16-SV-F004 115.95 Vac

Ambient temperature (T) measured at the failed solenoid valves was 102 °F.

Radiation environment surveyed at the failed solenoid valves was 400 to 500 mr/hr gamma.

For Compensatory Action normally energized ASCO L206-832 solenoid valves are being cycled at weekly intervals to reduce potential gelling effects. This compensatory action is consistent with other utilities corrective actions which experienced this deficiency.

The extent to which the equipment was covered by existing corrective action programs and the implication of the failures with respect to program effectiveness.

Previous corrective action programs were performed associated with ASCO solenoid valves. The valves were modified with an elastomer preference (Viton) when the industry had problems with the Ethylene Propylene Diene Monomer (EPDM) elastomers. This corrective action has proven to be effective in reducing problems with ASCO SOVs associated with the MSIVs. Additionally, CP&L participates in the Nuclear Utilities Group On Equipment Qualification (NUGEQ) which discusses many plant failures associated with age degradation and EQ related issues.

EWR 06741VR (initiated on 8/14/90) directed review of the NRC Preliminary Case Study Report on "Solenoid Valve Problems At U.S. Light Water Reactors". Disposition and Initial Implementation Recommendations of EWR 07641VR included performing training and/or procedure changes, as appropriate, to initiate a Root Cause Analysis for any SOV failure identified during surveillance testing, to assure adherence to manufacturers lubrication instructions, and consider performing maintenance, testing, and replacement of redundant SOV's on a staggered basis, when possible. Implementation of the recommended actions had not been completed at the time of this event.

Note: BSEP currently does not disassemble ASCO solenoid valves which is in accordance with ASCO recommendations

Currently failure trending is not performed for ASCO solenoids at BNP.

3.0 Conclusions

Based upon the information that was assembled per this root cause analysis the following conclusions and resolutions were reached.

- The Dow Corning 550 Lubricant showed evidence of age related degradation (gelling) in the normally energized ASCO Solenoid Operated Valve Model No. L206-832 top surface of the core assembly and contributed to the failure of the SOV to change state.

  All normally energized ASCO Model No. L206-832 Solenoid Valves need to continue to be cycled weekly as compensatory action.

All normally energized ASCO Model No. L206-832 solenoid valves should be replaced. In redundant systems the inboard and outboard solenoid valves should be replaced on a staggered basis per AEOD Case Study Report No. C-90-01 "Solenoid Valve Problems At U.S. Light Water Reactors".

Perform further testing of the Dow Corning 550 to identify any synergisms associated with the ASCO application. Additionally, include the ASCO heat rise data (i.e., actual measurements vs resistive calculation method). This should be performed on an industry basis.

Perform feasibility study for design modification options for a different type of SOV or model No. which could have a lower operating temperature and submit to plant for approval.

- The ASCO Model No. L206-832 solenoid valve has exhibited an abnormal failure history (i.e., sticking). If a SOV Failure Trending Program had been in place, the subject model solenoid valves would have been previously identified as a problem model valve. Therefore, a more in depth root cause analysis would have been performed to establish corrective actions to reduce/eliminate subsequent valve failures.

  SOV Failure Trending Program should be implemented to monitor/trend BNP SOV performance. SOV Trend data can provide indicators through evaluations/resolutions of failures to ensure that failures will decline.

- The ASCO solenoid valve testing does not demonstrate conditions of a solenoid which is only periodically cycled. ASCO testing performed cyclic aging (20,000 and 40,000 cycles) which may not be representative of actual installed conditions.

  Periodic cycling is to be investigated for ASCO L206-832 SOVs which may not cycle on a routine basis (i.e., < 1-month) to alleviate concerns of sticking.

- Solenoid valves are functionally tested prior to field installation. The maintenance practice is to use Service Air system (particulate filtered but not oil filtered) which could lead to internal contamination of a SOV. FPIs report did not identify contaminants which would have been induced due to air quality at BNP.

  Although a small pre-installation test could lead to a contaminant being induced, a plant maintenance procedure for bench testing should be developed and/or revised for use of an air system (equivalent to the plants instrument air or other engineering approve equivalent supply system), which is free of contaminants which could contribute to SOV failure.

See (p. 57 pp 28 (susqt

Based upon the above RCAR evaluation and compensatory actions, it can be determined that the Dow Corning 550 materials' physical endurance properties to the postulated BSEP normal HELB, LOCA, and post-LOCA environmental conditions would not impair the safety function of the SOV during the compensatory time period until the valves can be replaced with a staggered interval in accordance with AEOD Case Study Report No. C-90-01 "Solenoid Valve Problems At U.S. Light Water Reactors" recommendations.

This RCAR provides the root cause analysis assessment and assures the operability of the SOVs under its expected normal and postulated post-LOCA environmental service conditions through the operability compensatory actions currently taken.

The RCAR corrective actions provide reasonable assurance that postulated common mode equipment failure resulting from a normal and Design Basis Event (DBE) exposures would not degrade its safety function, the components would not cause the failure of any other safety related function or equipment, and the components would not result in misleading information to the operator during any installation.

Steps to prevent recurrence are addressed per this RCAR assessment by providing the following recommended corrective actions.

4.0 Recommended Corrective Actions

The following short term and long term corrective actions are recommended per this RCAR.

Short Term recommended corrective actions

1) Develope a staggered schedule for SOV replacements for all normally energized model no. L206-832 ASCO SOVs per AEOD Case Study Report No. C-90-01 "Solenoid Valve Problems At U.S. Light Water Reactors" recommendations.

2) Replace all Normally Energized L206-832 ASCO SOVs yearly (12-months) in accordance with plant approved procedures. This is to be performed on a staggered basis (6-months) for redundant systems/valves taking into consideration the AEOD Case Study Report No. C-90-01 "Solenoid Valve Problems At U.S. Light Water Reactors" recommendations.

3) Continue to perform weekly (7-days) cycling of normally Energized L206-832 ASCO SOVs. This is to be performed on a staggered basis (3 to 4-days) with redundant systems taken into consideration. Operations procedures for stroke time associated with ASCO SOVs should be reviewed and revised to include local verification of solenoid performance and staggering of stroke tests per AEOD Case Study Report No. C-90-01 "Solenoid Valve Problems At U.S. Light Water Reactors" recommendations.

4) Review and revise solenoid replacement procedures/practices to ensure that contaminants are not introduced during installation and/or shop testing.

Long Term recommended corrective actions

1) Perform feasibility study for design modification options for a different type of SOV or model No. with lower heat rise values and submit to plant for approval.

2) Implement a solenoid valve failure trending program to further identify SOV failure trends and to initiate root cause evaluations with corrective actions.

3) Perform testing on the Dow Corning 550 Silicone Lubricant for gelling characteristics and or synergisms associated with the ASCO SOVs. This should be done on an industry basis.

4) Revise EQ documentation to reflect the replacement times established for the ASCO SOVs as a result of this investigation.

Enclosure 3 to the Minutes of CRGR Meeting No. 209
Proposed Generic Letter on NRC Upgrade of the
Emergency Telecommunications System (ETS)

August 27, 1991

TOPIC

R. Wessman (AEOD) and T. Kellam (IRM) presented for CRGR review a proposed generic letter alerting power reactor licensees to the forthcoming NRC effort to upgrade the agency's emergency telecommunications system (ETS). The major expense of this effort is to be borne by NRC; but some level of licensee effort and cooperation will be required for successful implementation of this program, so this action is considered as a backfit. The staff invoked the compliance exception of 10 CFR 50.109 in justifying the proposed action. Briefing slides used by the staff to guide their presentations and discussions with the Committee at this meeting are enclosed (see Attachment).

BACKGROUND

The documents submitted for review by CRGR in this matter were transmitted by memorandum, dated August 12, 1991, R.L. Spessard to E.l. Jordan; the review package included the following items:

1. Draft Generic Letter (undated), "Emergency Telecommunications", and attachments as follows:

    a. Enclosure 1 - "Essential Emergency Communication Functions",

    b. Enclosure 2 - "Licensee Support for Upgrade to the Emergency Telecommunications System",

    c. Enclosure 3 - "Schedule for FTS 2000 Installation",

    d. Enclosure 4 - "Documented Evaluation" (providing the basis for invoking the compliance exception).

2. Commission Paper (SECY-91-149), dated May 11, 1991, "Upgrading the NRC Emergency Telecommunications System",

3. NRC Staff Responses to CRGR Charter Section IV.B., "Information Require for Packages Submitted to CRGR".

COMMENTS/RECOMMENDATIONS

1. As a result of their review of this matter, including the discussions with the staff at this meeting, the Committee recommended in favor of issuing the proposed generic letter, subject to incorporation of revisions to clarify and strengthen the justification provided in the package for proceeding under the compliance exception of 10 CFR 50.109, e.g.:

   a. Highlight the fact that after May 1992 the Emergency Notification System (ENS), required explicitly by NRC regulations, can no longer be practicably maintained in its present configuration due to unavailability of key components. Therefore, in the absence of an acceptable alternative, licensees will be unable to demonstrate compliance with the requirement for that essential communications link after that date. The NRC has determined that FTS-2000 is sufficiently reliable to be an acceptable alternative for ENS purposes; and it is less costly than other available alternatives (e.g., satellite link, microwave link, foreign exchange lines).

   b. Note explicitly that upgrading of the Emergency Response Data System (ERDS), also required explicitly by regulation, is already underway using FTS-2000; and the proposed overall ETS upgrade is consistent with that agency action.

   c. Cite the extensive background (e.g., regulations, approved guidance, Commission Papers, etc.) that has established the agency position that providing the seven essential ETS communications links identified in this package (i.e., ENS and ERDS <u>plus</u> the RSCL, HPN, PMCL, MCL, and LAN links) is an acceptable means of complying with the overall requirement for reliable emergency commications capability. Also state that the NRC has determined in connection with this proposed action that all seven essential ETS communications pathways should be upgraded by use of FTS-2000 in order to ensure the needed reliability for ETS, and complete compatibility among all of the component parts of ETS.

   All changes made to the package in response to this recommendation should be closely coordinated with the CRGR staff prior to final issuance of the generic letter.

2. As a separate matter, to be pursued on a basis not to interfere with expeditious issuance of the generic letter and implementation of the needed ETS upgrades identified in this package, the Committee recommended that the staff examine whether adequate consideration was given previously to the possible need for an eighth essential emergency communications link, dedicated to use by NRC/licensee safeguards officials in the case of an emergency situation involving significant safety and safeguards elements simultaneously.

PRESENTATION OF DRAFT GENERIC LETTER ON EMERGENCY TELECOMMUNICATIONS TO CRGR

BY:
R. WESSMAN, AEOD
T. KELLAM, IRM

AUGUST 27, 1991

Attachment to
Enclosure 3

Mtg 209
Wessman - AEOD

BACKGROUND
SIGNIFICANT COMMISSION DISCUSSION

- SECY-87-290 (NOVEMBER 27, 1987)
  - -PROPOSED 3 ALTERNATIVE SYSTEM UPGRADES
  - -DESIGNS FEATURED REDUNDANCY AND DIVERSITY
  - -SATELLITE AND TERRESTRIAL NETWORK

- SECY-89-340 (NOVEMBER 2, 1989)
  - -UPDATED COMMISSION ON STATUS AND SCHEDULE
  - -DISCUSSED NEED FOR RULEMAKING

- SECY-91-149 (MAY 21, 1991) RECOMMENDATIONS
  - -INSTALL FTS 2000
  - -EVALUATE RISK/NEED FOR REDUNDANT AND DIVERSE PATH

BACKGROUND
CURRENT EMERGENCY TELECOMMUNICATIONS

CIRCUIT	SERVICE PROVIDER	PROBLEMS
ENS	NRC/DEDICATED	OBSOLETE HARDWARE HIGH COST
HPN	NRC/PSN	PSN BLOCKAGE
RSCL	LICENSEE/PSN	PSN BLOCKAGE
PMCL	LICENSEE/PSN	PSN BLOCKAGE
MCL	LICENSEE/PSN	PSN BLOCKAGE
LAN ACCESS (E-MAIL)	LICENSEE/PSN	PSN BLOCKAGE
ERDS	NRC/PSN/FTS2000	PSN BLOCKAGE

DISCUSSION
CURRENT STATUS

- ENS SERVICE LIFE EXTENSION
- FTS 2000
- SATELLITE SYSTEM STATEMENT OF WORK
- RISK ANALYSIS

DISCUSSION
GENERIC LETTER

- UPGRADES NRC EMERGENCY TELECOMMUNICATIONS TO AVOID OBSOLESCENCE AND ENSURE AVAILABILITY

- NECESSARY TO MAINTAIN COMPLAINCE WITH CURRENT EMERGENCY TELECOMMUNICATIONS REQUIREMENTS
  - -10 CFR 50.47 (b)(6)
  - -10 CFR PART 50 APPENDIX E, IV.E.9d

- REQUIRES LICENSEES TO:
  - -PROVIDE INSIDE WIRING
  - -INSTALL NRC PROVIDED TELEPHONES
  - -ESCORT NRC CONTRACTOR FOR SERVICE INSTALLATION
  - -REVISE PROCEDURES AS APPROPRIATE FOR ENS DIALING
  - -IN SOME CASES PROVIDE SPACE AND DEDICATED POWER FOR MULTIPLEXING EQUIPMENT

DISCUSSION
COSTS

- LICENSEE COSTS
  - -$2.5K FOR INSIDE WIRING
  - -CABLE INSTALLATION FROM CENTRAL OFFICE NOT INCLUDED
  - -SPECIAL INSTALLATIONS (i.e. PENETRATION OF VITAL AREAS OR INTER CAMPUS WIRING) NOT INCLUDED
- NRC COSTS
  - -$1.3M INSTALLATION COSTS
  - -1 FTE (SUPPORTED BY CURRENT STAFFING)
  - -$300K SYSTEM INTEGRATION CONTRACT
  - -$23.1K ANNUAL OPERATING COST
- NRC COSTS MORE THAN OFFSET BY CURRENT $4.4M ANNUAL COST OF EMERGENCY TELECOMMUNICATIONS

Enclosure 4 to the Minutes of CRGR Meeting No. 209
Proposed Supplement to Generic Letter 88-01 to Modify
Augmented Inspection Requirements Relating to IGSCC in BWR Piping

August 27, 1991

TOPIC

B.D. Liaw (NRR) and W. Koo (NRR) presented for CRGR review a proposed generic letter to modify some aspects of the augmented inspection requirements contained in GL 88-01 for detection of intergranular stress corrosion cracking (IGSCC) in BWR austenitic stainless steel piping. The proposed changes include relaxations of existing staff positions on IGSCC inspections, and clarifications of other IGSCC positions. The staff requested waiver of formal review of this package by CRGR; but the Committee reviewed the item because of possible safety implications of proposed relaxation of IGSCC inspection frequencies in reactor water cleanup piping, and because some of the clarifications arguably involved backfitting. Copies of the briefing slides used by the staff to guide their presentation and discussion with the Comittee on this item are enclosed (Attachment 1).

BACKGROUND

1. The documents submitted for CRGR consideration in this matter were transmitted by memorandum, dated August 1, 1991, F.J. Miraglia to E.L. Jordan; the package included the following documents:

   a. Revised cover letter for the review package. (An earlier version of this letter was submitted to CRGR previously to transmit proposed relaxations to IGSCC inspection requirements; however, the earlier package was withdrawn by the staff in order to include new staff positions on IGSCC inspection as well as relaxations, as reflected in the current package.)

   b. Draft Generic Letter No. 88-01, Supplement 1 (undated), "NRC Position on IGSCC in BWR Austenitic Stainless Steel Piping"

   c. NRC Staff Responses to CRGR Charter, Section IV.B. (Contents of Packages Submitted to CRGR)

2. CRGR members were also provided copies of a letter, dated July 31, 1991, BWR Owners' Group to E.L. Jordan, regarding schedule of CRGR review of the proposed Generic Letter Supplement (Attachment 2).

COMMENTS/RECOMMENDATIONS

As a result of their review of this matter, the Committee recommended in favor of issuing the proposed supplement, subject to the minor revisions given below. The Committee agreed specifically with the staff view that the proposed generic letter contains only relaxations and clarifications of the existing staff positions in GL 88-01; it does not impose new requirements or staff positions on affected licensees.

Specific changes recommended by the Committee in the proposed Supplement are as follows:

1. At p.3 of the draft Supplement, change the last sentence under subparagraph (1) to read as follows:

   "Thus, RCS leakage measurements should be taken at least once per shift, not to exceed 12 hours."

2. At p.3 of the draft Supplement, rearrange/revise subparagraph to read as follows:

   "The staff found that the radiation level associated with the RWCU system outboard of the containment isolation valves is very high; and this portion of piping is designed to be isolable and is generally classified as nonsafety piping. Affected licensees requested that they be exempt from GL 88-01 with regard to the inspection of this piping. However, the service-sensitive stainless steel RWCU system piping is subject to the most aggressive environment with regard to IGSCC; therefore, until the actions associated with GL 89-10 on MOVs is completed by licensees, the staff determined that an inspection of the subject piping on a sampling basis...should be performed...to ensure structural integrity of the piping."

3. At pp.3-4 of the draft Supplement, revise the last sentence of subparagraph (3) to read as follows:

   "Therefore, the staff finds that manual leak rate measurements can be acceptable alternatives during the period (30 days) when the drain sump monitoring system is being restored, provided the licensee demonstrates their suitability with regard to accuracy and inspectability."

4. At p.4 of the draft Supplement, add a new phrase to begin subparagraph (5) as follows:

   "Consistent with Code requirements and the licensee's written commitments, when weld overlays...."

All changes made to the Supplement in response to these recommendations should be closely coordinated with the CRGR staff prior to issuance of the final Generic Letter Supplement.

BACKGROUND - SUPPLEMENT TO GL 88-01

- DISCUSSED STAFF POSITIONS IN 7 ITEMS
  - 3 ITEMS: -MODIFIED STAFF POSITIONS
    -HARDSHIP CONSIDERATIONS
  - 4 ITEMS: -CLARIFICATIONS & GUIDANCE

- IDENTIFIED DURING IMPLEMENTATION OF GL 88-01
  - RESPONSES TO GL 88-01
  - RESULTS OF IGSCC INSPECTION

- RESOLUTIONS OF HARDSHIP ISSUES
  - BWR OPERATORS
  - BWR OWNERS GROUP

- NO ADDITIONAL ACTIONS REQUIRED FROM LICENSEES

- NO CHANGE IN THE BASIS OF BACKFITTING
  - REGULATORY COMPLIANCE

- BENEFITS:
  - REDUCE BURDEN ON LICENSEES WITHOUT LOSS OF SAFETY BENEFITS
  - TO FACILITATE IMPLEMENTATION OF GL 88-01 BY GENERIC ACTION

Attachment 3 to Enclosure 4

Mtg 209 Liow/Koo-NRR

PROPOSED SUPPLEMENT TO GL 88-01

- UNIDENTIFIED LEAKAGE MONITORING FREQUENCY
- INSPECTION OF RWCU SYSTEM PIPING
  - OUTBOARD OF THE CONTAINMENT ISOLATION VALVES
- OUTAGE OF LEAKAGE MEASUREMENT INSTRUMENTS
- SAMPLE EXPANSION OF CATEGORY D WELDS
- ASSESSING SHRINKAGE EFFECTS
  - RESULTING FROM WELD OVERLAY REPAIR & SI
- TECH SPEC AMENDMENT -ISI STATEMENT
- TECH SPEC AMENDMENT -LEAKAGE DETECTION

RELAXED STAFF POSITIONS

- **UNIDENTIFIED LEAKAGE MONITORING FREQUENCY**

GL 88-01	SUPPLEMENT
EVERY 4 HRS	EVERY 8 HRS OR EVERY SHIFT

- **INSPECTION OF RWCU SYSTEM PIPING**
  - OUTBOARD OF THE CONTAINMENT ISOLATION VALVES

GL 88-01	SUPPLEMENT
100%	10% EACH REFUELING OUTAGE

- **OUTAGE OF LEAKAGE MEASUREMENT INSTRUMENTS**

GL 88-01	SUPPLEMENT
24 HRS	24 HRS, WHEN MANUAL METHODS ALSO FAILED

CLARIFICATION AND GUIDANCE

- SAMPLE EXPANSION OF CATEGORY D WELDS
  - SAMPLE EXPANSION WILL APPLY TO CATEGORY D WELDS IF INSPECTED ON A SAMPLING BASIS

- ASSESSING SHRINKAGE EFFECTS RESULTING FROM WELD OVERLAY REPAIR & STRESS IMPROVEMENT (SI)
  - STRESS ANALYSIS/DESIGN BASIS IN PIPING SYSTEM
  - PIPE WHIP RESTRAINTS & SUPPORTS
  - EFFECT OF INCREASED DEAD WEIGHT & STIFFNESS FROM OVERLAY

- TECH SPEC AMENDMENT RELATING TO ISI & LEAKAGE DETECTION
  - ISI SECTION WILL STAY IN IMPROVED TS.
  - INCORPORATION INTO AN ADMINISTRATIVE DOCUMENT IS NOT ACCEPTABLE.

(B)

AUGMENTED RWCU INSPECTION

- o NRC PROPOSED POSITION: 100% WELD INSPECTIONS REDUCED TO 10% INSPECTION

- o BWROG PROPOSED INSPECTION : 0% WELD INSPECTIONS WITH:

  1) GL 89-10 COMPLETION ON RWCU VALVES

  - OR -

  2) SECTIONS REPLACED WITH IGSCC RESISTANT MATERIALS

  - OR -

  3) STRESS IMPROVED SECTIONS

- o CONCERN: AUGMENTED INSPECTION REQUIREMENTS

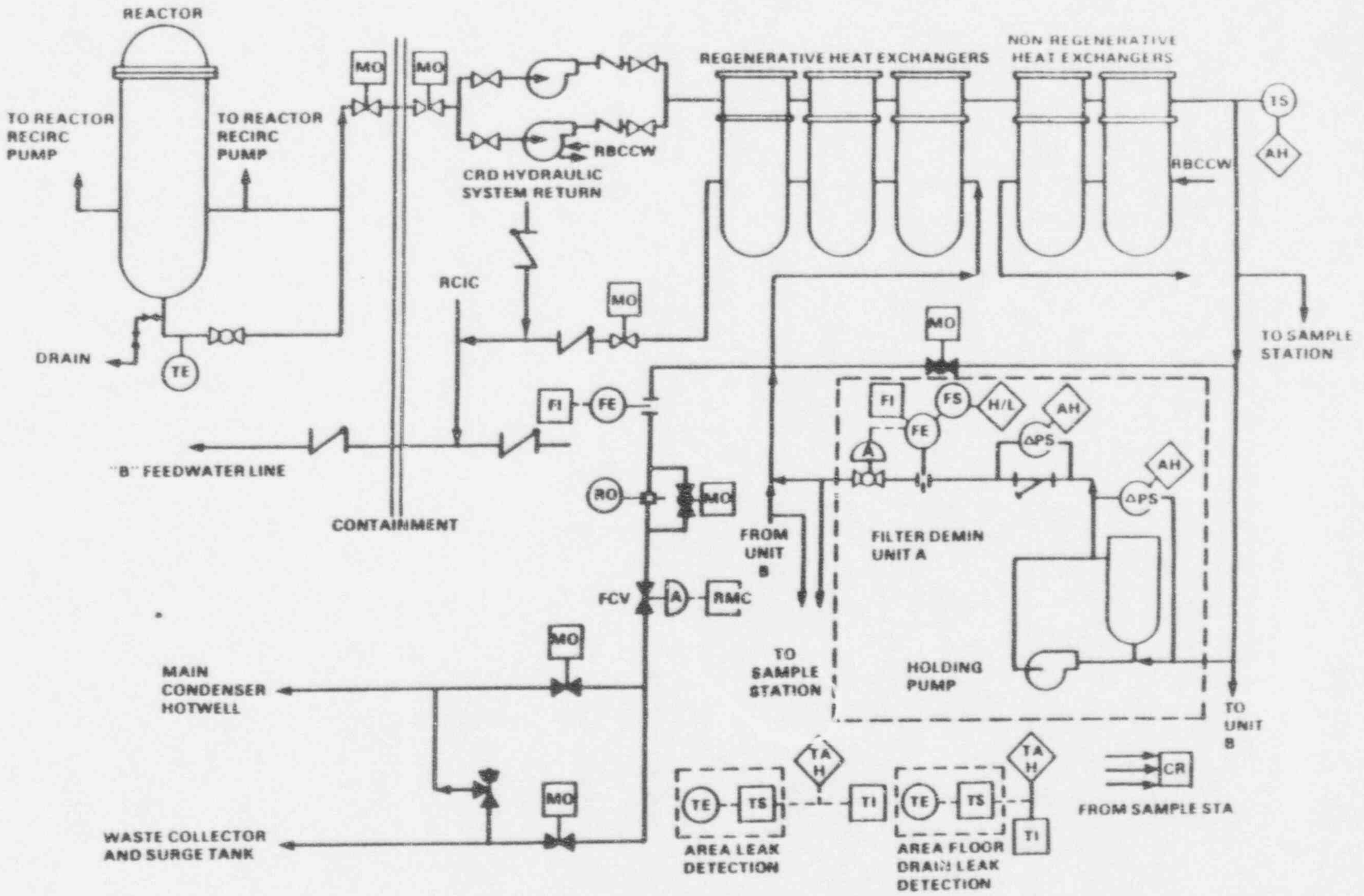
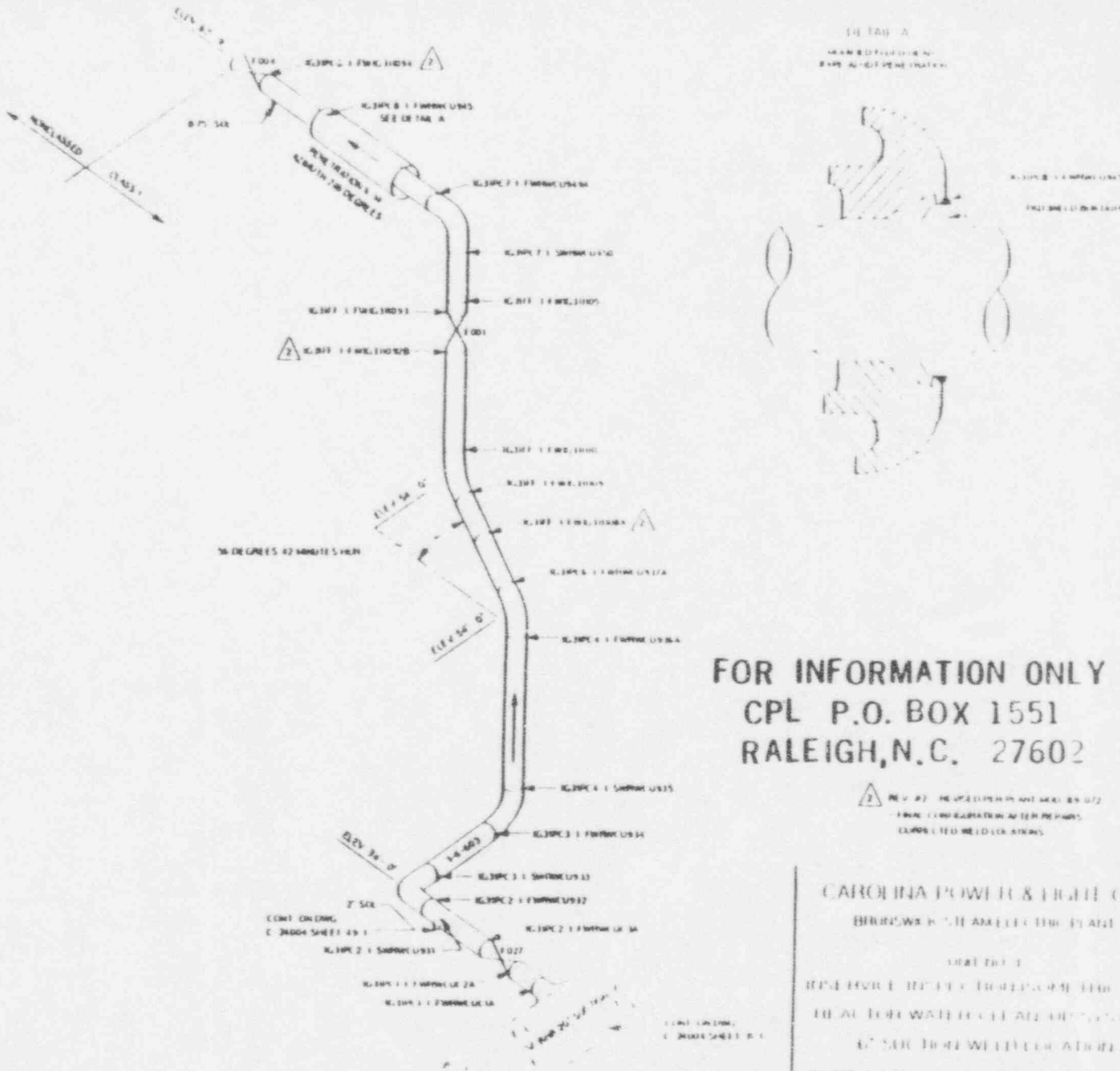


FIGURE 4.1-1 REACTOR WATER CLEAN-UP SYSTEM

0679



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CAROLINA POWER & LIGHT CO.
BRUNSWICK STEAM ELECTRIC PLANT

APPROVED BY S. D. CONNELLY

May 29, 1991
CHF-91-019

NUTECH ENGINEERS

Mr. Frank J. Miraglia, Jr.
Associate Director for Projects
Office of Nuclear Reactor Regulation
U.S. Nuclear Regulatory Commission
Washington, D.C. 20555

Subject: Effects of IGSCC Mitigation and Repair Techniques on Piping System Supports

Dear Mr. Miraglia:

It has recently come to our attention that the cumulative application of intergranular stress corrosion cracking (IGSCC) mitigation and/or repair techniques may affect the piping support components of a treated/repaired system. The application of a significant number of weld overlay repairs at three domestic Boiling Water Reactors appears to have caused upward movement of the Reactor Recirculation system ring headers. The owner of these plants has asked us to inform you that cumulative weld overlay repair axial shrinkage on each of the vertical risers has changed the air gaps of pipe whip restraints and the normal set-points of variable spring hangers (a more detailed discussion is presented in attached NUTECH Document No. COE-45-098).

Subsequent analyses have found that these air gap and set-point changes have not affected the operability of these systems, though hardware adjustments were required to both whip restraints and spring cans in order to restore their full design margins. It is recommended that any plant that has applied or will be applying repairs or stress improvement techniques which can change the axial length of significant numbers of piping system components address these effects. Both the affected piping system supports and the sustained stress level at each unrepaired and/or stress-improved weldment should be evaluated.

If you need additional information, please contact Jim Brown in NUTECH's Westmont, Illinois office at (708) 789-2800 or me at (408) 629-9800.

Very truly yours,

Carl H. Froehlich

Carl H. Froehlich, P.E.
Engineering Manager
Fracture Mechanics &
IGSCC Resolution Services

9404300258

NUTECH Engineers, Inc. 145 Martinvale Lane San Jose, California 95119 (408) 629-9800 Fax (408) 281-5186

cc: All GL 88-01 Respondees
W. H. Koo (USNRC)
EPRI (Palo Alto/Charlotte)

NUTECH
ENGINEERS

EFFECTS OF IGSCC MITIGATION AND REPAIR TECHNIQUES ON PIPING SYSTEM SUPPORTS

Prepared by: C. H. Froehlich
& J. A. Brown

Abstract

It has recently been discovered that the cumulative application of intergranular stress corrosion cracking (IGSCC) mitigation and/or repair techniques may affect the piping support components of a treated/repaired system. The application of a significant number of weld overlay repairs at three domestic Boiling Water Reactors appears to have caused upward movement of the Reactor Recirculation system ring headers. Cumulative weld overlay repair axial shrinkage on each of the vertical risers has changed the air gaps of pipe whip restraints and the normal set-points of variable spring hangers.

Subsequent analyses have found that these air gap and set-point changes have not affected the operability of these systems. However, it is recommended that any plant that has applied or will be applying repairs or stress improvement techniques which can change the axial length of significant numbers of piping system components address these effects. Not only should the effects on the sustained stress level at each unrepaired and/or stress-improved weldment be evaluated, but also the affected piping system supports.

Background

As discussed in Appendix A of United States Nuclear Regulatory Commission (USNRC) Document NUREG-0313, Revision 2 (Reference 1), the magnitude of both residual and service (applied) stresses present during normal operation must be known or assumed in order to perform a flawed pipe evaluation. To predict IGSCC growth, a "sustained stress" load combination including deadweight, internal pressure, and restraint-of-free end displacement thermal expansion loads must be determined. Since at least 1984, the USNRC has required that this load combination also include the effects of weld overlay repair axial shrinkage on a piping system receiving an overlay repair(s).

Recent Industry Experience

Since late 1989, it has become apparent that axial length change effects must also be addressed relative to their impact on the support systems of repaired piping systems. Quad Cities Nuclear Power Station Units 1 & 2 and Dresden Nuclear Power Station Unit 2 each have weld overlay repairs on at least one weld of almost every vertical riser on the pump discharge-side of their Reactor Recirculation systems. The overlays were applied during three different refueling outages at each of these units since late 1983. During a piping system support walkdown performed at the Quad Cities Unit 1 1989 outage, it was observed that the normal set-points on variable spring hangers and the air gaps between the ring header and its pipe whip restraints were just beyond their maximum allowable tolerance. This same out-of-tolerance condition was also observed at the Quad Cities Unit 2 and Dresden Unit 2 1990 outages. Although a root cause analysis has not yet been completed, it appears that these out-of-tolerance conditions were caused by upward movement of the ring header due to weld overlay axial shrinkage on the vertical risers. Piping system analyses performed for all three plants show that the affected piping systems met FSAR/UFSAR stress criteria during their operation even with these out-of-tolerance supports. However, to bring the subject supports back to their original "as-analyzed" condition, pipe support adjustments have been/will be made at each unit.

Generic Issue

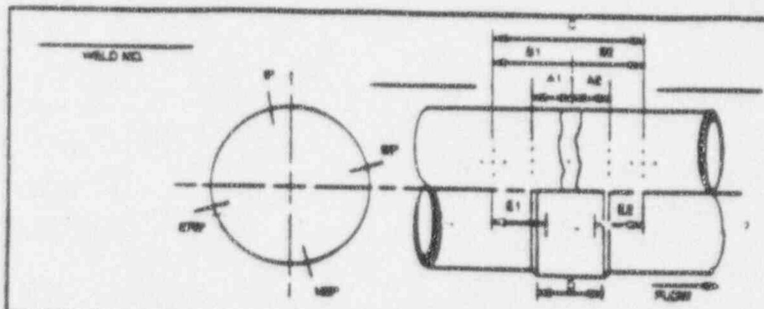
The nuclear power industry has been aware of the effects of weld overlay repair axial shrinkage on flawed pipe evaluations since 1984 and stress improvement effectiveness evaluations for the past few years. However, due to the application of a large number of weld overlay repairs at Quad Cities Units 1 & 2 and Dresden Unit 2, performed on a piecemeal basis over the past six to seven years, cumulative shrinkage effects on the supports of repaired piping systems were not recognized until recently. It is, therefore, recommended that any plant that has applied or will be applying significant numbers of weld overlay repairs address their effect not only in flawed pipe and stress improvement effectiveness evaluations, but also on the supports of repaired piping systems.

Attachment 1

TYPICAL WELD OVERLAY REPAIR DATA SHEET

WELD NO. ______

TRAVELER NO. ______



DESIGN DIMENSIONS	A1	A2	B1	B2	C	D	E1	E2	THICKNESS UPSTREAM	THICKNESS DOWNSTREAM

PREPARED BY/DATE ______ CHECKED BY/DATE ______ REVIEWED BY/DATE ______

Define 0° location: ______

NOTES

1. Azimuths are read clockwise looking in direction of flow.
2. Overlay Thickness = Total Thickness - (Pipe Wall + Last Delta Layer(s) Thickness).
3. C = Shrinkage measurement taken after [illegible] "C" does not equal B1 + B2 [illegible].
4. D = Width of overlay at design thickness.
5. E1 & E2 should be to a point approximately 1/2" [illegible] of overlay [illegible].
6. If first layer delta ferrite is acceptable, UT thickness check of this layer is not required.

DELTA FERRITE		MEASUREMENTS (8)	
		E1	E2
AFTER FIRST OVERLAY LAYER	0		
	90		
	180		
	270		
AFTER SUBSEQUENT FIRST OVERLAY LAYER	0		
	90		
	180		
	270		

Record Calibrated Instrument Number(s) for Thickness Measurements	
BEFORE OVERLAY	
AFTER FIRST LAYER	
AFTER OVERLAY	

Record Calibrated Instrument Number(s) for Shrinkage Measurements	
BEFORE OVERLAY	
AFTER OVERLAY	

Record Calibrated Instrument Number(s) for Delta Ferrite Measurements	
AFTER FIRST LAYER	
AFTER SUB. FIRST LAYER	

AS-BUILT DIMENSIONS		A1	A2	B1	B2	C	D	THICKNESS UPSTREAM	THICKNESS DOWNSTREAM
BEFORE OVERLAY	0								
	90								
	180								
	270								
AFTER FIRST OVERLAY LAYER (S)	0								
	90								
	180								
	270								
AFTER OVERLAY	0								
	90								
	180								
	270								

AVERAGE SHRINKAGE	

AVERAGE LENGTH	

AVERAGE THICKNESS UPSTREAM	AVERAGE THICKNESS DOWNSTREAM

PREPARED BY/DATE ______ CHECKED BY/DATE ______

[illegible]