Table A.1 Gall Report for NRC Generic Letters

Document: GL Letters, NRC Generic Letters, 1989-1994
Reviewed by: Dwight R. Diercks, ANL

Effect of Aging on Component Function	Contrib to Failure	Reported progs	Rel.progs	Report Recommendations	Page No.	Item
Erosion/corrosion caused by high-velocity flow of water through piping has caused several incidents of piping failure or wall thinning below ASME Code allowables.	Moderate	NUREG-1344		Implement long-term erosion-corrosion monitoring programs. [4]	89-08	1
Fluctuations in water temperature within BWR vessel in nozzle region produces high-cycle fatigue and resulting crack initiation and growth in nozzles.	Frequent	NUREG-0619		Not stated	89-21, p. 5	2
Fracture toughness of support materials may be inadequate, creating the potential for fracture or lamellar tearing in service.	Not stated	NUREG-0577		Maintain minimum temperature above fracture transition temperature; replace supports if necessary [4]	89-21, pp. 6	3
The gradual buildup of macroscopic biological fouling organisms (e.g., blue mussels, American oysters, Zebra mussels, and Asiatic clams) inhibits coolant flow, ultimately resulting in flow rates below technical specifications.	Frequent	NUREG/CR-5210; NUREG/CR-5234		Implement surveillance and control program outlined in Generic Letter 89-13[4]	89-13; 89-13, Suppl. 1	4
Combination of residual or service stresses, sensitization from welding, and oxygenated cooling water can cause IGSCC of piping, resulting in leakage.	Formerly frequent	NUREG-0313		Follow recommendations in NUREG-0313. [4]	89-21, p. 11	5
Neutron irradiation over extended time periods can cause embrittlement of the reactor pressure vessel material, particularly near the beltline, resulting in loss of impact resistance and possible failure in a severe pressurized overcool event	Not stated	NUREG-0744:ASTM E-185;Reg. Guide 1.99, Rev. 2		Follow NUREG-0744 methods for evaluating Charpy upper shelf impact strength. [4]	89-21, pp. 5-6, 16; 92-01, Rev. 1	6

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Item	System	Structure/Comp	Subcomponent	Materials	Manufacturer	ARD mechanism	ARD effects
1	Cooling system	Valves	Carbon steel valve bodies	Carbon steel	Not stated	ERO/CAV	Loss of material
2	Cooling system	Coolant pump	Pump shaft	A-286	Byron Jackson	FAT	Cumulative fatigue damage
3	Cooling system	Coolant pump	Ring surrounding bearing housing	Not stated	Byron Jackson	Not stated	Not stated
4	Cooling system	Steam generator	Tubing mechanical plugs	Inconel 600	Westinghouse	CORR/PWSCC	Crack initiation and growth
5	Cooling system	Steam generator	Tubing mechanical plugs	Inconel 600	Babcock & Wilcox	CORR/PWSCC	Crack initiation and growth
6	Cooling system	Steamlines	Atmospheric dump valves	Not stated	Control Components, Inc.	CONTAM	Loss of desired surface properties
7	(Various water systems)	Pumps	Impeller, bushings, and other internal components	Brass bushings; other materials not stated.	Not stated	ERO/CAV; VIBR	Loss of material; physical damage
8	Electrical control system		Electrical cable insulation	Neoprene chloroprene and other organic polymers	Not stated	ELE-TEMP	Chemical and physical degradation
9	Turbine	High-press. steam extraction line	14-in. piping	Carbon steel	Not stated	ERO/CORR	Wall thinning
10	Containment system	Containment structure	Steel shell	(Carbon?) steel	Not stated	CORR/BA	Loss of material

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Item	System	Structure/Comp	Subcomponent	Materials	Manufacturer	ARD mechanism	ARD effects
1	Service water system	Check valve	Swing arm	17-4 PH stain-less steel, H1100 heat treatment	Borg-Warner	CORR/SCC	Crack initiation and growth
2	Service water system	Motor-operated butterfly valve	Valve seat	Not stated	BIF/General Signal Corp.	ENVIR	Physical degradation
3	Service water system	Piping and heat exchangers	Valve seat	Not stated	Not stated	CONTAM	Buildup of deposits

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Effect of Aging on Component Function	Contrib to Failure	Reported progs	Rel.progs	Report Recommendations	Page No.	Item
Significant localized wall thinning of 16- and 24-in. valve bodies apparently caused by cavitation can lead to rupture.	Not stated	Not discussed in report		Not stated	89-01	1
Abrupt decoupling of pump shaft and impeller probably caused by shaft fracture or failure of cap screws and drive pins, resulting in pump failure. Root cause is undetermined, but possibly fatigue.	Not stated	Not discussed in report		Use improved vibration monitoring system to detect growing cracks in shaft [2]	89-15	2
Failure of attachment weld was repaired by fillet welds that failed four years later, resulting in pump failure and loose parts in the recirculation loop.	Not stated	Not discussed in report		Repair with full-penetration welds and realignment of ring. [2]	89-20	3
Intergranular cracking, apparently associated with improper heat treatment and/or susceptible heats of material, can cause mechanical tube plugs to loosen, leak, and sometimes be forcibly ejected, causing additional tube damage.	Not stated	Not discussed in report		Replace plugs from suspect heats of material; discontinue use of Westinghouse plugs. [4]	89-33; Bull. 89-01, 89-01, Suppl. 1 & 2.	4
Intergranular cracking, apparently associated with intragranular carbides and relatively little intergranular precipitation improper heat treatment and susceptible heats of material, could lead to possible plug failure.	Not stated	NRC Bull. 89-01		Conduct eddy current inspections of installed plugs. [4]	89-65	5
Foreign particles from steamlines lodge in valve clearance areas and on sealing surfaces, resulting in leakage past valve plug piston ring and consequent valve malfunctioning.	Not stated	Not discussed in report		Design modifications have been implemented by the manufacturer [1]	89-38	6
Repeated operation of the pumps at 60% or less of their design flow resulted in slow deterioration of internal components, causing eventual loss of pump function.	Not stated	Not discussed in report		Avoid sustained operation of pumps at low flow rates [4]	89-08	7
Prolonged exposure of electrical cable insulation to temperatures above their environmental qualification (EQ) design temperature, e.g., in reactor containment, can lead to insulation breakdown and failure.	Not stated	NRC Temporary Instruction 2515/98		Provide better containment cooling to maintain temperatures below the EQ temperature [4]	89-30	8
Abrupt change in I.D. at nozzle-to-pipe connection apparently causes flow turbulence, leading to accelerated erosion-corrosion of adjacent piping.	Not stated	NRC Bull. 87-01		Not stated	89-53	9
Boric acid leaking from instrument line compression fittings condenses on the outer surface of the containment steel shell, resulting in general and pitting corrosion.	Not stated	10CFR50, Appendix J		Containment in-service inspection for wall thinning by corrosion [4]	89-79; 89-79, Suppl. 1	10

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Preexisting casting defects, including porosity, hot cracks, and weld repairs, plus improper heat treatment, resulted in propagating cracks in the high chloride service water that caused fracture and loss of function.	Not stated	Aerospace Materials Spec. 5398A and Mil. Spec. MIL-H-6875		Replace with parts from another vendor; inspect parts for flaws before installation. [4]	90-03	1
Valve seat material hardens with time under service conditions, causing increase in coefficient of friction and possible failure of valve to open.	Not stated	GL 89-10		Set open torque switch to maximum value; test and inspect valves. [4]	90-21	2
Accumulation of silt and corrosion products in piping reduced emergency water flows to levels below design basis conditions.	Not stated	10CFR50, Append. A and B		Cleaning of contamination and adjustments in flow distribution [4]	90-39	3

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Item	System	Structure/Comp	Subcomponent	Materials	Manufacturer	ARD mechanism	ARD effects
4	Service water system	Containment air coolers	Tubes	Not stated	Not stated	CONTAM	Buildup of deposits
5	Service water system	Service water lines	Check valves	Not stated	Not stated	CONTAM	Buildup of deposits
6	Service water system	Piping		Not stated	Not stated	CORR; CORR/MIC	Loss of material; corrosion product buildup
7	Cooling system	Steam generator	Upper shell-to-transition cone girth welds	Not stated	Westinghouse and Combustion Engineering	CORR; FAT/THERM	Loss of material; cumulative fatigue damage
8	Cooling system	Steam generator	Tubes	Not stated	Westinghouse and Combustion Engineering	CORR/SCC	Crack initiation and growth
9	Cooling system	Pressurizer	Pressurizer heater thermal sleeves	Inconel 600	Not stated	CORR/PWSCC	Crack initiation and growth
10	Cooling system	Coolant pumps	Bolts fastening turning vanes	A453, Gr. 660 (Alloy A-286)	Not stated, but similar to Westinghouse design	CORR/IGSCC	Crack initiation and growth
11	Pressure vessel	Pressure vessel upper head	Weld cladding and base-metal heat-affected zone	Not stated	Not stated	CORR/SCC	Crack initiation and growth

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Item	System	Structure/Comp	Subcomponent	Materials	Manufacturer	ARD mechanism	ARD effects
1	Cooling system	Moisture separator drain	6-inch, schedule 40 piping	Carbon steel	Not stated	ERO/CORR	Wall thinning
2	Cooling system	Feedwater regulating valve bypass line	6-inch piping	Carbon steel	Not stated	ERO/CORR	Wall thinning
3	Cooling system	Low-pressure drain system	Piping	Carbon steel	Not stated	ERO/CORR	Wall thinning
4	Cooling system	Flow-measuring-orifice	Orifice flange	Carbon steel	Not stated	ERO/CORR	Wall thinning
5	Cooling system	Moisture separator reheater	8-inch elbow	Carbon steel	Not stated	ERO/CORR	Wall thinning
6	Cooling system	Steam generators	Feedwater distribution feedring piping	Carbon steel	Combustion Engineering	FAT/THERM;ERO/CORR	Cumulative fatigue damage; wall thinning

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Effect of Aging on Component Function	Contrib to Failure	Reported progs	Rel.progs	Report Recommendations	Page No.	Item
Buildup of silt and corrosion products in containment air cooler tubes reduced service water flow rates to unacceptable levels.	Not stated	10CFR50, Append. A and B		Remove deposits [4]	90-39	4
Buildup of silt in emergency water service line check valve could have prevented system from functioning.	Not stated	10CFR50, Append. A and B		Remove deposits [4]	90-39	5
Acidic well water and MIC have resulted in a corrosion pitting rate of 24 mils per year in the affected components.	Not stated	10CFR50, Append. A and B		Chemically clean system and/or replace pipe [4]	90-39	6
Corrosion fatigue from thermal cycling, dissolved oxygen in feedwater, and Cu alloys in feedwater system result in crack initiation at surface corrosion pits and subsequent crack growth into girth welds.	Not stated	Not discussed in report		Perform more frequent inspections of affected region. [4]	90-04	7
Secondary side-initiated cracking of steam generator tubes, typically in the expansion transition near the tubesheet or at the support plate, has resulted in leaking cracks in several PWRs.	Not stated	Not discussed in report		Plug leaking tubes; develop improved NDE techniques to detect cracks [4]	90-49	8
Residual stresses from reaming or roll joining plus a susceptible Inconel 600 microstructure and the PWR coolant environment lead to PWSCC and leakage.	Not stated	Not discussed in report		Implement augmented inspection program. [4]	90-10	9
Alloy A-286 is subject to IGSCC at peak stresses >100 ksi, depending upon Cr content, fabrication practice, and environment. The present failures occurred in foreign reactors and threatened coolant pump function.	Not stated	B&W Owner's Group Report BAW-1842		Discontinue the use of Alloy A-286 as a reactor structural material. [4]	90-68	10
Grinding residual stresses, low delta-ferrite content, and high dissolved-oxygen in the coolant induce interdendritic SCC of weld cladding, and resulting cracks propagate into underlying base metal, possibly threatening structural integrity.	Not stated	General Electric Co. RICSIL No. 050		PT of back-clad region for surface cracks and enhanced UT for subsurface cracks. [4]	90-29	11

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High-velocity turbulent flow of water through piping caused wall thinning by erosion/corrosion and resulted in pipe rupture and actuation of fire-protection deluge system.	Not stated	Not discussed in report		System found to be susceptible by EPRI CHEC code and should have been inspected [4]	91-18	1
High-velocity turbulent flow of water through piping caused wall thinning by erosion/corrosion and resulted in steam leak and repair outage.	Not stated	Not discussed in report		Failed piping replaced [4]	91-18	2
High-velocity turbulent flow of water through piping caused wall thinning by erosion/corrosion and resulted in piping rupture.	Not stated	Not discussed in report		Failed piping temporarily replaced with A106, Gr. B; permanent replacement to be A335-P22. [4]	91-18	3
High-velocity turbulent flow of water through piping caused wall thinning by erosion/corrosion and resulted in flange rupture.	Not stated	Not discussed in report		Failed flanges temporarily replaced with same material; more-resistant material being considered for permanent replacement. [4]	91-18	4
High-velocity turbulent flow of water through piping caused wall thinning by erosion/corrosion and resulted in elbow rupture and actuation of fire-protection deluge system.	Not stated	Not discussed in report		System found to be susceptible by CHECMATE code and should have been inspected [4]	91-18, Suppl. 1	5
Cracking and wall thinning resulted in component failure and introduction of loose parts into secondary side of steam generator.	Not stated	Not discussed in report		Component redesigned for increased strength and erosion resistance. [4]	91-19	6

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Item	System	Structure/Comp	Subcomponent	Materials	Manufacturer	ARD mechanism	ARD effects
7	Cooling system	Steam generators	Tubing	Not stated	Mitsubishi (based on Westinghouse design)	FAT	Cumulative fatigue damage
8	Cooling system	Steam generators	Tubing	Not stated	Combustion Engineering	Not stated	Not stated
9	Cooling system	Steam generators	Tubing	Not stated	Babcock & Wilcox	FAT	Cumulative fatigue damage
10	Cooling system	1-inch accumulator fill line	Nozzle-to-pipe weld	Not stated	Not stated	FAT; VIBR	Cumulative fatigue damage; crack initiation and growth
11	Cooling system	Condensate storage tanks	Diaphragm	Not stated	Goodyear Co.; Lorel Corp.	ENVIR	Chemical or physical degradation

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Item	System	Structure/Comp	Subcomponent	Materials	Manufacturer	ARD mechanism	ARD effects
1	Cooling system	Steam generators	4-inch, schedule 80 feedwater piping	A106B carbon steel	Westinghouse	ERO/CORR	Wall thinning
2	Cooling system	Primary coolant loop	Reducing tee riser	Not stated	Not stated	ERO/CORR	Wall thinning
3	Cooling system	Pressurizer power-operated relief valves	Valve stems	SA 564, Type 630, H900-H1150 (17-4 PH) stainless steel	Rockwell International (now Edward Valve Co.)	EMBR/TE	Loss of fracture toughness
4	Emergency condenser system	Manual gate valves	Valve bodies	CF8M cast stainless steel	Not stated	FAT	Cumulative fatigue damage
5	Reactor internal support structure	Core shroud support plate	Welded access hole	Inconel 600 with Inconel 82 or 182 weld filler metal	General Electric	CORR/IGSCC	Crack initiation and growth

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Item	System	Structure/Comp	Subcomponent	Materials	Manufacturer	ARD mechanism	ARD effects
1	Emergency Core Cooling system	Residual heat removal pump	Thrust bearing	Not stated	Ingersoll-Rand	WEAR	Attrition
2	Emergency Core Cooling system	Residual heat removal pump	Discharge check valve lock wire	Not stated	Copes-Vulcan	FAT	Cumulative fatigue damage
3	Emergency Core Cooling system	Residual heat removal pump	Discharge check valve disk and hanger assembly	Stainless steel locking device; other parts not stated	Pacific Valve Engineering	VIBR	Loosening

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High-cycle fatigue failure of steam generator tube at uppermost support plate resulted in excessive primary-to-secondary leak rate.	Not stated	Not discussed in report		Incorrect insertion of antivibration corrected [4]	91-43	7
Cracking of steam generator tube at U-bend at a location where flow conditions permit contaminants to be deposited on the tube surface resulted in excessive primary-to-secondary leak rate.	Not stated	NRC Bull. 88-02, Fig. 1		Not stated	91-43	8
Tube cracking at lower face of upper tubesheet resulted in excessive primary-to-secondary leak rate.	Not stated	NRC Bull. 88-02, Fig. 1		Not stated	91-43	9
Two ruptures of the nozzle-to-pipe weld in the accumulator fill line during filling were caused by flow-induced vibration and resulted in spillage of coolant.	Not stated	Not discussed in report		Revise operation procedures [4]	91-50	10
Long-term deterioration of diaphragms in contact with their service environment results in the development of holes and tears, with consequent leaks and possible clogging of equipment.	Not stated	Not discussed in report		Replace diaphragms after 9 years or more frequently if indicated by inspections. [4]	91-82	11

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Effect of Aging on Component Function	Contrib to Failure	Reported progs	Rel.progs	Report Recommendations	Page No.	Item
High-velocity flow of water through piping caused wall thinning by erosion/corrosion and necessitated the replacement of 90 feet of piping for which the wall thickness was at or near the minimum allowable.	Not stated	Not discussed in report		Redesign piping to reduce flow velocity. [4]	92-07	1
High-velocity flow of water through reducing tee riser caused wall thinning by erosion/corrosion and necessitated component replacement because wall thickness was near the minimum allowable.	Not stated	NRC Bull. 87-01; NRC GL 89-08		Not stated	92-35	2
Valve stems are subject to secondary aging after several thousand hours at 600 F, resulting in increased susceptibility to fracture when subjected to excessive torque from power actuator.	Not stated	Not discussed in report		Not stated	92-60	3
Fatigue (possibly thermal) resulted in leaking cracks in at least one gate valve and partially through-wall cracks in several other valves.	Not stated	Not discussed in report		Not stated	92-50	4
Apparent IGSCC of welds joining access hole covers to shroud support plates resulted in circumferential cracking in weld region, with some cracks possibly propagating into the adjacent base metal.	Not stated	GE SIL No. 462, Suppl. 3		Perform periodic visual and UT examinations of region; repair procedures being developed [4]	92-57	5

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Effect of Aging on Component Function	Contrib to Failure	Reported progs	Rel.progs	Report Recommendations	Page No.	Item
Thrust load during normal operation exceeded design value, resulting in abnormally high wear of bearing and failure after approx. eight fuel cycles.	Not stated	Not discussed in report		Redesign pump to reduce bearing load; replace periodically. [4]	93-08	1
Inadequate disk nut torquing allowed nut to rotate back and forth. Resulting cyclic loading caused high-cycle fatigue failure of lock wire, loss of disk nut and washer, and check valve failure.	Not stated	Not discussed in report		Replace lock wire with 1/8-in. cotter pin [4]	93-16	2
Inadequate capscrew torquing, missing capscrews, and improper reuse of locking device results in capscrew loosening, loss of disk and hanger assembly, and check valve failure.	Not stated	Not discussed in report		Revise maintenance procedure to ensure correct installation. [4]	93-16	3

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Item	System	Structure/Comp	Subcomponent	Materials	Manufacturer	ARD mechanism	ARD effects
4	Emergency Core Cooling system	Residual heat removal pump	Coolant pump strainers and containment sump screens	Not stated	Not stated	CLOG	Blockage of flow passages
5	Emergency Core Cooling system	High-pressure coolant injection pump	Steam exhaust rupture disk	Stainless steel	Black Sivalls & Bryson, Inc.	Not stated	Not stated
6	Cooling system	Steam generators	Feedwater piping	Not stated	Westinghouse and Combustion Engineering	FAT/THERM	Cumulative fatigue damage
7	Cooling system	Piping	Feedwater piping and other components	Carbon steel	Not stated	ERO/CORR	Wall thinning
8	Cooling system	Turbine-driven feedwater pumps	Turbine stop valve	Not stated	Not stated	CONTAM	Loss of lubricant properties
9	Cooling system	Motor-operated gate and globe valves	Valve yoke	Case carbon steel	Walworth	FAT	Cumulative fatigue damage
10	Cooling system	Jet pump	Hold-down beam	Not stated	General Electric Co.	CORR/IGSCC; FAT	Crack initiation and growth; cumulative fatigue damage
11	Spent fuel storage system	Spent fuel storage racks	Boraflex neutron absorbing material	Polymer base with silica filler and neutron absorber (boron?)	Brand Industrial Services, Inc.	ENVIR	Physical degradation
12	Reactor internals	Core shroud	Beltline region welds	Stainless steel	General Electric Co.	CORR/IGSCC	Crack initiation and growth
13	Reactor internals	Fuel rods	Fuel rod cladding	Zircaloy	Westinghouse, Siemens, General Electric Co.	WEAR/FRET	Attrition

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Item	System	Structure/Comp	Subcomponent	Materials	Manufacturer	ARD mechanism	ARD effects
1	Electrical generating system	Turbines	Turbine blades	Not stated	General Electric Co.	FAT	Cumulative fatigue damage
2	Electrical generating system	Turbine low auto stop oil pressure switch	Plunger rod, bushing, and case	stainless steel and aluminum	Not stated	CORR	Corrosion product buildup
3	Cooling system	Steam generator	Kinetically weld-repaired tubes	Inconel 600	Babcock & Wilcox	CORR/PWSCC	Crack initiation and growth

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Foreign debris can block emergency core cooling screens and sumps, resulting in possible reduced emergency core cooling in and accident situation.	Not stated	Not discussed in report		Remove debris [4]	93-34 and 93-34, Suppl. 1	4
Rupture disk failed unexpectedly after 20 years of service, resulting in personal injuries. Cause of failure is unclear, but vendor speculated that an unspecified aging process may have caused the strength to degrade.	Not stated	Not discussed in report		Replace 20-year-old rupture disks with new ones. [4]	93-67	5
Thermal stratification in feedwater lines, particularly during cold, low-flow conditions, leads to rapid thermal fatigue loading, resulting in cracking and leakage.	Frequent	NUREG/CR-0691		Reduce severity of thermal cycles. [4]	93-20	6
Erosion/corrosion has been observed to cause excessive wall thinning and possible piping failure in numerous plants. Inspection and repair procedures are often inadequate.	Frequent	ASME Section XI, IWA 4100 and 4300		Develop improved inspection and repair procedures in accordance with ASME Section XI. [4]	93-21	7
Gradual buildup of contaminants in the control oil for the stop valve on the turbine-driven feed water pump caused the valve to stick open when the main turbine tripped, resulting in overfill of the pressure vessel.	Not stated	Not discussed in report		Flush oil system [4]	93-48	8
Preexisting defects, component design, and insufficient bolt torque can lead to the initiation and growth of fatigue cracks that could cause eventual component failure.	Not stated	Not discussed in report		Weld repair cracks; torque bolts sufficiently when reinstalling yokes. [4]	93-97	9
IGSCC that initiated at a machined radius propagated over ~80% of the cross-sectional area. The resulting loss of preload apparently led to fatigue crack growth and eventual component failure.	Not stated	Not discussed in report		Replace beams of similar design if in service for more than 8 years. [4]	93-101	10
Surveillance coupons of Boraflex tested after five years had degraded substantially. Similar degradation of the Boraflex used in the high-density spent fuel storage racks would result in loss of subcriticality margin in the pool.	Not stated	EPRI TR-101986		Not stated	93-70	11
IGSCC in the HAZ of core shroud circumferential welds near the beltline resulted in axial cracking that may compromise the structural integrity of the shroud.	Not stated	GE RICSIL 054, Rev. 1		Add stiffening braces to the top portion of the shroud. [4]	93-79	12
Debris-induced fretting and grid-to-rod flow-induced vibrational fretting can lead to cladding perforation and fuel rod failure.	Not stated	Not discussed in report		Install vibration damping; redesign core to reduce vibration. [4]	93-82	13

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Torsional excitation of the turbine-generator shaft from an electrical system disturbance causes vibration, resulting in separation of turbine blades by high-cycle fatigue.	Not stated	Not discussed in report		Not stated	94-01	1
Apparent galvanic corrosion between the SS plunger rod and the remaining Al parts caused corrosion product buildup and switch malfunction, resulting in an erroneous signal to the control computer and turbine overspeed.	Not stated	Not discussed in report		Not stated	94-11	2
Tubes repaired with kinetically welded sleeves may be susceptible to PWSCC adjacent to the sleeve because of residual stresses introduced, despite the post-weld heat treatment. Result is tube leakage.	Not stated	Not discussed in report		Not stated; problem still under investigation [4]	94-05	3

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4	Cooling system	Main steam isolation valve	Guide ribs	Not stated	Atwood & Morrill Co., Inc.	WEAR	Attrition
5	Cooling system	Standby service water pump	Bolts and lockwashers in shaft coupling assemblies	Carbon steel	Not stated	CORR	Loss of material
6	Cooling system	Pipe snubbers	Internal lubricant	Hydrocarbon grease	Pacific Scientific	ELE-TEMP	Chemical and physical degradation
7	Emergency core cooling system	Air dampers and solenoid valves	Elastomer seals	Buna-N	Not stated	ELE-TEMP	Chemical and physical degradation
8	Emergency core cooling system	Shutdown cooling suction isolation valves	Sealing surfaces of valve disk and slide seat ring	Stellite	Anchor-Darling	RESID; FAT/THERM	Crack initiation; cumulative fatigue damage
9	Emergency core cooling system	High-pressure coolant injection motor-operated valve	Torque switch drive pinion gear roll pin	AISI 1070 carbon steel	Limitorque	EMBR; ENVIR	Loss of fracture toughness; chemical and physical degradation
10	Emergency core cooling system	High head safety injection pump	Pump casing	Carbon steel clad with stainless steel	Dresser Industries, Pacific Pump Division	Not stated; CORR/BA	Crack initiation and growth; loss of material
11	Reactor internals	Core shroud	Core plate support ring weldment	Stainless steel	General Electric Company	CORR/IGSCC	Crack initiation and growth

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Improper clearances between valve poppet and body can cause excessive wear of guide ribs, resulting in failure of valve to close properly.	Not stated	NRC Inspect. Rept. 50-458/93-18		Install anti-rotation modification from manufacturer [4]	94-08	4
Extensive general corrosion of the bolts and lockwashers in the pump shaft coupling assemblies caused shifting of internal parts and damage to impellers and bowls, resulting in degraded vibration performance.	Not stated	Not discusses in report		Rebuild pumps; modify testing procedure to detect internal changes before severe damage occurs. [4]	94-45	5
Prolonged exposure to temperatures of 38 to 93 deg. C caused the internal lubricant grease to bake and dry out, resulting in insufficient drag resistance during testing.	Common	Not discussed in report		Replace failed snubbers; develop criteria for service life program. [4]	94-48	6
Prolonged exposure to elevated temperatures causes the Buna-N elastomer seal material to break down, resulting in leakage of the nitrogen supply for the automatic depressurization valves and possible failure of these valves in a LOCA situation.	Not stated	Not discussed in report		Replace affected components with qualified replacements. [4]	94-06	7
High residual stresses from inadequate stress relief or thermal fatigue led to the initiation and growth of cracks in the sealing surfaces of the valves, resulting in excessive valve leakage.	Not stated	Not discussed in report		Not stated	94-30	8
Brittleness of roll pin material, possibly combined with hardening of grease in drive mechanism in one case, caused shear fracture of pin under load, resulting in failure of valve.	Not stated	Not discussed in report		Replace with larger diameter pin fabricated of Type 416 stainless steel for better ductility and impact resistance. [4]	94-49	9
Cracking of the stainless steel cladding from an unidentified cause leads to exposure of the underlying carbon steel, which corrodes relatively rapidly in contact with boric acid in the coolant.	Not stated	Pacific Pump Bulletin 037-0-0104-0		Perform field inspections described in Pacific Pump Bulletin 037-0-0104-0. [4]	94-63	10
IGSCC in and near the HAZ of the outside circumference of the core plate support ring weldment resulted in a 360 circum-ferential crack with a max. depth of ~2.13 cm in two different reactors.	Not stated	GE RICSIL 054, Rev. 1		Safety implications under investigation by NRC. [4]	94-42	11

Table A.1 Gall Report for Licensee Event Reports

Document: LER's, Licensee Event Reports (LERs)
Reviewed by: Ma and K. E. Kasza, ANL

Item	System	Structure/Comp	Subcomponent	Materials	Manufacturer	ARD mechanism	ARD effects
1	Control Rod Drive	Scram Solenoid Pilot Valves	Pressure and Exhaust Diaphragms	Rubber	Automatic Switch Company	ELE-TEMP	Hardening, cracking
2	Control rod drive	Scram solenoid pilot valves	Diaphragm	Buna-N	General Electric	EMBR	Loss of fracture toughness
3	Containment	Personal Airlock	Door Shaft Seal Flange Bolts	Not stated	Not stated	WEAR	Attrition
4	Containment	Main Steam Isolation Valves	Seat Surfaces, Actuator Spring	Not stated	Not stated	WEAR, RATCH	Attrition, change in dimension
5	Containment	Vent Valve	Seal	Nitrile Elastomer	Atwood and Morrill Co.	WEATH	Loss of capacity
6	Containment	H2/O2 gas analyzer	Analyzer pump diaphragm	Not stated	Teledyne	Not stated	Not stated
7	Penetration Pressurization System	Inboard Containment Purge Exhaust Valves	Boot Seal	Not stated	Not stated	ENVIR	Chemical or physical degradation
8	Condenser System	Low Pressure Turbines	Exhaust Boot Seal	Fabric Reinforced Rubber	Uniroyal	FAT	Cumulative Fatigue Damage
9	Feedwater	Check Valve	Seal	Rubber (Parker E692)	Not stated	ELE-TEMP/ERO	Physical degradation, loss of material
10	Hot Leg Loop	Isolation Valve	Valve Stem	17 4PH Stainless Steel (ASTM A 56M Type 630)	Not stated	CORR/SCC	Crack initiation and growth
11	Auxiliary Feedwater	Pump Pneumatic Speed Control Loop	Different Pressure Transmitter	Not stated	Not stated	EDS (setpoint drift)	Loss of function
12	Emergency diesel generator	Fuel oil injector pump	Injector screw	Not stated	Nordberg	Not stated	Not stated
13	Spent fuel pool exhaust ventilation	Charcoal absorber	Seal on bypass damper blade edge	Rubber	Johnson Controls	Not stated	Not stated
14	Spent fuel pool exhaust ventilation	Charcoal absorber	Damper blades	Not stated	Johnson Controls	Not stated	Not stated
15	Fail-safe accumulator	2 way solenoid valve	Seal O-ring	Not stated	Versa Product Co.	FAT	Cumulative fatigue damage
16	Power system	Steam generator	Tube	Not stated	Combustion Engineering System-80	CORR/IGSCC	Crack initiation and growth

Document: LER's, Licensee Event Reports (LERs)
Reviewed by: Ma and K. E. Kasza, ANL

Effect of Aging on Component Function	Contrib to Failure	Reported progs	Rel.progs	Report Recommendations	Page No.	Item
Control rod failed to scram due to degradation of pilot valve elastomers (hardening, cracking and permanent set) caused by high temperature produced by the energized solenoid coils.	Frequent	Not discussed in report	PS TS Req.	Use of new diaphragm material [2]	94-005-01	1
Control air leakage through degraded solenoid diaphragms rendered valve inoperable and failure to scram a control rod resulted.	Not applicable	Not discussed in report	PS TS Req.	Not stated	94-005-00	2
Excessive force to support shaft bearing and increased use of the airlock caused the shaft seal flange to loosen and move away from its seating, resulting in test pressure drop below criteria of containment airlock leakage test.	Moderate	Not discussed in report	10CFR50 App. J & PS TS Req.	Including inspection of the shaft seal gasket bolts in plant maintenance and inspection [4]	92-026-00	3
During local leak rate testing, the leak rate limit was exceeded due to degraded valve seal seat surfaces (misalignment of the poppet seat caused by wear of the guide ribs.)	Frequent	Not discussed in report	PS TS Req.	Replace springs on regular basis [4]	92-013-01	4
Leakage of rubber seal attributed to weather checking on exposed surface and storage causing unacceptable leakage in an Appendix J Type B leakrate test.	Not stated	Not discussed in report	PS TS Req.	The failed seal was replaced and the leak rate met acceptance cri teria. To prevent recurrence, both shelf life and durometer testing requirements shall be considered in the procurement documents [4]	89-005-00	5
Incorrect readings of oxygen concentration because of air leak into analyzer.	Not applicable	Not discussed in report	PS TS Req.	Not stated	92-009-00	6
Environmental aging of seal material caused leakage of PPS exceeding allowable rate. Seating area was cleaned and the leakage stopped.	Not stated	Not discussed in report	ASME Sec XI & PS TS Req.	Not stated	93-001-00	7
Loss of condenser vacuum due to fatigue failure of the north low pressure turbine exhaust boot seal (a fabric reinforced rubber expansion joint), causing an automatic turbine trip and reactor trip.	Moderate	Not discussed in report	PS TS Req.	Replace entire boot seal rather than performing local repair [2]	92-010-00	8
Leakage of rubber seal due to thermal aging and erosive wear, causing excessive leak rate of the check valves.	Frequent	Not discussed in report	ASME Sec XI IWV & PS TS Req.	Replace the soft seal material (Parker E692) with a new material more resistive to thermal aging and erosive wear than the original [4]	86-017-01	9
Crack due to tensile stress on the stem and entrapped water propagated through the valve stem diameter, resulting in the valve gate being in a partially closed position.	Infrequent	Not discussed in report	ASME Sec XI IWV & PS TS Req.	To minimize the in service stresses, the valves will be soft back seated during plant heatup and hard back seated only when operating temperature is reached [4]	86-008-01	10
Inoperability of the pump pneumatic speed control loop due to leaking bellows, setpoint drift, limited pump speed and discharge pressure below that needed to inject water into the steam generators under some accident conditions.	Not stated	Not discussed in report	PS TS Req.	Record turbine steam bowl pressures, including the speed control loop. In the preventive maintenance/calibration program at initial plant startup, perform periodic full flow test [4]	89-016-02	11
Emergency diesel generator not operable to allow fixing of injector pump.	Not applicable	Not discussed in report	PS TS Req.	Not stated	92-009-00	12
Over time the rubber seals lose pliability and allow leakage in the ventilation system.	Not applicable	Not discussed in report	PS TS Req.	Not stated	92-008-00	13
Bent damper blades prevented sealing and caused leakage in the ventilation system.	Not applicable	Not discussed in report	PS TS Req.	Not stated	92-008-00	14
Deterioration of O-ring caused control air leakage and failure of solenoid to meet specs.	Not applicable	Not discussed in report	PS TS Req.	Not stated	93-005-00	15
Rupture of tube causes leakage leading to low pressurizer level and pressure causing reactor trip and radiation in secondary system.	Not applicable	Steam Generator Task Force formed	ASME Sec XI IWB & PS TS Req.	Not stated	93-001-02	16

Table A.1 Gall Report for Licensee Event Reports

Document: LER's, Licensee Event Reports (LERs)
Reviewed by: Ma and K. Kasza, ANL

Item	System	Structure/Comp	Subcomponent	Materials	Manufacturer	ARD mechanism	ARD effects
17	Main steam line	Isolation valve (globe valve)	Seat	Not stated	Atwood and Morrill Company Inc.	CORR/PIT	Local loss of materia
18	Main steam line	Isolation valve (globe valve)	Seat	Not stated	Atwood and Morrill Company Inc.	CREEP	Change in dimension
19	Essential cooling water	Traveling screen filter	Flexible coupling	Elastomeric	Rexnord	ENVIR	Chemical or physical degradation
20	Not stated	High Pressure Turbine Stop Valve	Auto Stop Oil Line	Not stated	Not stated	RESID/FAT	Crack initiation, cumulative fatigue damage
21	Penetration Pressurization System	Inboard Containment Purge Exhaust Valves	Seal Seat	Not stated	Not stated	ENVIR	Chemical or Physica Degradation
22	Emergency Power System	Diesel Generator	Fuel Oil	Not stated	Not stated	OX	Buildup of Deposit
23	Emergency Power System	Diesel Generator	Fuel Oil	Not stated	Not stated	OX	Buildup of Deposit
24	Containment Spray System	Heading Piping	Spray Nozzle	Piping: Carbon Steel	Not stated	CLOG	Blockage of flow passages
25	Fire Protection	3-hour Fire-rated Barriers	Penetration Fire Seal	Silicone Foam	Not stated	Improper installation/lack of inspection rqmt.	Loss of Function
26	Steam Generator Blowdown Outlet	Air-operated Isolation Valve	Valve Actuator Rubber Diaphragm	Rubber	Not stated	ENVIR	Physical Degradation
27	Not stated	Main Condenser	Expansion Joint	Rubber	Not stated	ENVIR	Physical Degradation
28	Not stated	Turbine	Low Pressure Exhaust Boot Seal	Rubber	Uniroyal	FAT	Cumulative Fatigue Damage
29	Emergency Cooling System and Containment Spray System	Motor-operated Valves	Not stated	Not stated	Not stated	Improper Switch Setting	Loss of Function
30	Primary Containment Isolation System	Isolation Valves, Reactor Vessel Stabilizer Hatch	O-rings, Seat Rings, Gaskets	Ethylene-propylene, Rubber	Various	ENVIR/WEAR	Physical Degradation, Attritior
31	Containment Penetration	Electric Penetration Assemblies	Seals	Polyurethane	Bunker Ramo	Hydrolysis	Physical Degradation, Attritior

Document: LER's, Licensee Event Reports (LERs)
Reviewed by: Ma and K. Kasza, ANL

Effect of Aging on Component Function	Contrib to Failure	Reported progs	Rel.progs	Report Recommendations	Page No.	Item
Technical specifications for leakage limits on valves is exceeded.	Moderate	Not discussed in report	ASME Sec XI & PS TS Req.	Not stated	93-003-01; 003-02	17
Technical specification for leakage limits on valves is exceeded.	Infrequent	Not discussed in report	ASME Sec XI & PS S&T Req.	Not stated	93-003-01	18
Aging of elastomeric couplings resulted in their cracking and failure of traveling screen filter to operate.	Not applicable	Not discussed in report	PS S&T Req.	Not stated	93-010-00	19
Turbine stop valve closure due to auto stop oil line weld leak resulted in a manual reactor trip and a manual safety injection. The weld failure was due to inadequate field installation (overlapping welds) and fatigue.	Rare	Not stated	PS S&T Req.	Perform visual inspection of the accessible welds, measure vibration of the auto stop oil line during plant startup [4]	89-011-00	20
Environmental aging of seal material caused leakage of PPS exceeding allowable rate. Seating area was cleaned and the leakage stopped.	Not stated	Not stated	PS S&T Req.	Not stated	93-013-01	21
Oxidation of fuel oil due to a high concentration of insolubles clogging the sample filter, causing inoperability of diesel generator.	Infrequent	Not stated	RG 1.9, RG 1.108 & PS TS Req.	Periodic replace ment of the fuel oil and use of a higher grade diesel fuel oil which has a longer shelf life [4]	89-001-00	22
Oxidation of fuel oil due to a high concentration of insolubles clogging the sample filter, causing inoperability of diesel generator.	Infrequent	Not stated	RG 1.9, RG 1.108 & PS TS Req.	Periodic replacement of the fuel oil and use of a higher grade diesel fuel oil which has a longer shelf life. Add a biocide, a dispersant and a stabilizer to extend the shelf life. [4]	89-001-01	23
Nozzle blockage due to accumulation of the deteriorated coating of the CSS piping inner surface could block the CSS flow.	Frequent	Not stated	PS S&T Req. & PS TS Req.	Replacement of the CSS nozzles with clog resistant nozzles [4]	90-021-00	24
Gaps, tears, or splits due to improper installation and lack of inspection requirements were found in the seals. Propagation of a fire across boundary would affect the plant safe shutdown.	Frequent	Not stated	PS S&T Req.	Use a different type of foam and different installation techniques [4]	90-002-00	25
Failure of rubber diaphragm resulting in air leakage and failure of the valve closure.	Not stated	Not stated	ASME Sec XI IWV & PS S&T Req.	Not stated	92-001-00	26
The air leakage through the torn expansion joint rubber belt caused low vacuum in the main condenser and subsequent manual reactor and main turbine trip.	Infrequent	Not stated	PS S&T Req. & PS TS Req.	Periodic replacement of the expansion joints [2]	92-003-00	27
Failure of the north low pressure turbine boot seal due to fatigue caused condenser low vacuum and subsequent automatic reactor and turbine trip.	Not stated	Not stated	PS S&T Req.	Not stated	92-007-00	28
Isolation valves were not capable of full closure under design basis conditions due to improper drive gear sets and torque switch settings.	Frequent	GL89-10	ASME	Reconfigure and test the MOVs to satisfy the GL89 10 criteria [4]	92-006-00	29
Brittle and broken O-ring seals of the reactor vessel stabilizer hatch indicated that the ethylene propylene (EP) material is generally unable to resist harsh environments. O-rings made of silicone rubber were in good condition.	Frequent	Not stated	10CFR50 App. J	Periodic replacement of the O-rings [4]	88-014-00	30
Degradation of seal material, polyurethane, due to hydrolysis would allow moisture intrusion into the electrical penetration assembly during a LOCA event, potentially resulting in discontinuity of off-site power.	Frequent	Not stated	PS S&T Req	Use a more durable material, ethylene propylene rubber; install a silicone rubber O-ring as a backup seal; upgrade the nitrogen supply system to safety-grade system [4]	91-011-02	31

Document: BL 89-01, 1989 NRC Information Notices and Bulletins
Reviewed by: Dwight R. Diercks, ANL

Item	System	Structure/Comp	Subcomponent	Materials	Manufacturer	ARD mechanism	ARD effects
1	Cooling system	Steam generator	Tubing mechanical plugs	Inconel 600	Westinghouse	CORR/PWSCC	Crack initiation and growth

Document: BL 89-02, 1989 NRC Information Notices and Bulletins
Reviewed by: Dwight R. Diercks, ANL

Item	System	Structure/Comp	Subcomponent	Materials	Manufacturer	ARD mechanism	ARD effects
1	Residual heat-removal system	Swing check valve	Retaining block stud (bolt)	Type 410 stainless steel (A193, Gr B6, Type 410 SS)	Anchor Darling	CORR/SCC	Crack initiation and growth

Document: BL 89-01, 1989 NRC Information Notices and Bulletins
Reviewed by: Dwight R. Diercks, ANL

Effect of Aging on Component Function	Contrib to Failure	Reported progs	Rel.progs	Report Recommendations	Page No.	Item
Intergranular cracking, apparently associated with improper heat treatment and/or susceptible heats of material, can cause mechanical tube plugs to loosen, leak, and sometimes be forcibly ejected, causing additional tube damage.	Not stated	Not discussed in report		Replace plugs from suspect heats of material; discontinue use of Westinghouse plugs. [4]	89-33; Bull. 89-01, 89-01, Suppl. 1 & 2.	1

Document: BL 89-02, 1989 NRC Information Notices and Bulletins
Reviewed by: Dwight R. Diercks, ANL

Effect of Aging on Component Function	Contrib to Failure	Reported progs	Rel.progs	Report Recommendations	Page No.	Item
Susceptibility to SCC was apparently enhanced by improper heat treatment (hardness too high), coupled with presence of borated water. Resulting cracking led to bolt fracture.	Not stated	ASME SA193-B6		Inspect bolts for cracks; replace defective bolts with bolts having Rc hardness <=26. [4]	BL 89-02	1

A.2 Electrical Components and Systems

Document: BNL A-3270-11-85, Seismic Endurance Tests of Naturally Aged Small Electric Motors
Reviewed by: Jerry Edson, INEL

Item	System	Structure/Comp	Subcomponent	Materials	Manufacturer	ARD mechanism	ARD effects
1		Electric Motors	Terminal Boxes	Not stated	Not stated	CORR	Improper sealing of the cover gaskets
2		Electric Motors	Stator Winding	Not stated	Not stated	Not stated	Break down of varnish and insulation
3		Electric Motors	All Other Components	Not stated	Not stated	Not stated	Not stated

Document: BNL A-3270-3-86, Testing Program For The Monitoring of Degradation in a Continuous Duty 460 volt Class "B", 10 hp Electric Motor
Reviewed by: Jerry Edson, INEL

Item	System	Structure/Comp	Subcomponent	Materials	Manufacturer	ARD mechanism	ARD effects
1		Electric Motor	Dielectrics (Insulation)	Organic insulation materials	Not stated	ELETEMP MOIST-EL RAD, VIBR, CURSTR, VOLSTR, CONTAM	Insultion degradation causes leakage through the insulation
2		Electric Motor	Bearings	Not stated	Not stated	Not stated	Ball or roller surface defects cause vibration
3		Electric Motor	Cage (Rotor)	Not stated	Not stated	Not stated	Damaged or defective cage
4		Electric Motor	Stator	Steel, Copper, Organic insulation	Not stated	THERM-CY, FAT	Stress caused by differences in thermal expansion rates

Document: CHAPTER 24 CABLES, Aging and Life Extension of Major Light Water Reactor Components
Reviewed by: E. W. Roberts, INEL

Item	System	Structure/Comp	Subcomponent	Materials	Manufacturer	ARD mechanism	ARD effects
1			Non-Shielded Single & Multi-Conductor Jacketed	Polymers, Rubber, Sicicon, Copper, Kapton	Not stated	ELETEMP, MOIST-EL, OXIDAT, & RAD	Jacket embrittlement & cracking, propagating thru insulation
2			Shielded Pair Multi-Conductor Jacketed	Polymers, Rubber, Silicon & Copper	Not stated	ELETEMP, MOIST-EL, OXIDAT, & RAD	Jacket & cracking-moisture diffuses through jacket and cond.
3			Connections - Non-Sealed	Not stated	Not stated	ELETEMP & MOIST-EL	Moisture diffuses into cables and connection internals
4			Connections - Compression Sealed	Polymers	Not stated	ELETEMP, RAD, & VIBR	Seals not hermetic
5			Cables, Halogination of Filled Polymers	Polymers	Not stated	ELETEMP, RAD, & MOIST-EL	Electrolytes that increase leakage or losses
6			Mineral Insulated Cable	Not stated	Not stated	THERMO-CY & VIBR	Open hermetic seals
7			Terminal Strips	Not stated	Not stated	CONTAM	Increase leakage or losses

Document: Letter Report/INEL, Summaries of Research Reports Submitted in Connection With the Nuclear Aging RESEARCH (NPAR) PROGRAM
Reviewed by: L. C. Meyer, INEL

Item	System	Structure/Comp	Subcomponent	Materials	Manufacturer	ARD mechanism	ARD effects
1	Battery Chargers and Inverters	Circuit Breakers	Contacts, Coil, Linkages, & Case	Not stated	Not stated	WEAR & LOSLUB	Bearing wear & solidification of lubrication
2	Battery Chargers and Inverters	Circuit Breakers	Contacts, Coil, Linkages, & Case	Not stated	Not stated	FAT, OXIDAT	Metal fatigue, embrittlement & cracking of insulation
3	Battery Chargers and Inverters	Circuit Breakers	Contacts, Coil, Linkages, & Case	Not stated	Not stated	OXIDAT & WEAR	Oxidation and pitting of contact surfaces

Document: BNL A-3270-11-85, Seismic Endurance Tests of Naturally Aged Small Electric Motors
Reviewed by: Jerry Edson, INEL

Effect of Aging on Component Function	Contrib to Failure	Reported progs	Rel.progs	Report Recommendations	Page No.	Item
Leakage of moisture into the box could lead to termination corrosion and overheating which could cause degraded performance or failure to operate	Not stated	Not discussed in report	No specific program	Not stated	3, 4	1
Excessive leakage current and decreased performance or failure to operate	Not stated	Not discussed in report	No specific program	Not stated	4	2
Not stated	Not stated	Not discussed in report	No specific program	Not stated	A-6	3

Document: BNL A-3270-3-86, Testing Program For The Monitoring of Degradation in a Continuous Duty 460 volt Class "B", 10 hp Electric Motor
Reviewed by: Jerry Edson, INEL

Effect of Aging on Component Function	Contrib to Failure	Reported progs	Rel.progs	Report Recommendations	Page No.	Item
Leakage through the insulation causes imbalances between phases, phases with below normal current, and overheating in phases with above normal current. Results in decreased output.	Not stated	Not discussed in report	IEEE 334-1974 Section 14	Not stated	1, 3, 12	1
Increased friction and reduced output	Not stated	Not discussed in report	IEEE 334-1974 Section 14	Not stated	3, 15	2
Decreased speed or torque	Not stated	Not discussed in report	IEEE 334-1974 Section 14	Not stated	15	3
Additional aging stress to the windings	Not stated	Not discussed in report	IEEE 334-1974 Section 14	Not stated	3	4

Document: CHAPTER 24 CABLES, Aging and Life Extension of Major Light Water Reactor Components
Reviewed by: E. W. Roberts, INEL

Effect of Aging on Component Function	Contrib to Failure	Reported progs	Rel.progs	Report Recommendations	Page No.	Item
Circuit ground or short	Frequent	Limited	No specific program	Utilities (1) monitor temp/rad determine hot spots, (2) perform periodic inspections, & (3) don't disturb cables [4]	845,848,854,863, & 865	1
Circuit opens, grounds, total loss of function	Frequent	Limited	No specific program	Utilities adopt improved failure analysis & recording [4]	845,848,854,863, 865	2
Circuit opens, grounds, total loss of function	Not stated	Not discussed in report	No specific program	Not stated	845,848,863, 865	3
During DBE moisture enters through connection, contacts corride, circuit grounds or shorts	Not stated	Not discussed in report	No specific program	Not stated	845,848,850,863, & 865	4
Disable function during dbe	Not stated	Not discussed in report	No specific program	Not stated	845,848,863, & 865	5
DBE-excessive leakage disables cable	Not stated	Not discussed in report	No specific program	Not stated	845,848,851, & 865	6
DBE-excessive leakage disables cable	Not stated	Not discussed in report	No specific program	Not stated	833,845,848, & 865	7

Document: Letter Report/INEL, Summaries of Research Reports Submitted in Connection With the Nuclear Aging RESEARCH (NPAR) PROGRAM
Reviewed by: L. C. Meyer, INEL

Effect of Aging on Component Function	Contrib to Failure	Reported progs	Rel.progs	Report Recommendations	Page No.	Item
Failure to operate	Occasional	Not discussed in report	Vendor specific program, Tech. Spec. surveil.	Not stated	4-18	1
Fails to open - trip coil force becomes less than spring force.	Occasional	Not discussed in report	Vendor specific program, Tech. Spec. surveil.	Not stated	4-18	2
Fails to open - loss of continuity across contacts.	Rare	Not discussed in report	Vendor specific program, Tech. Spec. surveil.	Not stated	4-18	3

Table A.2 Gall Report for NPAR Reports

Document: Letter Report/INEL, Summaries of Research Reports Submitted in Connection With the Nuclear Aging RESEARCH (NPAR) PROGRAM
Reviewed by: L. C. Meyer, INEL

Item	System	Structure/Comp	Subcomponent	Materials	Manufacturer	ARD mechanism	ARD effects
4	Battery Chargers and Inverters	Fuse		Not stated	Not stated	FAT	Metal fatigue
5	Battery Chargers and Inverters	Fuse		Not stated	Not stated	ELE-TEMP	Melting of link
6	Battery Chargers and Inverters	Relay	Contacts	Not stated	Not stated	OXIDAT & WEAR	Oxidation & pitting of contact surfaces
7	Battery Chargers and Inverters	Relay	Coil	Not stated	Not stated	CORR	Electromechanical action causing corrosion of fine wires.
8	Battery Chargers and Inverters	Electrolytic Capacitors		Not stated	Not stated	ELETEMP	Over heating by internal stresses causes loss of electrolyte
9	Battery Chargers and Inverters	Electrolytic Capacitors		Not stated	Not stated	VIB	Failure of leads
10	Battery Chargers and Inverters	Oil Filled Capacitors		Not stated	Not stated	ELETEMP	Over heating forms gasses and dielectric breakdown
11	Battery Chargers and Inverters	Oil Filled Capacitors		Not stated	Not stated	VIB	Failure of leads
12	Battery Chargers and Inverters	Transformer	Wire	Not stated	Not stated	THERM-CY & ELETEMP	Cracking of insulation
13	Battery Chargers and Inverters	Transformer	Wire	Not stated	Not stated	LOTEMP	Cracking of moisture seals
14	Battery Chargers and Inverters	Transformer	Wire	Not stated	Not stated	VOLSTR	Insulaton material deterioration
15	Battery Chargers and Inverters	Transformer	Wire	Not stated	Not stated	VIB & ELETEMP	Fracture of connecting wires and changes in shunting.
16	Battery Chargers and Inverters	Silicon Controlled Rectifier		Not stated	Not stated	VOLSTR & CURSTR	Transients resulting in over voltage & current & overheating
17	Battery Chargers and Inverters	Resistor		Not stated	Not stated	VIB	Lead fails
18	Battery Chargers and Inverters	Resistor		Not stated	Not stated	ELETEMP	Decrease in resistance values as temperature increases
19	Battery Chargers and Inverters	Printed Circuit Boards		Not stated	Not stated	THERM-CY	Cracking of input lines
20	Battery Chargers and Inverters	Printed Circuit Boards		Not stated	Not stated	CORR	Loss of material
21	Battery Chargers and Inverters	Printed Circuit Boards		Not stated	Not stated	VIB	Loose or open connection
22	Battery Chargers and Inverters	Surge Suppressor		Not stated	Not stated	VOLSTR OR CURSTR	Semiconductor barrier breakdown due to overheating.
23	Battery Chargers and Inverters	Connectors		Not stated	Not stated	FAT & VIB	Fatigue of wires at terminals
24	Battery Chargers and Inverters	Meters		Not stated	Not stated	CONTAM	Dirt on movement and increase in bearing friction
25	Battery Chargers and Inverters	Meters	Coil Insulation	Not stated	Not stated	ELETEMP	Coil insulation degrades causing shorting
26	Battery Chargers and Inverters	Meters	Contacts	Not stated	Not stated	WEAR & CORR	Contacts pitting or corrosion
27		Cable	Insulation	Not stated	Not stated	ELETEMP, RAD, & MOIST-EL	Loss of dielectric properties & changes in structure

Document: Letter Report/INEL, Summaries of Research Reports Submitted in Connection With the Nuclear Aging RESEARCH (NPAR) PROGRAM
Reviewed by: L. C. Meyer, INEL

Effect of Aging on Component Function	Contrib to Failure	Reported progs	Rel.progs	Report Recommendations	Page No.	Item
Fails open due to equipment load cycling	Occasional	Not discussed in report	Vendor specific program, Tech. Spec. surveil.	Not stated	4-18	4
Fails open due to heat generated by surrounding components.	Rare	Not discussed in report	Vendor specific program, Tech. Spec. surveil.	Not stated	4-18	5
Contacts open - loss of continuity across contacts	Rare	Not discussed in report	Tech. Spec. surveillance	Not stated	4-18	6
Open circuit of coil - loss of continuity through coil wires.	Rare	Not discussed in report	Vendor specific program	Not stated	4-18	7
Loss of capacitance and degraded system operation.	Occasional	Not discussed in report	Vendor specific program	Not stated	4-18	8
Open circuit	Rare	Not discussed in report	Vendor specific program	Not stated	4-18	9
Loss of capacitance	Occasional	Not discussed in report	Vendor specific program	Not stated	4-18	10
Open circuit	Rare	Not discussed in report	Vendor specific program	Not stated	4-18	11
Short circuit - turn to turn or to ground	Occasional	Not discussed in report	Vendor specific program	Not stated	4-19	12
Short circuit - turn to turn or to ground	Occasional	Not discussed in report	Vendor specific program	Not stated	4-19	13
Short circuit - turn to turn or to ground	Occasional	Not discussed in report	Vendor specific program	Not stated	4-19	14
Change in inductance	Rare	Not discussed in report	Vendor specific program	Not stated	4-19	15
Short or open circuit	Occasional	Not discussed in report	Vendor specific program	Not stated	4-19	16
Open circuit	Rare	Not discussed in report	Vendor specific program	Not stated	4-19	17
Change in resistance value and degraded circuit operation.	Rare	Not discussed in report	Vendor specific program	Not stated	4-19	18
Change in output	Rare	Not discussed in report	Vendor specific program	Not stated	4-19	19
Open circuit at terminals or within printed circuit board.	Rare	Not discussed in report	Vendor specific program	Not stated	4-19	20
Change in output	Occasional	Not discussed in report	Vendor specific program	Not stated	4-19	21
Short circuit	Rare	Not discussed in report	Vendor specific program	Not stated	4-19	22
Open or short circuit	Occasional	Not discussed in report	Vendor specific program	Not stated	4-19	23
No response (stuck)	Occasional	Not discussed in report	Vendor specific program	Not stated	4-19	24
No response from meter	Rare	Not discussed in report	Vendor specific program	Not stated	4-19	25
Fails to open or close	Occasional	Not discussed in report	Vendor specific program	Not stated	4-19	26
Cracks when flexed & loss of flexibility, loss of imperviousness, failure frequently coupled with presence of moisture or water.	Rare	Not discussed in report	No specific program	Not stated	3-33	27

Document: Letter Report/INEL, Summaries of Research Reports Submitted in Connection With the Nuclear Aging RESEARCH (NPAR) PROGRAM
Reviewed by: L. C. Meyer, INEL

Item	System	Structure/Comp	Subcomponent	Materials	Manufacturer	ARD mechanism	ARD effects
28		Cable	Insulation	Not stated	Not stated	ELETEMP, RAD, & MOIST-EL	Loss of dielectric properties & changes in structure
29		Cable	Insulation	Not stated	Not stated	ELETEMP, RAD, & MOIST-EL	Loss of dielectric properties & changes in structure
30	(Pressure Transmitters)	Force Balance Type	Force Bar & Linkage	Not stated	Not stated	WEAR & VIB	Wear of pivot points
31	(Pressure Transmitters)	Force Balance Type	Force Motor (Feedback Coil)	Not stated	Not stated	VOLSTR ELETEMP	Insulation failure & coil burnout
32	(Pressure Transmitters)	Force Balance Type	Amplifier	Not stated	Not stated	THER-CY & VOLSTR	Shorting or opening of electronic components
33	(Pressure Transmitters)	Force Balance Type	Housing Seals	Not stated	Not stated	ELETEMP, RAD, OR EMBR	Compresive set or cracking
34	(Pressure Transmitters)	Force Balance Type	Diaphragm	Not stated	Not stated	CORR	Perforation of diaphragm from corrosion
35	(Pressure Transmitters)	Force Balance Type	Diaphragm Seal	Not stated	Not stated	Not stated	Seal deterioration from decomposition
36	(Pressure Transmitters)	Capicitance Type Transmitters	Sensing Cell	Not stated	Not stated	Not stated	Perforation in cell allowing leakage of fluid
37	(Pressure Transmitters)	Capicitance Type Transmitters	Terminal Cover Plate Seal	Not stated	Not stated	EMBR, ELETEMP, & RAD	Embrittlement and seal cracking
38	(Pressure Transmitters)	Capicitance Type Transmitters	Electronics	Not stated	Not stated	OXIDAT & CONTAM	Circuit continuity lost and bridging of circuits
39	(Pressure Transmitters)	Capicitance Type Transmitters	Electronics	Not stated	Not stated	VOLSTR & ELETEMP	Shorting or opening of component
40	(Pressure Transmitters)	Capicitance Type Transmitters	Sensing Cell	Not stated	Not stated	ELETEMP OR RAD	Chemical changes in fill-oil
41	(Pressure Transmitters)	Capicitance Type Transmitters	Electronics	Not stated	Not stated	RAD, ELETEMP, OR VOLSTR	Change in component parameters

Table A.2 Gall Report for NPAR Reports

Document: Letter Report/INEL, Summaries of Research Reports Submitted in Connection With the Nuclear Aging RESEARCH (NPAR) PROGRAM
Reviewed by: L. C. Meyer, INEL

Effect of Aging on Component Function	Contrib to Failure	Reported progs	Rel.progs	Report Recommendations	Page No.	Item
Cracks when flexed & loss of flexibility, loss of imperviousness, failure frequently coupled with presence of moisture or water.	Rare	Not discussed in report	No specific program	Not stated	3-34	28
Cracks when flexed & loss of flexibility, loss of imperviousness, failure frequently coupled with presence of moisture or water. Adverse changes in insulation resistance may cause attenuation of signals.	Rare	Not discussed in report	No specific program	Not stated	3-34	29
Failure to operate - decrased accuracy or complete failure. Zero shift may result from bent components causing transmitter failure to operate as required.	Occasional	Not discussed in report	RG 1.118, IEEE 338-1987, ISA 67.06, Tech Spec	Not stated	4-43	30
Failure to operate - loss of output	Rare	Not discussed in report	RG 1.118, IEEE 338-1987, ISA 67.06, Tech Spec	Not stated	4-43	31
Failure to operate - may fail high, low, lose accuracy, or fail with steady output.	Occasional	Not discussed in report	RG 1.118, IEEE 338-1987, ISA 67.06, Tech Spec	Not stated	4-43	32
Failure to operate - inability of seal to provide moisture and pressure barrier results in failure of electronics due to shorting and corrosion from ingress of environmental contaminants.	Occasional	Not discussed in report	RG 1.118, IEEE 338-1987, ISA 67.06, Tech Spec	Not stated	4-43	33
Failure to operate as required - zero shift or leakage through diaphram causing variable instrument drift as pressures across diapharam equalize	Occasional	Not discussed in report	RG 1.118,IEEE 338-1987,ISA 67.06,10 CFR 50.49	Not stated	4-43	34
Failure to operate as required - leakage through diaphram causing variable instrument drift as pressures across diapharam equalize	Occasional	Not discussed in report	RG 1.118, IEEE 338-1987, ISA 67.06, Tech Spec	Not stated	4-43	35
Failure to operate or loss of accuracy or drift	Rare	Not discussed in report	RG 1.118, IEEE 338-1987, ISA 67.06, Bul 90-01	Not stated	4-44	36
Failure to operate - inability to provide moisture and pressure boundary resulting in loss of electronics due to ingress of environmental contaminants	Rare	Not discussed in report	RG 1.118,IEEE 338-1987,ISA 67.06,10 CFR 50.49	Not stated	4-44	37
Failure to operate or loss of signal or sporadic operation	Occasional	Not discussed in report	RG 1.118, IEEE 338-1987, ISA 67.06, Tech Spec	Not stated	4-44	38
Failure to operate - loss of output, may fail high or low.	Occasional	Not discussed in report	RG 1.118, IEEE 338-1987, ISA 67.06, Tech Spec	Not stated	4-44	39
Failure to operate as required such as zero shift, reduced accuracy, or changes in response time.	Rare	Not discussed in report	RG 1.118, IEEE 338-1987, ISA 67.06, IN 95-20	Not stated	4-45	40
Failure to operate as required - loss of accuracy, drift, or zero shift.	Occasional	Not discussed in report	RG 1.118, IEEE 338-1987, ISA 67.06, Tech Spec	Not stated	4-45	41

Table A.2 Gall Report for NPAR Reports

Document: Letter Report/INEL, Summaries of Research Reports Submitted in Connection With the Nuclear Aging RESEARCH (NPAR) PROGRAM
Reviewed by: L. C. Meyer, INEL

Item	System	Structure/Comp	Subcomponent	Materials	Manufacturer	ARD mechanism	ARD effects
42	(Pressure Transmitters)	Strain Gage Type	Strain Gage	Not stated	Not stated	Not stated	Loss of continuity in bridge circuit related to aging
43	(Pressure Transmitters)	Strain Gage Type	Seals	Not stated	Not stated	CONTAM, EMBR, ELETEMP, OR RAD	Embrittlenent or cracking
44	(Pressure Transmitters)	Strain Gage Type	Potentiometer	Not stated	Not stated	CORR & ELETEMP	Corrodes open due to thermal stress
45	(Pressure Transmitters)	Strain Gage Type	Electric Module	Not stated	Not stated	Not stated	Component deterioration or change in parameters
46	(Pressure Transmitters)	Strain Gage Type	Bourdon Tube	Not stated	Not stated	CORR	Perforation of tube allowing leaks to transmitter housing

Document: NISTIR 4485, Annotated Bibliography - Diagnostic Methods and Measurement Approached to Detect Incipient Defects Due to Aging of Cables
Reviewed by: L. C. Meyer, INEL

Item	System	Structure/Comp	Subcomponent	Materials	Manufacturer	ARD mechanism	ARD effects
1		Cable	Not stated	Not stated	Not stated	Not stated	Not stated

Document: NISTIR 4487, Detection of Incipient Defects in Cables by Partial Discharge Signal Analysis
Reviewed by: L. C. Meyer, INEL

Item	System	Structure/Comp	Subcomponent	Materials	Manufacturer	ARD mechanism	ARD effects
1		Cable	Insulation	Not stated	Not stated	MOIST-EL, OXIDAT, ELETEMP, & RAD	Defects develop from these mechanisms

Document: NISTIR 4787, The Use of Time-Domain Dielectric Spectroscopy to Evaluate the Lifetime of Nuclear Power Station Cables
Reviewed by: Jerry Edson, INEL

Item	System	Structure/Comp	Subcomponent	Materials	Manufacturer	ARD mechanism	ARD effects
1		Electrical Cable	Jacket	Vinyl	Not stated	Not stated	Not stated
2		Electrical Cable	Insulation	PE, XLPE, XLPO	Not stated	ELETEMP & RAD	Chemical reactions, crosslinking, ionization
3		Electrical Cable	Insulation	PE, XLPE, XLPO	Not stated	ELETEMP COMBINED WITH RAD	Chemical reactions, crosslinking, ionization

Document: NUREG-1377 R3, NRC Research Program on Plant Aging: Listing and Summaries of Reports Issued Through July 1992
Reviewed by: Jerry Edson, INEL

Item	System	Structure/Comp	Subcomponent	Materials	Manufacturer	ARD mechanism	ARD effects
1	Listing and Summaries of 123 NPAR Reports					NOT SPECIFICALLY ADDRESSED IN THE REPORT	

Document: Letter Report/INEL, Summaries of Research Reports Submitted in Connection With the Nuclear Aging RESEARCH (NPAR) PROGRAM
Reviewed by: L. C. Meyer, INEL

Effect of Aging on Component Function	Contrib to Failure	Reported progs	Rel.progs	Report Recommendations	Page No.	Item
Failure to operate - loss of output.	Rare	Not discussed in report	RG 1.118, IEEE 338-1987, ISA 67.06, Tech Spec	Not stated	4-45	42
Failure to operate - inability to provide moisture and pressure barrier leading to failure of electronics due to contamination.	Occasional	Not discussed in report	RG 1.118,IEEE 338-1987,ISA 67.06,10 CFR 50.49	Not stated	4-45	43
Failure to operate - fails over range, wire-wound potentiometer corrosion of resistive elements leads to failure	Occasional	Not discussed in report	RG 1.118, IEEE 338-1987, ISA 67.06, Tech Spec	Not stated	4-45	44
Failure to operate or loss of full output	Occasional	Not discussed in report	RG 1.118, IEEE 338-1987, ISA 67.06, Tech Spec	Not stated	4-45	45
Failure to operate as required - drift, contamination of transmitter internals, and failure to respond	Rare	Not discussed in report	RG 1.118, IEEE 338-1987, ISA 67.06, Tech Spec	Not stated	4-45	46

Document: NISTIR 4485, Annotated Bibliography - Diagnostic Methods and Measurement Approached to Detect Incipient Defects Due to Aging of Cables
Reviewed by: L. C. Meyer, INEL

Effect of Aging on Component Function	Contrib to Failure	Reported progs	Rel.progs	Report Recommendations	Page No.	Item
This is a collection of 156 reveiwed abstracts of reports and papers related to cable aging and defect assessment covering the 1970-1986 period. An additional list of 850 citations was compiled from references given in the reveiwed papers.	Not stated	Not discussed in report	No specific program	Not stated	NA	1

Document: NISTIR 4487, Detection of Incipient Defects in Cables by Partial Discharge Signal Analysis
Reviewed by: L. C. Meyer, INEL

Effect of Aging on Component Function	Contrib to Failure	Reported progs	Rel.progs	Report Recommendations	Page No.	Item
The defects will degrade insulating properties of cable insulation.	Occasional	Not discussed in report	No specific program	Six recommendations each for partial discharge research and hardware development. Three for software. [4]	1 and 120	1

Document: NISTIR 4787, The Use of Time-Domain Dielectric Spectroscopy to Evaluate the Lifetime of Nuclear Power Station Cables
Reviewed by: Jerry Edson, INEL

Effect of Aging on Component Function	Contrib to Failure	Reported progs	Rel.progs	Report Recommendations	Page No.	Item
Not stated	Not stated	Not discussed in report	No specific program	Not stated	15	1
Embrittlement, softening, loss of elongation and reduced dielectric strength could cause failure to accurately transmit voltage or current.	Not stated	Not discussed in report	No specific program	Not stated	1, 2, 4, 7, 8, 15, 17, 22-38	2
Embrittlement, softening, loss of elongation and reduced dielectric strength could cause failure to accurately transmit voltage or current.	Not stated	Not discussed in report	No specific program	Not stated	1, 2, 4, 7, 8, 15, 17, 22-38	3

Document: NUREG-1377 R3, NRC Research Program on Plant Aging: Listing and Summaries of Reports Issued Through July 1992
Reviewed by: Jerry Edson, INEL

Effect of Aging on Component Function	Contrib to Failure	Reported progs	Rel.progs	Report Recommendations	Page No.	Item
The purpose of the report is to present a listing and summaries of 123 NPAR reports. Specific aging effects and recommendations are addressed by the individual reports.		Not discussed in the report	No specific program	Not stated		1

Document: NUREG/CP-0100, Proceedings of the International Nuclear Aging Symposium, Session 3
Reviewed by: L. C. Meyer, INEL

Item	System	Structure/Comp	Subcomponent	Materials	Manufacturer	ARD mechanism	ARD effects
17		Resistance Temperature Devices		Not stated	Not stated	THERM-CY	Conductive compounds become insulative
18		Electrical Wiring	Insulation	Kapton (Aeromatic polymide)	Not stated	MOIST-EL & ELE-TEMP	Insulation cracking and loss of mechanical properties
19		Pressure Transducers	Force Balance Type Sensors	Not stated	Foxboro	CONTAM & FRZ-THAW	Blockage of sensing lines
20		Pressure Transducers	Not stated	Not stated	Rosemount	CONTAM & FRZ-THAW	Blockage of sensing lines
21		Micro Processor & ICs	IC DIE	Silicon, Silicon oxide, & interfaces	Not stated	CONTAM, VOTSTR, CURSTR	Contamination causes shorts, V & I stresses cause burnout
22		Micro Processor & ICs	IC DIE	Metalization	Not stated	CORR	Corrosion from adjacent materials
23		Micro Processor & ICs	IC Package	Metalic leads & container and glass seals	Not stated	FAT, CORR, VIB, & CONTAM	Corr from adjacent materials, vib causes fat, contam shorts
24	Diesel Generator	Not stated	Not stated	Not stated	Not stated	WEAR & LOSLUB	Wear from lack of lubrication during fast starts
25		Cable	Insulation	EPR, CSPE, & XLPE	Four vendors listed	RAD, ELETEMP, & MOIST-EL	Insulation degradation from all three mechanisms

Document: NUREG/CP-0105, Seventeenth Water Reactor Safety Information Meeting (Electrical Parts)
Reviewed by: L. C. Meyer, INEL

Item	System	Structure/Comp	Subcomponent	Materials	Manufacturer	ARD mechanism	ARD effects
14	Auxliary Feedwater System		Not stated	Not stated	Not stated	Not stated	
15	Auxliary Feedwater System	Cable		Various cable materials	Seven vendors identified	RAD AND ELETEMP	Not stated
16	Auxliary Feedwater System	Steam Generator	Tubes	Not stated	Westinghouse	FAT, EROS, CORR	Primary water stress corrosion cracking (PWSCC)
17	Auxliary Feedwater System	Circuit Breakers		Not stated	Not stated	Not stated	Not stated
18	Auxiliary Feedwater System	Turbine Driven Pump		Not stated	Not stated	Not stated	Not stated
19	Auxiliary Feedwater System	Compressors		Not stated	Not stated	WEAR, CONTAM, & VIB	Set point drift, degraded parts, & loose connections
20	Auxiliary Feedwater System	Dryers		Not stated	Not stated	CORR & CONTAM	Blockage, deteriation of components
21	Auxiliary Feedwater System	Valve		Not stated	Not stated	WEAR, CONTAM, AND CORR	Set point drift, fracture/cracking, component deterioration

Document: NUREG/CP-0100, Proceedings of the International Nuclear Aging Symposium, Session 3
Reviewed by: L. C. Meyer, INEL

Effect of Aging on Component Function	Contrib to Failure	Reported progs	Rel.progs	Report Recommendations	Page No.	Item
Never-seez usd in thermal wells lose conductivity with age and effects response time of RTD.	Not stated	Reg Guides 1.118 and 1.105	Reg Guides 1.118 and 1.105	Not stated	363-366	17
Cracking can result in contamination intrusion and improper output.	Occasional	Not discussed in report	No specific program	Not stated	130-131	18
Partial or full blockage of sensing lines effects the transducer response time.	Not stated	IEEE-Std 338, Reg Guide 1.118, & ISA Std 67.06	IEEE 338, Reg Guide 1.118, ISA 67.06	Not stated	137-139	19
Partial or full blockage of sensing lines effects the transducer response time.	Not stated	IEEE-Std 338, Reg Guide 1.118, & ISA Std 67.06	IEEE 338, Reg Guide 1.118, ISA 67.06	Not stated	138-139	20
Contamination enters by cracks or from MFG process and if moved by handling can short gate elements, voltage and current spikes may overstress leads or connections weakened by manufacturing process or chemical reactions of materials used in IC.	Not stated	IEEE-323-1983	No specific program	As new vendors & technologies emerge, their aging sensitivity should be addressed. [2]	146-152	21
Metalization may fail because of corrosion from adjacent materials	Not stated	IEEE-323-1983	No specific program	As new vendors & technologies emerge, their aging sensitivity should be addressed. [2]	146-152	22
Vibration may crack glass seals allowing contamination to enter case, corr from moisture entering cracked seals or adjacent materials, contamination left from mfg process or entering through seal cracks may cause component shorting.	Not stated	IEEE-323-1983	No specific program	As new vendors & technologies emerge, their aging sensitivity should be addressed. [2]	146-152	23
Decreases reliable life of diesels	Not stated	Not discussed in report	IEEE 387-1984 Section 7.5, IEEE 749-1983	Not stated	153-157	24
The report is not an aging evaluation, but only describes long term tests to determine the amount of insulation degratation from radiation, elevated temperature, pwr atmospheres, and inerted BWR atmospheres.	Not stated	IEEE Std-74 & IEEE STD-383-1974	No specific program	Not stated	158-166	25

Document: NUREG/CP-0105, Seventeenth Water Reactor Safety Information Meeting (Electrical Parts)
Reviewed by: L. C. Meyer, INEL

Effect of Aging on Component Function	Contrib to Failure	Reported progs	Rel.progs	Report Recommendations	Page No.	Item
This report develops an aging risk assesment methodology using the aPWR AFW system to demonstrate method	Not stated	Not discussed in report	No specific program	Not stated	377-398	14
This report covered loca testing of aged cables. Aging information provided in other Sandia reports on cable aging	Not stated	Not discussed in report	No specific program	Not stated	399-410	15
PWSCC damages steam tubes at three locations; roll transition regions, U-bends, and tube dents. Leaks at these locations can lead to shuting down the reactor.	Rare	Not discussed in report	No specific program	Not stated	411-431	16
This report covers NPAR phase 2 tasks related to resolving technical safety issues	Not stated	NPAR	No specific program	Not stated	433-437	17
This report only provides an overview and identifies the turbine driven pump as historically having the most failures with the turbine i&c/governor control system having half of these failures. Does not have specific aging data.	Not stated	Not discussed in report	No specific program	Comprehensive testing of components and i&c. [2]	439-451	18
Degraded operation or failure	Occasional	Not discussed in report	No specific program	Not stated	453-471	19
Failure or degraded operation	Occasional	Not discussed in report	No specific program	Not stated	453-471	20
Failure to operate, failure to open or close, or degraded operation	Occasional	Not discussed in report	No specific program	Not stated	453-471	21

Document: NUREG/CP-0105, Seventeenth Water Reactor Safety Information Meeting (Electrical Parts)
Reviewed by: L. C. Meyer, INEL

Item	System	Structure/Comp	Subcomponent	Materials	Manufacturer	ARD mechanism	ARD effects
22	Auxiliary Feedwater System	Diesel Generator		Not stated	Not stated	Not stated	Not stated
23	Auxiliary Feedwater System	Circuit Breakers	Not stated	Not stated	Not stated	Not stated	Not stated
24	Auxiliary Feedwater System	Not stated	Not stated	Not stated	Not stated	Not stated	Not stated
25	Auxiliary Feedwater System	Not stated	Not stated	Not stated	Not stated	Not stated	Not stated

Document: NUREG/CR-3956, In Situ Testing of the Shippingport Atomic Power Station Electrical Circuits
Reviewed by: L. C. Meyer, INEL

Item	System	Structure/Comp	Subcomponent	Materials	Manufacturer	ARD mechanism	ARD effects
1	Pressurizer Heater Feeder Circuit	Cable	Conductor	NO. 6 AWG, single copper conductor	Okonite	CORR	Increased loop resistance
2	Pressurizer Heater Feeder Circuit	Cable	Insulation	1/16 IN. thick oil base	Okonite	Not stated	Low insulation resistance
3	Pressurizer Heater Feeder Circuit	Cable	Jacket	1/32-IN. black neoprene	Okonite	Not stated	Not stated
4	Pressurizer Heater Main Feeder Circuit	Cable	Conductor	NO. 10 AWG Copper	Not stated	CORR	Not stated
5	Pressurizer Heater Main Feeder Circuit	Cable	Insulation	Silicon rubber with glass braid	Not stated	OXIDAT	Degraded insulation resistance
6	Pressurizer Heater Main Feeder Circuit	Cable	Jacket	Silicon rubber	Not stated	Not stated	Not stated
7	Instrumentation and Control	Heater, MOV, and RTD Circuits	Stop Joint, Splices, and Terminals	Not stated	Not stated	MOIST-EL AND CORR	Loss of material, and corrosion product buildup
8	Rod Control Position Indicator Cables	Cable	33 Conductor, NO. 16 AWG, Stranded Wire	Copper	Okonite	Not stated	Not stated
9	Rod Control Position Indicator Cables	Cable	Insulation	Oil base insulation	Okonite	Not stated	Not stated
10	Rod Control Position Indicator Cables	Cable	Jacket	Neoprene	Okonite	Not stated	Not stated
11	Resistance Temperature Detector Circuits	Cable	Insulation	NO. 18 AWG, tinned copper stranded. spiral wrapped and shielded with a chrome vinyl jacket	Not stated	Not stated	Not stated
12	Resistance Temperature Detector Circuits	RTDs	Sensing Element	Platinum	Leeds and Northrup	Not stated	Not stated
13	Resistance Temperature Detector Circuits	Terminals and Stop Joints	Not stated	Not stated	Not stated	CORR AND MOIST-EL	Increase in resistance, open circuit, and film on terminals
14	Nuclear Instrumentation	RG-149U Cables	Insulation	NO. 18 AWG copper center conductor and polyethylene insulation	Not stated	Not stated	Not stated
15	Motor Operated Valves	Limit Switches	Contacts	Not stated	Not stated	CORR	Material buildup on contacts
16	Motor Operated Valves	Cable	Not stated	Not stated	Not stated	Not stated	Not stated
17	Motor Operated Valves	Motor	Not stated	Not stated	Not stated	Not stated	Not stated

Table A.2 Gall Report for NPAR Reports

Document: NUREG/CP-0105, Seventeenth Water Reactor Safety Information Meeting (Electrical Parts)
Reviewed by: L. C. Meyer, INEL

Effect of Aging on Component Function	Contrib to Failure	Reported progs	Rel.progs	Report Recommendations	Page No.	Item
Failure to start	Occasional	Not discussed in report	IEEE 387-1984 Section 7.5, IEEE 749-1983	Not stated	473-495	22
Failure to transfer	Occasional	Not discussed in report	IEEE 741-1986 Section 7	Not stated	473-495	23
This report only covers the use of NPAR results in inspection activities. Aging summaries are covered in other npar reports	Not stated	Not discussed in report	N/A	Not stated	497-407	24
This report covers a methodology for managing aging in nuclear power plants	Not stated	Not discussed in report	N/A	Not stated	509-529	25

Document: NUREG/CR-3956, In Situ Testing of the Shippingport Atomic Power Station Electrical Circuits
Reviewed by: L. C. Meyer, INEL

Effect of Aging on Component Function	Contrib to Failure	Reported progs	Rel.progs	Report Recommendations	Page No.	Item
The effect was a small decrease in available wattage to heaters	Rare	Plant specific maintenance	No specific program	Keep moisture out [2]	5, 6, & 7	1
Degraded heater oeration, one circuit failed because of low insulation resistance	Rare	Plant specific maintenance	No specific program	Keep moisture out of cables [2]	5, 6, 7, & 21	2
Not stated	Rare	Not discussed in report	No specific program	Not stated	6	3
Marginal operation	Rare	Not discussed in report	No specific program	Not stated	6	4
Marginal operation of heaters	Rare	Not discussed in report	No specific program	Not stated	6	5
Not stated	Rare	Not discussed in report	No specific program	Not stated	6	6
Nonenvironmentaly sealed splices and terminals presents vulnerable areas for oxidation, corrosion, dust, and moisture contamination to set in.	Occasional	Not discussed in report	No specific program	Periodic plant maintenance to clean terminals and check seals and to use ECCAD to check circuits before failure [2]	7 and 21	7
None	Rare	Not discussed in report	No specific program	Not stated	7, 8, and 21	8
None	Rare	Not discussed in report	No specific program	Not stated	7, 8, and 21	9
None	Rare	Not discussed in report	No specific program	Not stated	7, 8, and 21	10
None	Rare	Not discussed in report	No specific program	Not stated	7, 8, and 21	11
One circuit shorted to ground at the instrument end	Rare	Not discussed in report	ANSI/IEEE 338-1987	Not stated	8, 9, and 21	12
Circuits had higher than expected loop resistance, four circuits had a series resistance occuring at the stop joints, resistance problem also observed at termination points in the control room, one circuit was shorted to ground at the instrument end	Occasional	Not discussed in report	No specific program	Not stated	9, 10, and 21	13
None	Rare	Not discussed in report	ANSI N42.4-1971	Not stated	12. 13, and 21	14
Insulation resistance exceeded the standard recommended minimum, although not serious enough to alter the intended limit switch function	Rare	Not discussed in report	Vendor specific, GL 89-10, NUREG-1352	Not stated	12, 20, and 21	15
None	Rare	Not discussed in report	No specific program	Not stated	12, 20, and 21	16
None except two movs located outside, exposed to weather were inoperable.	Rare	Not discussed in report	Vendor specific, GL 89-10, NUREG-1352	Not stated	12, 20, and 21	17

Document: NUREG/CR-3956, In Situ Testing of the Shippingport Atomic Power Station Electrical Circuits
Reviewed by: L C. Meyer, INEL

Item	System	Structure/Comp	Subcomponent	Materials	Manufacturer	ARD mechanism	ARD effects
18	Motor Operated Valves	Not stated	Not stated	Not stated	Not stated	WEATH	Not stated

Document: NUREG/CR-4156, Operating Experience and Aging-Seismic Assessment of Electric Motors
Reviewed by: L C. Meyer, INEL

Item	System	Structure/Comp	Subcomponent	Materials	Manufacturer	ARD mechanism	ARD effects
1		3 Phase Induction & Synchronous Motors	Stator - Conductors and Structural Components	Copper	Not stated	VIB, THERM, AND SHRINK	Loosening of laminations and locking devices
2		3 Phase Induction & Synchronous Motors	Stator - Insulation	Mica, glass, resins, enamels, mylars, figer, varnish, and nonhygroscopic materials	Not stated	THERM, OXIDAT, MOIST-EL, AND RAD	Degraded dielectric properties & tensile strength, brittle
3		3 Phase Induction & Synchronous Motors	Rotor - Contuctors and Structural Components	Copper	Not stated	VIB & THERM	Rotor embalance, loose parts, and overheating
4		3 Phase Induction & Synchronous Motors	Rotor - Insulating Materials	Mica, glass, resins, enamels, mylars, fiber, varnish, and nonhygroscopic marteials	Not stated	CURSTR, THERM, RAD, AND MOIST-EL	Insulation damage, winding short, overheating of rotor coils
5		3 Phase Induction & Synchronous Motors	Rotor - Commutator and Brushes	Mica, copper, carbon, and steel in spring mechanism	Not stated	WEAR, FAT, DIRT, CONTAM, AND OXIDAT	Brush wearout, relaxed spring, oil deposits, & loose contact
6		3 Phase Induction & Synchronous Motors	Bearings	Steel, brass, and bronze	Not stated	VIB, THERM, WEAR, CONTAMIN, AND LOSLUBE	Material attrition, cracking of bearings, scoring of surface
7		3 Phase Induction & Synchronous Motors	Bolts, Flanges, and Housing	Steel, cast iron, brass, and copper	Not stated	VIB, CORR, FAT, THERM, AND MECHSTR	Sheared bolts, cracked flanges or housing, overheated frame
8		3 Phase Induction & Synchronous Motors	Seals and Gaskets	Polymers	Not stated	THERM, VIB, AND RAD	Cracking, shrinking, leaking of oil or water, embrittlement
9		3 Phase Induction & Synchronous Motors	MOV's Break Coils	Copper	Not stated	THERM, CORR, CURSTR	Corrosion product buildup, current overload, & misoperation
10		3 Phase Induction & Synchronous Motors	Conduit Box, Leads, and Connections	Copper	Not stated	VIB AND CORR, CONTAM, MOIST-EL	Leak, poor electrical contact, loose leads, improper seals
11		3 Phase Induction & Synchronous Motors	Motor	See sub-components	Not stated	WEAR, THERM, VIB, CURSTR, RAD, FAT, AND MOIST-EL	Misaligned parts, burned out motor, & disengaged motor

Document: NUREG/CR-4234 V2, Aging and Service Wear of Electric Motor-Operated Valves Used in Engineered Safety-Feature Systems of Nuclear Power Plants
Reviewed by: Jerry Edson, INEL

Item	System	Structure/Comp	Subcomponent	Materials	Manufacturer	ARD mechanism	ARD effects
1		Motor Operated Valve	Gearbox - Gears	Not stated	EIM, Limitorque, Rotork	WEAR	Not stated

Table A.2 Gall Report for NPAR Reports

Document: NUREG/CR-3956, In Situ Testing of the Shippingport Atomic Power Station Electrical Circuits
Reviewed by: L. C. Meyer, INEL

Effect of Aging on Component Function	Contrib to Failure	Reported progs	Rel.progs	Report Recommendations	Page No.	Item
Inoperable	Rare	Not discussed in report	N/A	Not stated	12, 20, and 21	18

Document: NUREG/CR-4156, Operating Experience and Aging-Seismic Assessment of Electric Motors
Reviewed by: L. C. Meyer, INEL

Effect of Aging on Component Function	Contrib to Failure	Reported progs	Rel.progs	Report Recommendations	Page No.	Item
Not stated	Occasional	Not discussed in report	IEEE 334-1974 Section 14	Preventive maintenance programms, operational readiness acceptance criteria, in-situ testing and monitoring programs [2]	S-2, 2-15, and 4-23	1
Degraded operation or failure to function	Occasional	Not discussed in report	IEEE 334-1974 Section 14	Preventive maintenance programms, operational readiness acceptance criteria, in-situ testing and monitoring programs [2]	S-2, 2-15, & 4-23	2
Frame distortion, shift in rotor center of gravity, insuficient cooling, winding short short or overheating of rotor coils leading to burnt motor and failure to function.	Occasional	Not discussed in report	IEEE 334-1974 Section 14	Preventive maintenance programms, operational readiness acceptance criteria, in-situ testing and monitoring programs [2]	S-2, 2-20, 4-23	3
Excess current due to aging from many starts, cage winding failure due to jogging, over heating of rotor coils leading to burnt motor, winding shorts, insulation shrinkage results in decreased output or failure to function.	Occasional	Not discussed in report	IEEE 334-1974 Section 14	Preventive maintenance programms, operational readiness acceptance criteria, in-situ testing and monitoring programs [2]	2-15, S-2, 4-24	4
Loose brush connection, dirt & foreign particles, wear out of carbon brushes, relaxed spring load in the brush holder mechanisms, dirt/ moisture on commutator and oxidation effects results in decreased output or failure to function.	Occasional	Not discussed in report	IEEE 334-1974 Section 14	Preventive maintenance programms, operational readiness acceptance criteria, in-situ testing and monitoring programs [2]	2-22, S-2, 4-25	5
Seized bearings, and overheating, excessive vibration could cause fracture and bearing scoring, corrosion due to exposure to air.	Occasional	Not discussed in report	IEEE 334-1974 Section 14	Preventive maintenance programms, operational readiness acceptance criteria, in-situ testing and monitoring programs [2]	2-15, 4-22, 4-23, 4-25, 4-26, and 4-27	6
Failure to function or degraded operation	OCCCASIONAL	Not discussed in report	IEEE 334-1974 Section 14	Preventive maintenance programms, operational readiness acceptance criteria, in-situ testing and monitoring programs [2]	2-15, 4-24, 4-25, 4-25, 4-27, and 4-28	7
Decreased output or failure to function.	Occasional	Not discussed in report	IEEE 334-1974 Section 14	Preventive maintenance programms, operational readiness acceptance criteria, in-situ testing and monitoring programs [2]	5-15 & 4-28	8
Burning of motor windings, jamming of break coil, overload the motor drawing large currents into the windings results in failure to operate.	Rare	Not discussed in report	Vendor specific, GL 89-10, NUREG-1352	Preventive maintenance programms, operational readiness acceptance criteria, in-situ testing and monitoring programs [2]	5-15 & 4-28	9
Degraded insulation, shorts, or open circuits result in decreased output or failure to function.	Occasional	Not discussed in report	No specific program	Preventive maintenance programms, operational readiness acceptance criteria, in-situ testing and monitoring programs [2]	4-28	10
Burned or dead motor, disengaged motor, & overcurrent results in decreased output or failure to function.	Rare	Not discussed in report	IEEE 334-1974 Section 14	Preventive maintenance programms, operational readiness acceptance criteria, in-situ testing and monitoring programs [2]	4-29	11

Document: NUREG/CR-4234 V2, Aging and Service Wear of Electric Motor-Operated Valves Used in Engineered Safety-Feature Systems of Nuclear Power Plant:
Reviewed by: Jerry Edson, INEL

Effect of Aging on Component Function	Contrib to Failure	Reported progs	Rel.progs	Report Recommendations	Page No.	Item
Failure to open or close, failure to operate as required	Not stated	Not discussed in report	Vendor specific, GL 89-10, NUREG-1352	Accurate and consistent mov testing should be performed. Good records should be maintained [4]	5 - 12, 15, 72, 167	1

Table A.2 Gall Report for NPAR Reports

Document: NUREG/CR-4234 V2, Aging and Service Wear of Electric Motor-Operated Valves Used in Engineered Safety-Feature Systems of Nuclear Power Plants
Reviewed by: Jerry Edson, INEL

Item	System	Structure/Comp	Subcomponent	Materials	Manufacturer	ARD mechanism	ARD effects
2		Motor Operated Valve	Gearbox -Fasteners	Not stated	EIM, Limitorque, Rotork	Not stated	Fastener loosening
3		Motor Operated Valve	Gearbox - Stem Nut	Not stated	EIM, Limitorque, Rotork	WEAR	Not stated
4		Motor Operated Valve	Gearbox - Drive Sleeve	Not stated	EIM, Limitorque, Rotork	WEAR	Not stated
5		Motor Operated Valve	Gearbox - Bearings	Not stated	EIM, Limitorque, Rotork	WEAR	Not stated
6		Motor Operated Valve	Gearbox - Lubericant	Not stated	EIM, Limitorque, Rotork	Not stated	Hardening
7		Motor Operated Valve	Gearbox - Shaft	Not stated	EIM, Limitorque, Rotork	WEAR, MECHSTR	Tapering of the shaft
8		Motor Operated Valve	Gearbox - Clutch	Not stated	EIM, Limitorque, Rotork	WEAR	Not stated
9		Motor Operated Valve	Gearbox - Spring Pack and Torque Switch	Not stated	EIM, Limitorque, Rotork	Not stated	Response change
10		Motor Operated Valve	Gearbox - Stem Lock Nut	Not stated	EIM, Limitorque, Rotork	Not stated	Loosening
11		Motor Operated Valve	Gearbox - Seal	Not stated	EIM, Limitorque, Rotork	WEAR	Deterioration
12		Motor Operated Valve	Motor	Not stated	EIM, Limitorque, Rotork	CORR, WEAR	Not stated
13		Motor Operated Valve	Motor	Not stated	EIM, Limitorque, Rotork	ELETEMP	Break down of insulation
14		Motor Operated Valve	Switches - Contacts	Not stated	EIM, Limitorque, Rotork	CORR, CORR/PIT	Not stated
15		Motor Operated Valve	Switches - Insulation	Not stated	EIM, Limitorque, Rotork	ELETEMP	Insulation breakdown
16		Motor Operated Valve	Switches - Grease	Not stated	EIM, Limitorque, Rotork	Not stated	Harnening
17		Motor Operated Valve	Switches - Gear and Cam	Not stated	EIM, Limitorque, Rotork	WEAR	Not stated
18		Motor Operated Valve	Switches - Fastener	Not stated	EIM, Limitorque, Rotork	Not stated	Loosening

Document: NUREG/CR-4234 V2, Aging and Service Wear of Electric Motor-Operated Valves Used in Engineered Safety-Feature Systems of Nuclear Power Plant:
Reviewed by: Jerry Edson, INEL

Effect of Aging on Component Function	Contrib to Failure	Reported progs	Rel.progs	Report Recommendations	Page No.	Item
Failure to open or close, failure to operate as required	Not stated	Not discussed in report	Vendor specific, GL 89-10, NUREG-1352	Accurate and consistent mov testing should be performed. Good records should be maintained [4]	5 - 12, 15, 72, 167	2
Failure to open or close, failure to operate as required	Not stated	Not discussed in report	Vendor specific, GL 89-10, NUREG-1352	Accurate and consistent mov testing should be performed. Good records should be maintained [4]	5 - 12, 15, 72, 167	3
Failure to open or close, failure to operate as required	Not stated	Not discussed in report	Vendor specific, GL 89-10, NUREG-1352	Accurate and consistent mov testing should be performed. Good records should be maintained [4]	5 - 12, 15, 72, 167	4
Failure to open or close, failure to operate as required	Not stated	Not discussed in report	Vendor specific, GL 89-10, NUREG-1352	Accurate and consistent mov testing should be performed. Good records should be maintained [4]	5 - 12, 15, 72, 167	5
Failure to open or close, failure to operate as required	Not stated	Not discussed in report	Vendor specific, GL 89-10, NUREG-1352	Accurate and consistent mov testing should be performed. Good records should be maintained [4]	5 - 12, 15, 72, 167	6
Failure to open or close, failure to operate as required	Not stated	Not discussed in report	Vendor specific, GL 89-10, NUREG-1352	Accurate and consistent mov testing should be performed. Good records should be maintained [4]	5 - 12, 15, 72, 167	7
Failure to open or close, failure to operate as required	Not stated	Not discussed in report	Vendor specific, GL 89-10, NUREG-1352	Accurate and consistent mov testing should be performed. Good records should be maintained [4]	5 - 12, 15, 72, 167	8
Failure to open or close, failure to operate as required	Not stated	Not discussed in report	Vendor specific, GL 89-10, NUREG-1352	Accurate and consistent mov testing should be performed. Good records should be maintained [4]	5 - 12, 15, 72, 167	9
Failure to open or close, failure to operate as required	Not stated	Not discussed in report	Vendor specific, GL 89-10, NUREG-1352	Accurate and consistent mov testing should be performed. Good records should be maintained [4]	5 - 12, 15, 72, 167	10
Leakage of lubricant out from gearbox or leakage of contaminants into the gear box resulting in failure to open or close or failure to operate as required	Not stated	Not discussed in report	Vendor specific, GL 89-10, NUREG-1352	Accurate and consistent mov testing should be performed. Good records should be maintained [4]	5 - 12, 15, 72, 167	11
Failure to open or close or failure to operate as required	Not stated	Not discussed in report	Vendor specific, GL 89-10, NUREG-1352	Accurate and consistent mov testing should be performed. Good records should be maintained [4]	5 - 12, 15, 72, 167	12
Failure to open or close or failure to operate as required	Not stated	Not discussed in report	Vendor specific, GL 89-10, NUREG-1352	Accurate and consistent mov testing should be performed. Good records should be maintained [4]	5 - 12, 15, 72, 167	13
Failure to open or close or failure to operate as required	Not stated	Not discussed in report	Vendor specific, GL 89-10, NUREG-1352	Accurate and consistent mov testing should be performed. Good records should be maintained [4]	5 - 12, 15, 72, 167	14
Failure to open or close or failure to operate as required	Not stated	Not discussed in report	Vendor specific, GL 89-10, NUREG-1352	Accurate and consistent mov testing should be performed. Good records should be maintained [4]	5 - 12, 15, 72, 167	15
Failure to open or close or failure to operate as required	Not stated	Not discussed in report	Vendor specific, GL 89-10, NUREG-1352	Accurate and consistent mov testing should be performed. Good records should be maintained [4]	5 - 12, 15, 72, 167	16
Failure to open or close or failure to operate as required	Not stated	Not discussed in report	Vendor specific, GL 89-10, NUREG-1352	Accurate and consistent mov testing should be performed. Good records should be maintained [4]	5 - 12, 15, 72, 167	17
Failure to open or close or failure to operate as required	Not stated	Not discussed in report	Vendor specific, GL 89-10, NUREG-1352	Accurate and consistent mov testing should be performed. Good records should be maintained [4]	5 - 12, 15, 72, 167	18

Table A.2 Gall Report for NPAR Reports

Document: NUREG/CR-4234 V2, Aging and Service Wear of Electric Motor-Operated Valves Used in Engineered Safety-Feature Systems of Nuclear Power Plant:
Reviewed by: Jerry Edson, INEL

Item	System	Structure/Comp	Subcomponent	Materials	Manufacturer	ARD mechanism	ARD effects
19		Motor Operated Valve	Valves - Operator	Not stated	Anchor Darling, Velan, ET	WEAR, CORR	Not stated
20		Motor Operated Valve	Valves - Yoke Bushing	Not stated	Anchor Darling, Velan, ET	WEAR	Not stated
21		Motor Operated Valve	Valves - Valve Stem	Not stated	Anchor Darling, Velan, ET	WEAR, MECHSTR	Tapering of the shaft
22		Motor Operated Valve	Valves - Fasteners	Not stated	Anchor Darling, Velan, ET	Not stated	Loosening
23		Motor Operated Valve	Valves - Valve Seat	Not stated	Anchor Darling, Velan, ET	WEAR, CORR	Not stated
24		Motor Operated Valve	Valves - Bonnet Seal	Not stated	Anchor Darling, Velan, ET	Not stated	Deterioration
25		Motor Operated Valve	Valves - Stem Packing	Not stated	Anchor Darling, Velan, ET	Not stated	Deterioration

Document: NUREG/CR-4257, Inspection, Surveillance, and Monitoring of Electrical Equipment Inside Containment of Nuclear Power Plants - With Applications to :
Reviewed by: L. C. Meyer, INEL

Item	System	Structure/Comp	Subcomponent	Materials	Manufacturer	ARD mechanism	ARD effects
1		Cable	600 V, 4 kV, and 13 kV Power Cable Insulation	Cross-linked polyethylene (XLPE)	Not stated	THERM, RAD, CHEM, AND MOIST-EL	Chemical changes, dielectric degradation, & cracks
2		Cable	600 V, 4 kV, and 13 kV Power Cable Insulation	Ethylene propylene	Not stated	THERM, RAD, CHEM, AND MOIST-EL	Chemical changes, dielectric degradation, & cracks
3		Cable	600 V, 4 kV, and 13 kV Power Cable Insulation	Polyvinyl chloride (PVC)	Not stated	THERM, RAD, CHEM, AND MOIST-EL	Radiation deterioration, dielectric degradation, & cracks
4		Cable	Cable Sheathing and Jacket	Chlorosulfonated polyethylene (CSP) and Kapton	Not stated	THERM, RAD, & CHEM.	Radiation deterioration, dielectric degradation, & cracks
5		Cable	Control Cable	Cross-linked polyethylene (XLPE)	Not stated	THERM, RAD, & CHEM.	Radiation deterioration, dielectric degradation, & cracks
6		Cable	Coaxial Cable	Cross-linked polyethylene (XLPE)	Not stated	THERM, RAD, & CHEM.	Radiation deterioration, dielectric degradation, & cracks
7		Cable	Mineral Insulation Metal Jacket Cable	Not stated	Not stated	RAD & VIB	Wear

Table A.2 Gall Report for NPAR Reports

Document: NUREG/CR-4234 V2, Aging and Service Wear of Electric Motor-Operated Valves Used in Engineered Safety-Feature Systems of Nuclear Power Plants
Reviewed by: Jerry Edson, INEL

Effect of Aging on Component Function	Contrib to Failure	Reported progs	Rel.progs	Report Recommendations	Page No.	Item
Failure to open or close or failure to operate as required	Not stated	Not discussed in report	Vendor specific, GL 89-10, NUREG-1352	Accurate and consistent mov testing should be performed. Good records should be maintained [4]	5 - 12, 15, 72, 167	19
Failure to open or close or failure to operate as required	Not stated	Not discussed in report	Vendor specific, GL 89-10, NUREG-1352	Accurate and consistent mov testing should be performed. Good records should be maintained [4]	5 - 12, 15, 72, 167	20
Failure to open or close or failure to operate as required	Not stated	Not discussed in report	Vendor specific, GL 89-10, NUREG-1352	Accurate and consistent mov testing should be performed. Good records should be maintained [4]	5 - 12, 15, 72, 167	21
Failure to open or close or failure to operate as required	Not stated	Not discussed in report	Vendor specific, GL 89-10, NUREG-1352	Accurate and consistent mov testing should be performed. Good records should be maintained [4]	5 - 12, 15, 72, 167	22
Failure to open or close or failure to operate as required	Not stated	Not discussed in report	Vendor specific, GL 89-10, NUREG-1352	Accurate and consistent mov testing should be performed. Good records should be maintained [4]	5 - 12, 15, 72, 167	23
Leakage	Not stated	Not discussed in report	Vendor specific, GL 89-10, NUREG-1352	Accurate and consistent mov testing should be performed. Good records should be maintained [4]	5 - 12, 15, 72, 167	24
Leakage	Not stated	Not discussed in report	Vendor specific, GL 89-10, NUREG-1352	Accurate and consistent mov testing should be performed. Good records should be maintained [4]	5 - 12, 15, 72, 167	25

Document: NUREG/CR-4257, Inspection, Surveillance, and Monitoring of Electrical Equipment Inside Containment of Nuclear Power Plants - With Applications to I
Reviewed by: L. C. Meyer, INEL

Effect of Aging on Component Function	Contrib to Failure	Reported progs	Rel.progs	Report Recommendations	Page No.	Item
Chemical changes in polymer resulting from aging, loss of dielectric generally occurs after deterioration of mechanical properties, treeing may cause rapid breakdown of dielectric capabilities. loss of flexibility, can't withstand voltage stress	Rare	Not discussed in report	No specific program	Testing to be based on safety importance, determine root cause of failures, remove samples after 5 to 10 years for tests [4]	26,38, 40, & 53	1
Loss of dielectric generally occurs after detenoration of mechanical properties, treeing may cause rapid breakdown of dielectric capabilities. loss of flexibility, can't with stand voltage stress	Rare	Not discussed in report	No specific program	Testing to be based on safety importance, determine root cause of failures, remove samples after 5 to 10 years for tests [4]	26,38, 40, & 53	2
Subject to deterioration from radiation, loss of dielectric generally occurs after detenoration of mechanical properties.	Rare	Not discussed in report	No specific program	Testing to be based on safety importance, determine root cause of failures, remove samples after 5 to 10 years for tests [4]	26,38, 40, & 53	3
Major failure modes for sheathing are loss of flexibility and imperviousness. teflon glue fails at low radiaton doses resulting in inability to protect conductor insulation.	Rare	Not discussed in report	No specific program	Testing to be based on safety importance, kapton not recommended for applications subject to radiation doses > 0.01 mrad [4]	26,38, 40, & 53	4
Loss of dielectric generally occurs after deterioration of mechanical properties, loss of flexibility, loss of imperviousness, aging similar to power cable. Results in failure to properly transmit voltage or current.	Rare	Not discussed in report	No specific program	Testing to be based on safety importance, determine root cause of failures, remove samples after 5 to 10 years for tests [4]	26, 39, 40, & 53	5
Loss of dielectric generally occurs after deterioration of mechanical properties, loss of flexibility, loss of imperviousness, aging similar to power cable. Results in failure to properly transmit voltage or current.	Rare	Not discussed in report	No specific program	Testing to be based on safety importance, determine root cause of failures, remove samples after 5 to 10 years for tests [4]	26, 39, 40, & 53	6
Conductor wear through insulation due to bending or vibration. Results in ffailure to ransmit voltage or current.	Rare	Not discussed in report	No specific program	Testing to be based on safety importance, determine root cause of failures. [4]	26, 30,	7

Document: NUREG/CR-4257 V2, Inspection, Surveillance, and Monitoring of Electrical Equipment in Nuclear Power Plants - Pressure Transmitters
Reviewed by: L. C. Meyer, INEL

Item	System	Structure/Comp	Subcomponent	Materials	Manufacturer	ARD mechanism	ARD effects
1		Force Balance Type Transmitter	Force Balance Bar & Linkage	316 stainless steel	The Foxboro Company	VIB AND WEAR	Wear, failure to operate, bending component, zero shift
2		Force Balance Type Transmitter	Feedback Coil	Copper	The Foxboro Company	THERM,	Burnout
3		Force Balance Type Transmitter	Amplifier	Carbon resistors, transistors, OP amps, capacitors & diodes	The Foxboro Company	THERM, RAD, VOLSTR	Degradation of insulation, insulation breakdown, & cracks
4		Force Balance Type Transmitter	Housing Seals	Viton	The Foxboro Company	THERM, RAD, & CONTAM	Embrittlement, cracking, and inability to seal
5		Force Balance Type Transmitter	Diaphragm Capsule	316 stainless steel	The Foxboro Company	CORR	Leakage or perforation
6		Force Balance Type Transmitter	Diaphragm Seal	316 stainless steel	The Foxboro Company	THERM OR RAD	Inability to maintain pressure barrier, variable instrument
7		Capacitance Type Transmitter	Sensing Cell	316 stainless steel	Rosemount	THERM AND RAD	Leakage, rupture, oil breakdown, or perforation
8		Capacitance Type Transmitter	Terminal Cover Seal	Ethylene propylene	Rosemount	THERM AND RAD	Embrittlement and cracking
9		Capacitance Type Transmitter	Electronics Cover Seal	Ethylene propylene	Rosemount	THERM AND RAD	Embrittlement and cracking
10		Capacitance Type Transmitter	Electronics Parts - Misc Small Components	Not stated	Rosemount	OXIDAT, THERM, AND VOLSTR	Degradation of insulation, arcing, shorts and open circuits
11		Strain Gage Type	Strain Gage	Resistive material	ITT Barton Instruments	VIB	Loss of continuity or open resistor
12		Strain Gage Type	Housing Seal	Ethylene propylene	ITT Barton Instruments	THERM AND RAD	Embrittlement or cracking
13		Strain Gage Type	Potentiometer	Phenolic body, nylon rotor, and slider	ITT Barton Instruments	CORR AND THERM	Corrosion material buildup lubricant loss
14		Strain Gage Type	Electric Module	Carbon resistor, transistors, operational amplifier, capacitors, and diodes	ITT Barton Instruments	VIB, THERM, OR RAD	Component deterioration or change in component parameters.
15		Strain Gage Type	Bourdon Tube	Haynes alloy NO 25	ITT Barton Instruments	CORR	Contamination build up and material loss.

Document: NUREG/CR-4257 V2, Inspection, Surveillance, and Monitoring of Electrical Equipment in Nuclear Power Plants - Pressure Transmitters
Reviewed by: L. C. Meyer, INEL

Effect of Aging on Component Function	Contrib to Failure	Reported progs	Rel.progs	Report Recommendations	Page No.	Item
Wear of pivot points, decreased accuracy, complete failure, zero shift, bending of components in level system,	Rare	Not discussed in report	IEEE 338-1987	Not stated	9, 18 & 21	1
Loss of output	Rare	Not discussed in report	IEEE 338-1987	Not stated	9, 18 & 21	2
Shorting or opening of electronic components, loss of accuracy, drift, zero shift, loss of signal, may fail high or low, lose accuracy, or fail with steady output.	Occasional	Not discussed in report	IEEE 338-1987	Not stated	9, 18 & 21	3
Inability of seal to provide moisture and pressure barrier, ingress of environmental contaminants, and loss of pressure barrier results in transmitter drift or failure to respond.	Occasional	Not discussed in report	10 CFR 50.49	Not stated	9, 18 & 21	4
Perforation of diaphragm from corrosion or flaw, variable instrument drift as pressures across diaphragm equalize, and leakage through diaphragm, permanent deformation of diaphragm, and zero shift.	Rare	Not discussed in report	IEEE 338-1987	Not stated	9, 18 & 21	5
Variable instrument drift as pressures across diaphragm equalize, and inablitity to maintain pressure barrier.	Rare	Not discussed in report	IEEE 338-1987	Not stated	9, 18 & 21	6
Leakage of cell fluid through diaphragm, loss of accuracy and drift, rupture allows equalization of forces on diaphragm, drastic change in sensing cell characteristics, oil breakdown due to thermal or radiation stress.	Rare	Not discussed in report	Enhanced Surveillance - GL 90-01 Suppl. 1	Not stated	9, 11, 19 & 21	7
Inability of seal to provide moisture and pressure boundary, cracking due to thermal or radiation stresses, and loss of electronics due to ingress of environmental contaminants. Results in transmitter drift or failure to respond.	Occasional	Not discussed in report	10 CFR 50.49	Not stated	9, 11, 19 & 21	8
Inability of seal to provide moisture and pressure boundary, cracking due to thermal or radiation stresses, and loss of electronics due to ingress of environmental contaminants. Results in transmitter drift or failure to respond.	Occasional	Not discussed in report	10 CFR 50.49	Not stated	9, 11, 19 & 21	9
Loss of signal, sporadic operation, shorting or opening of components, oxidation of contacts, bridging of circuits.	Occasional	Not discussed in report	IEEE 338-1987	Not stated	9, 11, 19 & 21	10
Loss of continuity in bridge circuit, loss of output, loss of response to input pressure, and failure of instrument.	Occasional	Not discussed in report	IEEE 338-1987	Not stated	6, 7, 20 & 22	11
Inability to provide moisture and pressure barrier, failure of electronics due to contamination. Results in instrument drift or failure to respond.	Occasional	Not discussed in report	10 CFR 50.49	Not stated	6, 7, 20 & 22	12
Corrosion of resistive elements in potentiometer, wirewound potentiometer corrodes open due to thermal stress and corrosive lubricant, fails over range, and loss of span adjustment.	Occasional	Not discussed in report	IEEE 338-1987	Not stated	6, 7, 20 & 22	13
Loss of full output, calibration shift, component parameters change.	Occasional	Not discussed in report	IEEE 338-1987	Not stated	6, 7, 20 & 22	14
Permanent deformation of tube, zero shift, leaks in bourdon tube to transmitter housing, perforatioon due to corrosion, drift of transmitter, failure of transmitter to respond.	Occasional	Not discussed in report	IEEE 338-1987	Not stated	6, 7, 20 & 22	15

Document: NUREG/CR-4457, Aging of Class 1E Batteries in Safety Systems of Nuclear Power Plants
Reviewed by: Jerry Edson, INEL

Item	System	Structure/Comp	Subcomponent	Materials	Manufacturer	ARD mechanism	ARD effects
1		Batteries - General			GNB/Gould, Exide, C&D		
2		Batteries	Grids	Lead-calcium alloy	GNB/Gould, Exide, C&D	ELETEMP	Plate growth, loss of contact with active material
3		Batteries	Active Material	Lead, lead dioxide	GNB/Gould, Exide, C&D	GAS, CONTAM	Dislodging or shedding of active material from the grid
4		Batteries	Separators	Rubber/glass mat, polyethelene sheets	GNB/Gould, Exide, C&D	ELETEMP	Decreased electrical insulation
5		Batteries	Electrolyte	Sulfuric acid and water	GNB/Gould, Exide, C&D	CONTAM	Chemical reactions, hydolysis
6		Batteries	Vents	Fused Alumina	GNB/Gould, Exide, C&D	MECHSTR	Vent breaks allowing contamination to enter
7		Batteries	Top Conductors	Lead-calcium alloy	GNB/Gould, Exide, C&D	ELETEMP, CORR, EMBR	Low electrolyte level causes corrosion and embrittlement
8		Batteries	Terminals	Lead-calcium alloy, lead-calcium with copper insert	GNB/Gould, Exide, C&D	CORR/OX, CORR	Poor electrical contact with external busses
9		Batteries	Container and Cover	Polycarbonate, styrene acrylonitrile, acrylo butadiene styrene	GNB/Gould, Exide, C&D	MECHSTR, CORR/OX	Oxidation of the lead causes plate growth

Document: NUREG/CR-4564, Operating Experience and Aging-Seismic Assessment of Battery Chargers and Inverters
Reviewed by: Jerry Edson, INEL

Item	System	Structure/Comp	Subcomponent	Materials	Manufacturer	ARD mechanism	ARD effects
1		Chargers and Inverters	General				
2		Chargers and Inverters	Circuit Breakers	Not stated	PCP, Elgar	CONTAM, WEAR, EMBR, FAT, CORR/PIT, LOSLUB	Increased friction, binding, loss of continuity
3		Chargers and Inverters	Fuse	Not stated	PCP, Elgar	FAT, ELETEMP	Metal fatigue and melting of the fuse material
4		Chargers and Inverters	Relay	Not stated	PCP, Elgar	CORR/PIT, CORR	Loss of continuity across contacts and thru coil
5		Chargers and Inverters	Electrolytic Capacitors	Not stated	PCP, Elgar	ELETEMP, VIBR	Loss of electrolyte, failure of leads
6		Chargers and Inverters	Oil Filled Capacitors	Not stated	PCP, Elgar	ELETEMP, VIBR	Dielectric breakdown, failure of leads
7		Chargers and Inverters	Magnetics (Transformer, Inductor)	Copper, polyamide polymer, mylar tape, ferite steel	PCP, Elgar	ELETEMP THERM-C VIBR, LOTEMP, VOLSTR	Cracking/degr. of insulation and seals, wire fracture
8		Chargers and Inverters	Silicon Controlled Rectifier	Not stated	PCP, Elgar	ELETEMP, VOLSTR, CURSTR	Over heating due to transients

Table A.2 Gall Report for NPAR Reports

Document: NUREG/CR-4457, Aging of Class 1E Batteries in Safety Systems of Nuclear Power Plants
Reviewed by: Jerry Edson, INEL

Effect of Aging on Component Function	Contrib to Failure	Reported progs	Rel.progs	Report Recommendations	Page No.	Item
		Not discussed in report	N/A	A Phase 2 study of seismic vulnerability and advanced surveillance methods for identying seismic vulnerability [1]	31	1
Increased temp. from overcharging, ac ripple, and the environment accelerates oxidation. Poor electrical contact and breaking of the container with subsequent loss of electrolyte results in reduced capacity or failure	Frequent	IEEE 450, RG 1.129	IEEE 450, RG 1.129	Not stated	8, 12, 13, 14, 24-26, 32, 33	2
Gassing caused by overcharging or contamination introduced into the electrolyte deteriorates the active material resulting in reduced capacity	Occasional	IEEE 450, RG 1.129	IEEE 450, RG 1.129	Not stated	8, 12, 13, 14, 24-26, 32, 33	3
Decreased electrical insulation resulting in internal shorts and failure of the battery	Not stated	IEEE 450, RG 1.129	IEEE 450, RG 1.129	Not stated	8, 12, 13, 14, 24-26, 32, 33	4
Chemical reactions and hydrolysis causes loss of electrolyte and loss of sulfuric acid resulting in reduced battery capacity	Not stated	IEEE 450, RG 1.129	IEEE 450, RG 1.129	Not stated	8, 12, 13, 14, 24-26, 32, 33	5
Contaminates in the electrolyte result in reduced capacity	Not stated	IEEE 450, RG 1.129	IEEE 450, RG 1.129	Not stated	8, 12, 13, 14, 24-26, 32, 33	6
Embrittled top conductors are susceptible to breaking and causes loss of capacity	Occasional	IEEE 450, RG 1.129	IEEE 450, RG 1.129	Not stated	8, 12, 13, 14, 24-26, 32, 33	7
Poor electrical contact results in loss of capacity and may result in total battery failure	Not stated	IEEE 450, RG 1.129	IEEE 450, RG 1.129	Not stated	8, 12, 13, 14, 24-26, 32, 33	8
Plate growth and handling stresses results in cracked containers which allow electrolyte to escape resulting in reduced capacity or total failure	Frequent	IEEE 450, RG 1.129	IEEE 450, RG 1.129	Not stated	8, 12, 13, 14, 24-26, 32, 33	9

Document: NUREG/CR-4564, Operating Experience and Aging-Seismic Assessment of Battery Chargers and Inverters
Reviewed by: Jerry Edson, INEL

Effect of Aging on Component Function	Contrib to Failure	Reported progs	Rel.progs	Report Recommendations	Page No.	Item
		Not discussed in report	N/A	A comprehensive PM and testing program supported by personnel training should be implemented. Procedures are needed [2]	6-7	1
Failure to operate, fails open	Occasional	IEEE-650, NEMA PE 5, IEC 146-2, IEEE-944	ANSI/IEEE 741-1986 Section 7.3	Not stated	4-25, 4-27, 5-4 thru 5-9	2
Fuse fails open. Failure to operate	Occasional	IEEE-650, NEMA PE 5, IEC 146-2, IEEE-944	ANSI/IEEE 741-1986 Section 7.3	Pursue fuse failures due to thermal fatigue [2]	4-25, 4-27, 5-4 thru 5-9, 6-7	3
Contacts open, open ciruit of the coil, and relay fails to operate	Occasional	IEEE-650, NEMA PE 5, IEC 146-2, IEEE-944	Vendor specific, NEMA PE 5, IEC 142-2	Not stated	4-25, 4-27, 5-4 thru 5-9	4
Loss of capacitance and open circuit resulting in improper output or failure to operate	Frequent	IEEE-650, NEMA PE 5, IEC 146-2, IEEE-944	Vendor specific, NEMA PE 5, IEC 142-2	Not stated	4-25, 4-27, 5-4 thru 5-9 .	5
Loss of capacitance and open circuit resulting in improper output or failure to operate	Frequent	IEEE-650, NEMA PE 5, IEC 146-2, IEEE-944	Vendor specific, NEMA PE 5, IEC 142-2	Not stated	4-25, 4-27, 5-4 thru 5-9	6
Short circuits (turn to turn or to ground)or change in inductuance resulting in improper output.	Occasional	IEEE-650, NEMA PE 5, IEC 146-2, IEEE-944	Vendor specific, NEMA PE 5, IEC 142-2	Not stated	2-19, 4-25, 4-28, 5-4 thru 5-9	7
Short or open circuit resulting in improper or no output	Occasional	IEEE-650, NEMA PE 5, IEC 146-2, IEEE-944	Vendor specific, NEMA PE 5, IEC 142-2	Not stated	4-25, 4-28, 5-4 thru 5-9	8

Document: NUREG/CR-4564, Operating Experience and Aging-Seismic Assessment of Battery Chargers and Inverters
Reviewed by: Jerry Edson, INEL

Item	System	Structure/Comp	Subcomponent	Materials	Manufacturer	ARD mechanism	ARD effects
9		Chargers and Inverters	Resistors	Not stated	PCP, Elgar	ELETEMP, VIBR	Lead fails, decrease in resistance
10		Chargers and Inverters	Printed Circuit Boards	Not stated	PCP, Elgar	THERM-CY, CORR, VIBR	Cracking of circuit lines, open/loose at terminals
11		Chargers and Inverters	Surge Suppressors	Not stated	PCP, Elgar	ELETEMP, VOLSTR, CURSTR	Semiconductor barrier breakdown
12		Chargers and Inverters	Connectors	Not stated	PCP, Elgar	FAT	Wire breaks
13		Chargers and Inverters	Meters	Not stated	PCP, Elgar	CONTAM, ELETEMP	Increase in bearing friction, coil degrades
14		Chargers and Inverters	Switches	Not stated	PCP, Elgar	CORR, CORR/PIT	Loss of continuity across contacts
15		Chargers and Inverters	Potentiometer	Not stated	PCP, Elgar	ELETEMP	Loss of continuity across wiper arm and coil

Document: NUREG/CR-4715, An Aging Assessment of Relays and Circuit Breakers and System Interactions
Reviewed by: L. C. Meyer, INEL

Item	System	Structure/Comp	Subcomponent	Materials	Manufacturer	ARD mechanism	ARD effects
1		Protective, Auxiliary, and Control Relays	Relay	Steel, aluminum, lexan, and phenolic	GE & Westinghouse	THERM	Shape changes for lexan, no effect for steel, al., or phnol.
2		Protective, Auxiliary, and Control Relays	Coil Wire, Spools, & Coatings	polyamide-imide insulated wire, copper magnet wire, and nylon bobbins	Not stated	THERM & VOLSTR	Thermally caused failures, open circuits, and shorts
3		Protective, Auxiliary, and Control Relays	Coil Spools	Nylon, Zytel & lexan	Not stated	THERM	Thermally caused failures
4		Protective, Auxiliary, and Control Relays	Coil Coating	Polyester tape, fiber glass tape, & varnish	Not stated	THERM	Thermally caused failures
5		Protective, Auxiliary, and Control Relays	Contact Carriers	Phenolic, Zytel, delrin, & nylon	Not stated	THERM	Nylon may change in shape
6		Protective, Auxiliary, and Control Relays	Contacts	Silver alloy	Not stated	WEAR, CHEM	Oxidation when exosed to air & material attrition
7		Protective, Auxiliary, and Control Relays	Lead Wires	Copper	Not stated	VIB	Loose terminals
8		Protective, Auxiliary, and Control Relays	Coil Lead Wire Insulation	Teflon, silicon rubber, and Tefzel	Not stated	THERM & RAD	Slow aging effects, degradation in insulation

Document: NUREG/CR-4564, Operating Experience and Aging-Seismic Assessment of Battery Chargers and Inverters
Reviewed by: Jerry Edson, INEL

Effect of Aging on Component Function	Contrib to Failure	Reported progs	Rel.progs	Report Recommendations	Page No.	Item
Open circuits, change in resistance values resulting in improper or no output	Rare	IEEE-650, NEMA PE 5, IEC 146-2, IEEE-944	Vendor specific, NEMA PE 5, IEC 142-2	Not stated	4-25, 4-28, 5-4 thru 5-9	9
Change in output of the charger/inverter	Occasional	IEEE-650, NEMA PE 5, IEC 146-2, IEEE-944	Vendor specific, NEMA PE 5, IEC 142-2	Not stated	4-25, 4-28, 5-4 thru 5-9	10
Short ciruit within the surge arrestor and failure to operate	Rare	IEEE-650, NEMA PE 5, IEC 146-2, IEEE-944	Vendor specific, NEMA PE 5, IEC 142-2	Not stated	4-25, 4-28, 5-4 thru 5-9	11
Fatigue caused by installation stress causes wires to break resulting in open or short circuits and failure to operate	Occasional	IEEE-650, NEMA PE 5, IEC 146-2, IEEE-944	Vendor specific, NEMA PE 5, IEC 142-2	Not stated	4-25, 4-28, 5-4 thru 5-9	12
No or improper response from the meter	Occasional	IEEE-650, NEMA PE 5, IEC 146-2, IEEE-944	Vendor specific, NEMA PE 5, IEC 142-2	Not stated	4-25, 4-28, 5-4 thru 5-9	13
Switch failes open or closed	Occasional	IEEE-650, NEMA PE 5, IEC 146-2, IEEE-944	Vendor specific, NEMA PE 5, IEC 142-2	Not stated	4-25, 4-28, 5-4 thru 5-9	14
Thermal degradation results in open or short circuit and improper output	Frequent	IEEE-650, NEMA PE 5, IEC 146-2, IEEE-944	Vendor specific, NEMA PE 5, IEC 142-2	Not stated	4-25, 4-28, 5-4 thru 5-9	15

Document: NUREG/CR-4715, An Aging Assessment of Relays and Circuit Breakers and System Interactions
Reviewed by: L. C. Meyer, INEL

Effect of Aging on Component Function	Contrib to Failure	Reported progs	Rel.progs	Report Recommendations	Page No.	Item
Binding of control relays, have been noted for continuously energized compact relays with plastic cases resulting in improper operation or failure to operate	Rare	Not discussed in report	Protection: IEEE 741, IEEE 338	Perform root cause failure evaluation, develop test method for thermally induced failure cause, see report for more rec. [2]	28, 29, 35, and 160	1
The higher temperatures associated with continuously energized coils have caused failures of relay coils and bobbins resulting in improper operation or failure to operate.	Rare	Not discussed in report	Protection: IEEE 741, IEEE 338	Perform root cause failure evaluation, develop test method for thermally induced failure cause, see report for more rec. [2]	28, 29, 35, and 160	2
The higher temperatures associated with continuously energized coils have caused failures of relay bobbins resulting in relay having improper operation or failure to operate.	Rare	Not discussed in report	Protection: IEEE 741, IEEE 338	Perform root cause failure evaluation, develop test method for thermally induced failure cause, see report for more rec. [2]	28, 29, 35, and 160	3
The higher temperatures associated with continuously energized coils have caused failures of relay coils (assumed it includes coatings) resulting in improper operation or failure of relay.	Rare	Not discussed in report	Protection: IEEE 741, IEEE 338	Perform root cause failure evaluation, develop test method for thermally induced failure cause, see report for more rec. [2]	28, 29, 35, and 160	4
Change in shape due to thermal aging can cause binding or improper contact mating resulting in improper operation or failure of relay.	Rare	Not discussed in report	Protection: IEEE 741, IEEE 338	Perform root cause failure evaluation, develop test method for thermally induced failure cause, see report for more rec. [2]	28, 29, 35, and 160	5
Wear due to use and testing resulting in failure to make proper contact	Rare	Not discussed in report	Protection: IEEE 741, IEEE 338	Perform root cause failure evaluation, develop test method for thermally induced failure cause, see report for more rec. [2]	28, 29, 35, and 160	6
Loose terminations can cause ohmic heating and burnout	Rare	Not discussed in report	Protection: IEEE 741, IEEE 338	Perform root cause failure evaluation, develop test method for thermally induced failure cause, see report for more rec. [2]	28, 29, 35, and 160	7
Improper operation or failure to operate.	Rare	Not discussed in report	Protection: IEEE 741, IEEE 338	Perform root cause failure evaluation, develop test method for thermally induced failure cause, see report for more rec. [2]	28, 29, 35, and 160	8

Document: NUREG/CR-4715, An Aging Assessment of Relays and Circuit Breakers and System Interactions
Reviewed by: L. C. Meyer, INEL

Item	System	Structure/Comp	Subcomponent	Materials	Manufacturer	ARD mechanism	ARD effects
9		Protective, Auxiliary, and Control Relays	Slip Motor Rotor	Aluminum disc & stainless steel shaft	Not stated	CONTAM	Metalic iron based particles can prevent operation
10		Time Delay Relays	Case	Steel, Lexan, and phenolic	Not stated	THERM	Shape changes for lexan & phenolic
11		Time Delay Relays	timing Motor	Magent wire with formal varnish	Not stated	THERM	Same as other insulation varnish
12		Time Delay Relays	Relay	Silver	Not stated	WEAR	Wear with use
13		Time Delay Relays	Relay	Delrin, Zytel, phenolic, & nylon.	Not stated	THERM	Oxidation of contacts
14		Time Delay Relays	Cams	Delrin & metal	Not stated	THERM & WEAR	Delrin may change shape, metal may wear
15		Time Delay Relays	Timing Circuits	Resistance and capacitance networks with solid state components	Not stated	Not stated	Not stated
16		Time Delay Relays	Timing Diaphragm (Applies to Pneumatic Relay Only)	Silicon rubber	Not stated	THERM	Material may take a set if not exercised periodically.
17		Solid State Relays	Solid state Components - SCRs & TRIAC	Not stated	Not stated	THERM, RAD, VOLSTR, CURSTR, & VIB.	Insulation degradation from therm & rad, fatique from vib.
18		Molded Case Circuit Breakers	Contacts, Trip Device, Spring, and Case	Not stated	GE, Westinghouse, & Gould	THERM, ELECT, MECH, & ENV.	Material vaporized, annealing bimetal, wear, friction & fat
19		Metal-Clad Circuit Breakers	Housing, Doors, Frame & Mechanisms	Steel, electroplated steel, & cast bronze	GE, Westinghouse, & Gould	CURSTR, VIB, FAT, & CORR.	Loose parts, component failure, stiffening of joints.
20		Metal-Clad Circuit Breakers	Mechanisms Lubricants	Molybenium disulfide & petroleum-based grease	Not stated	LOSLUB AND THERM	Dryout and hardening of lubricants
21		Metal-Clad Circuit Breakers	Contacts	Silver Alloy on copper base	GE, Westinghouse, & Gould	CURSTR, WEAR, THERM, AND CONTAM	Loss of material, wear, and contamination
22		Metal-Clad Circuit Breakers	Insulating Materials for Power Path	Polyester, glass fiber-filled epoxy resin, & phenolic	GE, Westinghouse, & Gould	THERM, EMBR, AND VOLSTR	Contamination, loss of dielectric properties, & leakage path
23	Safety Injection	Relays	See relay Subcomponent Descriptions	See relay material descriptions	GE & Agastat	VOLSTR, THERM, VIB, AND WEAR	Thermal stress, coil burnout, set point drift, & con. wear
24	Safety Injection	Circuit Breakers	Molded Case and Metal-Clad Circuit Breakers	See CB detail descriptions	GE, Westinghouse, & Gould	ELECT, THERM, VIB, WEAR, & ENV	Loss of material, corr, & arcing evaporation of contacts

Table A.2 Gall Report for NPAR Reports

Document: NUREG/CR-4715, An Aging Assessment of Relays and Circuit Breakers and System Interactions
Reviewed by: L. C. Meyer, INEL

Effect of Aging on Component Function	Contrib to Failure	Reported progs	Rel.progs	Report Recommendations	Page No.	Item
Metalic iron based particles can lodge between the disc and magnet preventing operation.	Rare	Not discussed in report	IEE 741-1986 Section 7, IEEE 338-1987	Perform root cause failure evaluation, develop test method for thermally induced failure cause, see report for more rec. [2]	28, 29, 35, and 160	9
Some rare instances of case shape changes resulting in binding of contacts resulting in failure to operate.	Rare	Not discussed in report	Safety related: IEEE 741, IEEE 338	Perform root cause failure evaluation, develop test method for thermally induced failure cause, see report for more rec. [2]	28, 30, 35, & 36.	10
Insulaton failure may cause shorts and failure to provide timing delay function.	Rare	Not discussed in report	Safety related: IEEE 741, IEEE 338	Not stated	30, 35, & 36.	11
Contacts wear with cycling and making and breaking load resulting in failure to make proper contact.	Rare	Not discussed in report	Safety related: IEEE 741, IEEE 338	Not stated	30, & 35	12
Failure to make proper contact.	Rare	Not discussed in report	Safety related: IEEE 741, IEEE 338	Not stated	30, & 35	13
Cams may wear and high temperature may deform delrin cams resulting in degraded operation or relay failure.	Rare	Not discussed in report	Safety related: IEEE 741, IEEE 338	Not stated	30, & 35	14
Not stated	Rare	Not discussed in report	Safety related: IEEE 741, IEEE 338	Not stated	30	15
The first operation of relay after a long period will have an improper time delay.	Rare	Not discussed in report	Safety related: IEEE 741, IEEE 338	Not stated	30 & 36	16
Breakdown of insulation, ohmic heating lead to insulation and component failure, vib. may loosen sockets/pins causing opens, shorts resulting relay failure.	Occasional	Not discussed in report	Safety related: IEEE 741, IEEE 338	Not stated	26, 27, 28, & 30.	17
Damage contacts & arc chute materials, annealed bimetal strips causes nuisance trips, vaporized material deposits on insulation, loose connections, leakage paths, component failure, hardening of lubricants, stiffening of joints, & loss of operability.	Occasional	Not discussed in report	Safety related: IEEE 741. Others: No specific	Replace after two nuisance trips, develop diagnostic techniques for early detection of component failures. [2]	78, 83, 91, 97,99, 113, and 163	18
Freezing of joints, increased friction, & loss of operability	Rare	Not discussed in report	Safety related: IEEE 741. Others: No specific	Inspection and cleaning after each interruption of a major fault. [2]	85, 98, 99, 100, & 163	19
Evaporation of petrolium based grease may leave a nonlubricating soap base & high temperatures may cause harding of lubricants resulting in loss of operability.	Occasional	Not discussed in report	Vendor specific programs	Inspection and cleaning after each interruption of a major fault. [2]	85, 98, 99, 100, & 163	20
Failure to operate as required.	Occasional	Not discussed in report	Vendor specific programs	Inspection and cleaning after each interruption of a major fault. [2]	85, 98, 99, 100, 101, & 163.	21
Failure to provide insulation results in circuit failure.	Occasional	Not discussed in report	Vendor specific programs	Inspection and cleaning after each interruption of a major fault. [2]	85, 98, 99, 100, 101, & 163.	22
Coil failures, binding, and electrical component failures increase with age. Protection relays may also fail due to drift	Occasional	Not discussed in report	IEE 741-1986 Section 7, IEEE 338-1987	Desirable to have incipient failure detection technique to detect both old and new failure modes [2]	142, 159, & 160	23
Loss of operability.	Occasional	Plant maintenance	IEEE 741-1986 Section 7	Dagnostic techniques should be developed for use with physical inspections to determine condition of circuit breakers. [2]	142, 161, 162, & 163.	24

Table A.2 Gall Report for NPAR Reports

Document: NUREG/CR-4740, Nuclear Plant-Aging Research on Reactor Protection Systems
Reviewed by: L. C. Meyer, INEL

Item	System	Structure/Comp	Subcomponent	Materials	Manufacturer	ARD mechanism	ARD effects
1	Reactor Protection System	Pressure Transmitter	Seals	Ethylene propylene	Not stated	THERM, RAD, MOIST-EL	Leaks
2	Reactor Protection System	Pressure Transmitter	Fill-Oil	Silicon	Not stated	THERM & RAD	Oil degradation
3	Reactor Protection System	Pressure Transmitter	Electronic Components	Epoxy glass laminate, seats, & insulation materials	Not stated	THERM, RAD, MOIST-EL	Drift and subcomponent degradation
4	Reactor Protection System	Pressure Transmitter	Piping & Valves	Stainless steel	Not stated	CORR	Blockage, leaks
5	Reactor Protection System	Pressure Transmitter	Valve Packing	Not stated	Not stated	WEAR	Leaks
6	Reactor Protection System	Strain Gage Pressure Transduce	Bourdon Tube, Electronic Components, Seals & Wire	EDPM, Nylon, copper, tefzel, & steel	Not stated	RAD, THERM, MOIST-EL, & CONTAM	Resistance change, tube blockage, and shunting
7	Reactor Protection System	Pressure Switch	Bellows, Switch Contacts, Seals & Wire	Copper	Not stated	THERM, MOIST-EL, CONTAM, WEAR	Wear, tube blockage, and contact resistance change
8	Reactor Protection System	Resistance Temperature Device	Sensing Wire, Insulator & Sheath	Platinum, aluminum oxide powder, and inconel X750 or stainless steel sheath	Not stated	RAD, THERM, AND MOIST-EL	Resistance change and shunting
9	Reactor Protection System	Nuclear Instrument	Nuclear Sensitive Ion Chamber	Not stated	Not stated	THERMAL-CY AND MOIST-EL	Degrades sensor, low resistance, and erratic output
10	Reactor Protection System	Electronic Modules	Various Electronic Components	Not stated	Not stated	FAT & VIB	Loss of fatigue resistance
11	Reactor Protection System	Relays	Coils and Contacts	Not stated	Not stated	WEAR, CONTAM, CORR, AND CURSTR	Contacts wear, foreign material build up causes short ckt.
12	Reactor Protection System	Scram Breakers	Contacts, Under Volatge & Shunt Trip Attachments	Not stated	Westinghouse	WEAR	Contact wear, pin binding in uv attachent, lack of lubricant
13	Reactor Protection System	Control Cable	Conductor	#16 AWG copper except nuclear instruments sue RG11/CU Coax	Not stated	CORR, MOIST-EL, RAD, & WEAR	Mechanical damage & corrosion on terminations
14	Reactor Protection System	Control Cable	Insulation	Cross linked polyethylene and polyethylene	Not stated	MOIST-EL, RAD, & WEAR	Mechanical damage, insulaton degradation, and low ir

Document: NUREG/CR-4740, Nuclear Plant-Aging Research on Reactor Protection Systems
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Effect of Aging on Component Function	Contrib to Failure	Reported progs	Rel.progs	Report Recommendations	Page No.	Item
Seal failure allows leaks leading to transmitter drift and moisture intrusion.	Occasional	Not discussed in report	IEEE 338-1987, RG 1.118, ISA 67.06, Tech Spec	Not stated	15, 18, 61, 65, & 69	1
Degradation or loss of fill-oil causes transmitter drift and signal variance from other channels.	Rare	Not discussed in report	IEEE 338-1987, RG 1.118, ISA 67.06, Tech Spec	Not stated	18, & 62	2
Components are subject to drift of zero & span set points, and ultimate failure, resulting in loss of data channel.	Occasional	Not discussed in report	IEEE 338-1987, RG 1.118, ISA 67.06, Tech Spec	Not stated	18, 65, & 70	3
Blockage causes degraded channel operation, components are subject to loss of calibration, resulting in loss of data channel.	Occasional	Not discussed in report	IEEE 338-1987, RG 1.118, ISA 67.06, Tech Spec	Not stated	17, 19,28, 42, & 69	4
Components are subject to loss of calibration, resulting in loss of data channel.	Occasional	Not discussed in report	IEEE 338-1987, RG 1.118, ISA 67.06, Tech Spec	Not stated	65	5
Sensing element resistance change due to radiation, seal failure allows moisture to get into connectors that lead to shunting signal, foreign material blocks sensing tube.	Occasional	Not discussed in report	IEEE 338-1987, RG 1.118, ISA 67.06, Tech Spec	Not stated	15, 17, 48, & 69	6
Wear leads to switch failure, seal failure allows moisture to get into connectors that lead to shunting signal, foreign material blocks sensing tube.	Occasional	Not discussed in report	IEEE 338-1987, RG 1.118, ISA 67.06, Tech Spec	Not stated	17, 34, 37, 49, & 65	7
Sensing element resistance change due to radiation, seal failure allows moisture to get into sensor and moisture causes shunting of signal.	Rare	Not discussed in report	IEEE 338-1987, RG 1.118, ISA 67.06, Tech Spec	Not stated	17, 19, 27, 32, & 70	8
Transmitter becomes noisy or erratic, also low insulation resistance (few problems reported).	Rare	Not discussed in report	IEEE 338-1987, RG 1.118, ISA 67.06, Tech Spec	Not stated	19, 20, 27, 33, 65, & 66	9
Small system components such as transistors, capacitors, logic elements, terminals and wire connectors are subject to mechanical fatigue-related failures due to vibration, most failures are catastropic with unknown cause.	Occasional	Not discussed in report	IEEE 338-1987, RG 1.118, ISA 67.06, Tech Spec	Not stated	27, 29-33, 35-37, 42-45, 47-49, 65, & 70	10
Sticking armature, open or short circuits in the coil of the electromagnet, and contact degradation causes failure to function.	Occasional	Not discussed in report	IEEE 338-1987, RG 1.118, ISA 67.06, Tech Spec	Not stated	11, 13, B-7, & C-3	11
Increased friction, nicking of latch surfaces caused by repeated opeations, binding and friction causes degraded operation or failure to operate.	Occasional	Not discussed in report	IEEE 338-1987, RG 1.118, ISA 67.06, Tech Spec	Not stated	66, 70, . and Appendix B	12
Increase in series resistance and loose connections cause failure to accurately conduct current.	Rare	Not discussed in report	No specific program	Further research is needed to determine if improved maintenance and new predictive techniques are needed. [4]	20, 21, 23, 48, & 70	13
Decreased insulation resistance damage due to handling will accelerate aging and result in cable failing to accurately transmit voltage and current.	Rare	Not discussed in report	No specific program	Further research is needed to determine if improved maintenance and new predictive techniques are needed. [4]	20, 21, 23, 48, & 70	14

Table A.2 Gall Report for NPAR Reports

Document: NUREG/CR-4740, Nuclear Plant-Aging Research on Reactor Protection Systems
Reviewed by: L. C. Meyer, INEL

Item	System	Structure/Comp	Subcomponent	Materials	Manufacturer	ARD mechanism	ARD effects
15	Reactor Protection System	Control Cable	Jacket	Neoprene and galvanized steel except nuclear cable had PVC and galvanized steel	Not stated	CORR, MOIST-EL, RAD, EMBR, & WEAR	Loss of material, attrition, and insulation degradation
16	Reactor Protection System	Cable Penetrations	Assembly, Seals, Cable, Connectors, & Inert Gas	SS, brass, elastomer, insul. Matl, polysulfone, polyolefin, gold plated copper	Not stated	CORR, MOIST-EL, & RAD	Loss of material, insulation degradation, loss of fill gass
17	Reactor Protection System		Transmitters, Electronic Modules, Cables, Breakers	See components	B & W	CORR, RAD, VIB, CURSTR, THERM, & CONTAM	See components

Document: NUREG/CR-4747 V1, An Aging Failure Survey of LWR Safety Systems and Components
Reviewed by: L. C. Meyer, INEL

Item	System	Structure/Comp	Subcomponent	Materials	Manufacturer	ARD mechanism	ARD effects
1	Four Systems Covered (Same as Volume 2)			Not stated	Not stated	Not stated	

Document: NUREG/CR-4747 V2, An Aging Failure Survey of Light Water Reactor Safety Systems and Components (Electrical)
Reviewed by: L. C. Meyer, INEL

Item	System	Structure/Comp	Subcomponent	Materials	Manufacturer	ARD mechanism	ARD effects
1	Auxiliary Feedwater System	AC Circuit Breakers	Not stated	Not stated	Not stated	CONTAM	Buildup of deposits
2	Auxiliary Feedwater System	AC Circuit Breakers	Not stated	Not stated	Not stated	WEAR	Attrition
3	Auxiliary Feedwater System	AC Circuit Breakers	Not stated	Not stated	Not stated	VIBR	Loosening
4	Auxiliary Feedwater System	Flow Controllers	Not stated	Not stated	Not stated	CLOG	Flow blockage
5	Auxiliary Feedwater System	Flow Controllers	Not stated	Not stated	Not stated	Not stated	Loss of performance
6	Auxiliary Feedwater System	Flow Controllers	Not stated	Not stated	Not stated	Not stated	Drift, contact failure, module failure, or elect. failure
7	Auxiliary Feedwater System	Flow Control Recorders	Not stated	Not stated	Not stated	WEAR	Attrition
8	Auxiliary Feedwater System	Flow Control Recorders	Not stated	Not stated	Not stated	Not stated	Loss of performance
9	Auxiliary Feedwater System	Flow Transmitters	Not stated	Not stated	Not stated	CONTAM	Buildup of deposites causing erroneous/erratic signals
10	Auxiliary Feedwater System	Flow Transmitters	Not stated	Not stated	Not stated	Not stated	Out of calibration, drift, or module faulty

Document: NUREG/CR-4740, Nuclear Plant-Aging Research on Reactor Protection Systems
Reviewed by: L. C. Meyer, INEL

Effect of Aging on Component Function	Contrib to Failure	Reported progs	Rel.progs	Report Recommendations	Page No.	Item
Failure to protect cable insulation and conductors.	Occasional	Not discussed in report	No specific program	Further research is needed to determine if improved maintenance and new predictive techniques are needed. [4]	20, 21, & 48	15
Radiation causes embrittlement and insulation degradation, corrosion causes material degradation and material build up, leaking seal allow loss of fill gas and then moisture intrusion resulting in failure to accurately transmit voltage and current.	Rare	Not discussed in report	No specific program	Further research is needed to determine if improved maintenance and new predictive techniques are needed. [2]	20 & 23	16
See components	Rare	Not discussed in report	IEE 338-1987, RG 1.118, ISA 67.06, Tech. Spec	Further research is needed to determine if improved maintenance and new predictive techniques are needed. [2]	IV, 69, & A-16	17

Document: NUREG/CR-4747 V1, An Aging Failure Survey of LWR Safety Systems and Components
Reviewed by: L. C. Meyer, INEL

Effect of Aging on Component Function	Contrib to Failure	Reported progs	Rel.progs	Report Recommendations	Page No.	Item
The aging information in Volume 1 is the same as that covered in the Volume 2 reveiw.	Not stated	Not discussed in report	N/A	Not stated		1

Document: NUREG/CR-4747 V2, An Aging Failure Survey of Light Water Reactor Safety Systems and Components (Electrical)
Reviewed by: L. C. Meyer, INEL

Effect of Aging on Component Function	Contrib to Failure	Reported progs	Rel.progs	Report Recommendations	Page No.	Item
Fails to close	Rare	Not discussed in report	IEE 741-1986 Section 7	Not stated	F-20	1
Failure to operate - the circuit breaker does not function properly, either fails to open or fails to close on demand.	Occasional	Not discussed in report	IEE 741-1986 Section 7	Not stated	F-20	2
Failure to operate - the circuit breaker does not function properly, either fails to open or fails to close on demand.	Rare	Not discussed in report	IEE 741-1986 Section 7	Not stated	F-20	3
Erroneous or erraric signals - erroneous or erraric signals are produced by the instrument because of foreign material intrusion.	Rare	Not discussed in report	IEEE 338-1987, Tech. Spec. requirements	Not stated	F-21	4
Erroneous or erratic signals - erroneous or erratic signals are produced by the instrument due to faulty module or loss of calibration.	Rare	Not discussed in report	IEEE 338-1987, Tech. Spec. requirements	Not stated	F-21	5
Failure to operate	Rare	Not discussed in report	IEEE 338-1987, Tech. Spec. requirements	Not stated	F-21	6
Erroneous/erratic signals - erroneous erratic signals are produced by the instrument.	Rare	Not discussed in report	IEEE 338-1987, Tech. Spec. requirements	Not stated	F-22	7
Erroneous/erratic signals - erroneous erratic signals are produced by the instrument being out of calibration.	Rare	Not discussed in report	IEEE 338-1987, Tech. Spec. requirements	Not stated	F-22	8
Eroneous or erratic signals are produced by the instrument	Rare	Not discussed in report	IEEE 338-1987, RG 1.118, ISA 67.06, Tech Spec	Not stated	F-23	9
Loss of performance	Occasional	Not discussed in report	IEEE 338-1987, RG 1.118, ISA 67.06, Tech Spec	Not stated	F-23	10

Document: NUREG/CR-4747 V2, An Aging Failure Survey of Light Water Reactor Safety Systems and Components (Electrical)
Reviewed by: L. C. Meyer, INEL

Item	System	Structure/Comp	Subcomponent	Materials	Manufacturer	ARD mechanism	ARD effects
11	Auxiliary Feedwater System	Flow Transmitters	Not stated	Not stated	Not stated	WEAR	Attrition
12	Auxiliary Feedwater System	Level Control Indicators	Not stated	Not stated	Not stated	Not stated	Erroneous/erratic signals
13	Auxiliary Feedwater System	Level Control Indicators	Not stated	Not stated	Not stated	FAT	Cumulative fatigue damage
14	Auxiliary Feedwater System	Level Control Indicators	Not stated	Not stated	Not stated	WEAR	Attrition
15	Auxiliary Feedwater System	Level Control Indicators	Not stated	Not stated	Not stated	Not stated	Loss of performance or end of life
16	Auxiliary Feedwater System	Level Controllers	Not stated	Not stated	Not stated	Not stated	Erroneous/erratic signals
17	Auxiliary Feedwater System	Level Controllers	Not stated	Not stated	Not stated	FAT	Cumulative fatigue damage
18	Auxiliary Feedwater System	Level Controllers	Not stated	Not stated	Not stated	Not stated	Loss of performance
19	Auxiliary Feedwater System	Pressure Switch	Not stated	Not stated	Not stated	CONTAM	Buildup of deposits
20	Auxiliary Feedwater System	Pressure Switch	Not stated	Not stated	Not stated	Not stated	Loss of performance
21	Auxiliary Feedwater System	Pressure Switch	Not stated	Not stated	Not stated	WEAR	Attrition
22	Auxiliary Feedwater System	Pressure Switch	Not stated	Not stated	Not stated	CORR	Loss of material
23	Auxiliary Feedwater System	Pressure Switch	Not stated	Not stated	Not stated	CURSTR	Arcing, material attrition, and carbon deposits
24	Auxiliary Feedwater System	Pressure Transmitter	Not stated	Not stated	Not stated	Not stated	Loss of performance

Document: NUREG/CR-4747 V2, An Aging Failure Survey of Light Water Reactor Safety Systems and Components (Electrical)
Reviewed by: L. C. Meyer, INEL

Effect of Aging on Component Function	Contrib to Failure	Reported progs	Rel.progs	Report Recommendations	Page No.	Item
Failure to operate	Rare	Not discussed in report	IEEE 338-1987, RG 1.118, ISA 67.06, Tech Spec	Not stated	F-23	11
Out of calibration or faulty module related to aging.	Rare	Not discussed in report	IEEE 338-1987, RG 1.118, ISA 67.06, Tech Spec	Not stated	F-27	12
Failure to operate	Rare	Not discussed in report	IEEE 338-1987, RG 1.118, ISA 67.06, Tech Spec	Not stated	F-27	13
Failure to operate	Rare	Not discussed in report	IEEE 338-1987, RG 1.118, ISA 67.06, Tech Spec	Not stated	F-27	14
Failure to operate because of end of life or faulty module related to aging.	Rare	Not discussed in report	IEEE 338-1987, RG 1.118, ISA 67.06, Tech Spec	Not stated	F-27	15
Loss of performance due to out of calibration or faulty module	Rare	Not discussed in report	IEEE 338-1987, RG 1.118, ISA 67.06, Tech Spec	Not stated	F-28	16
Failure to operate	Rare	Not discussed in report	IEEE 338-1987, RG 1.118, ISA 67.06, Tech Spec	Not stated	F-28	17
Failure to operate due to faulty module related to aging.	Rare	Not discussed in report	IEEE 338-1987, RG 1.118, ISA 67.06, Tech Spec	Not stated	F-28	18
Erroneous or erratic signals are produced by the instrument.	Rare	Not discussed in report	IEEE 338-1987, RG 1.118, ISA 67.06, Tech Spec	Not stated	F-38	19
Erroneous signals are produced by the instrument because of out of calibration	Occasional	Not discussed in report	IEEE 338-1987, RG 1.118, ISA 67.06, Tech Spec	Not stated	F-38	20
Failure to operate	Rare	Not discussed in report	IEEE 338-1987, RG 1.118, ISA 67.06, Tech Spec	Not stated	F-38	21
Failure to operate	Rare	Not discussed in report	IEEE 338-1987, RG 1.118, ISA 67.06, Tech Spec	Not stated	F-38	22
Failure to operate	Rare	Not discussed in report	IEEE 338-1987, RG 1.118, ISA 67.06, Tech Spec	Not stated	F-38	23
Erroneous signals are produced by the instrument due to out of calibration or faulty module.	Rare	Not discussed in report	IEEE 338-1987, RG 1.118, ISA 67.06, Tech Spec	Not stated	F-39	24

Document: NUREG/CR-4747 V2, An Aging Failure Survey of Light Water Reactor Safety Systems and Components (Electrical)
Reviewed by: L. C. Meyer, INEL

Item	System	Structure/Comp	Subcomponent	Materials	Manufacturer	ARD mechanism	ARD effects
25	Auxiliary Feedwater System	Pressure Transmitter	Not stated	Not stated	Not stated	WEAR	Attrition
26	Auxiliary Feedwater System	Pressure Transmitter	Not stated	Not stated	Not stated	Not stated	Open circuit
27	Auxiliary Feedwater System	Relays	Not stated	Not stated	Not stated	WEAR	Attrition
28	Auxiliary Feedwater System	Relays	Not stated	Not stated	Not stated	Not stated	Loss of function
29	Auxiliary Feedwater System	Relays	Not stated	Not stated	Not stated	WEAR	Attrition
30	Chemical and Volume Control System	AC Circuit Breakers	Not stated	Not stated	Not stated	FAT	Cumulative fatigue damage
31	Chemical and Volume Control System	Heat Tracing Heaters	Not stated	Not stated	Not stated	CORR	Loss of material
32	Chemical and Volume Control System	Heat Tracing Heaters	Not stated	Not stated	Not stated	Not stated	Abnormal resistance or aging related set point drift.
33	Chemical and Volume Control System	Level Controllers	Not stated	Not stated	Not stated	FAT	Cumulative fatigue damage
34	Chemical and Volume Control System	Level Controllers	Not stated	Not stated	Not stated	Not stated	Loss of performance
35	Chemical and Volume Control System	Level Transmitters	Not stated	Not stated	Not stated	Not stated	Loss of performance
36	Class 1E DC Power Supply System	Batteries	Not stated	Not stated	Not stated	Not stated	Cause accelerated aging, not hold charge, or end of life
37	Class 1E DC Power Supply System	Battery	Not stated	Not stated	Not stated	WEAR	Attrition
38	Class 1E DC Power Supply System	Battery	Not stated	Not stated	Not stated	CONTAM	Buildup of deposits
39	Class 1E DC Power Supply System	Battery	Not stated	Not stated	Not stated	Not stated	Loss of performance
40	Class 1E DC Power Supply System	AC Circuit Breaker	Not stated	Not stated	Not stated	WEAR	Attrition
41	Emergency On-Site Power Supply System	Diesel Generator	Not stated	Not stated	Not stated	Not stated	Loss of performance

Document: NUREG/CR-4747 V2, An Aging Failure Survey of Light Water Reactor Safety Systems and Components (Electrical)
Reviewed by: L. C. Meyer, INEL

Effect of Aging on Component Function	Contrib to Failure	Reported progs	Rel.progs	Report Recommendations	Page No.	Item
Failure to open - failure to operate	Rare	Not discussed in report	IEEE 338-1987, RG 1.118, ISA 67.06, Tech Spec	Not stated	F-39	25
Failure to operate	Rare	Not discussed in report	IEEE 338-1987, RG 1.118, ISA 67.06, Tech Spec	Not stated	F-39	26
Fails to open - failure of a normally closed relay to open upon demand because of binding, or wear	Rare	Not discussed in report	Vendor specific, NEMA PE 5, IEC 146-2	Not stated	F-40	27
Failure to operate because of drift or insulation breakdown related to aging.	Rare	Not discussed in report	Vendor specific, NEMA PE 5, IEC 146-2	Not stated	F-40	28
Failure to operate	Rare	Not discussed in report	Vendor specific, NEMA PE 5, IEC 146-2	Not stated	F-41	29
Failure to operate - the circuit breaker does not function properly, either fails to open or fails to close on demand.	Rare	Not discussed in report	ANSI/IEEE 741-1986 Section 7	Not stated	F-47	30
Loss of function	Rare	Not discussed in report	No specific program	Not stated	F-48	31
Loss of function	Rare	Not discussed in report	No specific program	Not stated	F-48	32
Erroneous or erratic signals are produced by the instrument.	Rare	Not discussed in report	IEEE 338-1987, RG 1.118, ISA 67.06	Not stated	F-49	33
Erroneous or erratic signals are produced by the instrument because of being out of calibration.	Occasional	Not discussed in report	IEEE 338-1987, RG 1.118, ISA 67.06	Not stated	F-49	34
Erroneous or erratic signals are produced by the instrument because of being out of calibration or faulty module.	Occasional	Not discussed in report	IEEE 338-1987, RG 1.118, ISA 67.06	Not stated	F-50	35
Loss of function - lack of specified output from batteries	Occasional	Not discussed in report	IEEE 450-1987, RG 1.129, Tech Spec Surveil.	Not stated	F-56	36
Loss of function - inability of the charging unit to perform its function to specifications.	Rare	Not discussed in report	Vendor specific, NEMA PE 5, IEC 146-2	Not stated	F-57	37
Loss of function - inability of the charging unit to perform its function to specifications.	Rare	Not discussed in report	Vendor specific, NEMA PE 5, IEC 146-2	Not stated	F-57	38
Loss of function - inability of the charging unit to perform its function to specifications because of set point drift or faulty module.	Frequent	Not discussed in report	Vendor specific, NEMA PE 5, IEC 146-2	Not stated	F-57	39
Failure to operate - the circuit breaker does not function properly, either fails to open or fails to close on demand.	Occasional	Not discussed in report	IEEE 741-1986 Section 7	Not stated	F-58	40
Failure to perform as expected because of aging related component drift or out of calibration.	Rare	Not discussed in report	Vendor specific, RG 1.108, Tech. Specs.	Not stated	F-61	41

Table A.2 Gall Report for NPAR Reports

Document: NUREG/CR-4747 V2, An Aging Failure Survey of Light Water Reactor Safety Systems and Components (Electrical)
Reviewed by: L. C. Meyer, INEL

Item	System	Structure/Comp	Subcomponent	Materials	Manufacturer	ARD mechanism	ARD effects
42	Emergency On-Site Power Supply System	Diesel Generator	Not stated	Not stated	Not stated	Not stated	Loss of function
43	CLASS 1E Instrumentation, Uninterruptable Power Supply System	AC Circuit Breaker	Not stated	Not stated	Not stated	WEAR	Attrition
44	CLASS 1E Instrumentation, Uninterruptable Power Supply System	Inverter	Not stated	Not stated	Not stated	WEAR	Attrition
45	CLASS 1E Instrumentation, Uninterruptable Power Supply System	Inverter	Not stated	Not stated	Not stated	Not stated	Loss of function
46	CLASS 1E Instrumentation, Uninterruptable Power Supply System	Inverter	Not stated	Not stated	Not stated	Not stated	Loss of performance
47	High Pressure Injection System	AC Circuit Breakers	Not stated	Not stated	Not stated	FAT	Cumulative fatigue damage
48	High Pressure Injection System	AC Circuit Breakers	Not stated	Not stated	Not stated	WEAR	Attrition
49	High Pressure Injection System	AC Circuit Breakers	Not stated	Not stated	Not stated	Not stated	Los of performance
50	High Pressure Injection System	Flow Transmitter	Not stated	Not stated	Not stated	Not stated	Cause accelerated aging
51	High Pressure Injection System	Flow Transmitter	Not stated	Not stated	Not stated	Not stated	Loss of performance
52	High Pressure Injection System	Flow Transmitter	Not stated	Not stated	Not stated	FAT	Cumulative fatigue damage
53	High Pressure Injection System	Flow Transmitter	Not stated	Not stated	Not stated	WEAR	Attrition
54	High Pressure Injection System	Heat Tracing Heaters	Not stated	Not stated	Not stated	CORR	Loss of material
55	High Pressure Injection System	Heat Tracing Heaters	Not stated	Not stated	Not stated	Not stated	Winding failure, open, short, or high resistance
56	High Pressure Injection System	Load Sequence Controllers	Not stated	Not stated	Not stated	Not stated	End of life
57	High Pressure Injection System	Load Sequence Controllers	Not stated	Not stated	Not stated	CONTAM	Builup of deposits
58	High Pressure Injection System	Load Sequence Controllers	Not stated	Not stated	Not stated	Not stated	Loss of performance
59	High Pressure Injection System	Level Transmitters	Not stated	Not stated	Not stated	Not stated	Loss of performance
60	High Pressure Injection System	Pressure Transmitter	Not stated	Not stated	Not stated	Not stated	Loss of performance
61	Service Water System	AC Breakers	Not stated	Not stated	Not stated	FAT	Fatigue accumulative damages

Table A.2 Gall Report for NPAR Reports

Document: NUREG/CR-4747 V2, An Aging Failure Survey of Light Water Reactor Safety Systems and Components (Electrical)
Reviewed by: L. C. Meyer, INEL

Effect of Aging on Component Function	Contrib to Failure	Reported progs	Rel.progs	Report Recommendations	Page No.	Item
Failure due to open circuit.	Rare	Not discussed in report	Vendor specific, RG 1.108, Tech. Specs.	Not stated	F-61	42
Failure to operate - the circuit breaker does not function properly, either fails to open or fails to close on demand.	Rare	Not discussed in report	IEEE 741-1986 Section 7	Not stated	F-63	43
Loss of function - the inverter fails to perform its intended function to specified requirements.	Occasional	Not discussed in report	Vendor specific programs. Tech. Specs.	Not stated	F-64	44
The inverter fails to perform its intended function to specified requirements due to electrical failure, insulation breakdown, open or short circuit related to aging.	Occasional	Not discussed in report	Vendor specific programs. Tech. Specs.	Not stated	F-64	45
The inverter has degraded operation because of aging related drift or faulty modules.	Occasional	Not discussed in report	Vendor specific programs. Tech. Specs.	Not stated	F-64	46
Failure to operate - the circuit breaker does not function properly, either fails to open or fails to close on demand.	Occasional	Not discussed in report	IEEE 741-1986 Section 7	Not stated	F-66	47
Failure to operate - the circuit breaker does not function properly, either fails to open or fails to close on demand.	Occasional	Not discussed in report	IEEE 741-1986 Section 7	Not stated	F-66	48
Failure to operate - the circuit breaker does not function properly, either fails to open or fails to close on demand because of a faulty module.	Rare	Not discussed in report	IEEE 741-1986 Section 7	Not stated	F-66	49
Erroneous or erratic signals are produced by the instrument	Rare	Not discussed in report	IEEE 338-1987, RG 1.118	Not stated	F-67	50
Erroneous or erratic signals are produced by the instrument because out of calibration.	Occasional	Not discussed in report	IEEE 338-1987, RG 1.118	Not stated	F-67	51
Failure to operate	Rare	Not discussed in report	IEEE 338-1987, RG 1.118	Not stated	F-67	52
Failure to operate	Rare	Not discussed in report	IEEE 338-1987, RG 1.118	Not stated	F-67	53
Loss of function	Rare	Not discussed in report	No specific program	Not stated	F-71	54
Loss of function	Occasional	Not discussed in report	No specific program	Not stated	F-71	55
Erroneous or erratic signals	Rare	Not discussed in report	IEEE 338-1987, RG 1.118	Not stated	F-72	56
Failure to operate	Occasional	Not discussed in report	IEEE 338-1987, RG 1.118	Not stated	F-72	57
Failure to operate because of faulty module	Occasional	Not discussed in report	IEEE 338-1987, RG 1.118	Not stated	F-72	58
Erroneous or erratic signals because unit out of calibration.	Occasional	Not discussed in report	IEEE 338-1987, RG 1.118	Not stated	F-73	59
Erroneous or erratic signals are produced by the instrument because of set point drift due to aging.	Occasional	Not discussed in report	IEEE 338-1987, RG 1.118	Not stated	F-82	60
Failure to operate - the circuit breaker does not function properly, either fails to open or fails to close on demand.	Rare	Not discussed in report	IEEE 741-1986 Section 7	Not stated	F-88	61

Table A.2 Gall Report for NPAR Reports

Document: NUREG/CR-4747 V2, An Aging Failure Survey of Light Water Reactor Safety Systems and Components (Electrical)
Reviewed by: L. C. Meyer, INEL

Item	System	Structure/Comp	Subcomponent	Materials	Manufacturer	ARD mechanism	ARD effects
62	Service Water System	AC Breakers	Not stated	Not stated	Not stated	WEAR	Attrition
63	Service Water System	AC Breakers	Not stated	Not stated	Not stated	Not stated	Binding or out of adjustment
64	Service Water System	AC Breakers	Not stated	Not stated	Not stated	CONTAM	Buildup of deposits
65	Service Water System	AC Breakers	Not stated	Not stated	Not stated	Not stated	Coil failure
66	Service Water System	Flow Indicators	Not stated	Not stated	Not stated	Not stated	Loss of performance
67	Service Water System	Flow Swicthes	Not stated	Not stated	Not stated	CONTAM	Buildup of deposits
68	Service Water System	Flow Swicthes	Not stated	Not stated	Not stated	Not stated	Loss of performance
69	Service Water System	Pressure Indicators	Not stated	Not stated	Not stated	CLOG	Buildup
70	Service Water System	Pressure Indicators	Not stated	Not stated	Not stated	Not stated	Loss of performance

Document: NUREG/CR-4819 V1, Aging and Service Wear of Solenoid-Operated Valves Used in Safety Systems of Nuclear Power Plants
Reviewed by: E. W. Roberts, INEL

Item	System	Structure/Comp	Subcomponent	Materials	Manufacturer	ARD mechanism	ARD effects
1		SOV ASCO 3-Way Direct Acting	Coil	Class H insulation	ASCO	ELETEMP, CURSTR, & VOLSTR	Loss of dieletric strength and conductor short/open
2		SOV	Core	Stainless steel	ASCO	CONTAM	Friction between core and guide
3		SOV	Disk Holder Assy Seat	EPDRM OR Vitron	ASCO	ELETEMP	Degradation of elastomers
4		SOV	Disc Holder Spring	Steel	ASCO	CORR	Spring relaxation or failure
5		SOV	Core Spring	Stainless steel	ASCO	CORR	Spring failure
6		SOV	Disc Holder Assembly Seat	EPDM OR Viton	ASCO	CONTAM & ELETEMP	Seat degradation
7		SOV 3-Way Pilot Operated	Coil	Not stated	ASCO	ELETEMP, CURSTR, & VOLSTR	Insulation failure and conductor open/short
8		SOV	Core	Not stated	ASCO	CONTAM	Binding between core and guide
9		SOV	Disc Holder Assy Seat	Elastomers	ASCO	CORR ELETEMP	Valve disc adheres to oriface

Document: NUREG/CR-4747 V2, An Aging Failure Survey of Light Water Reactor Safety Systems and Components (Electrical)
Reviewed by: L. C. Meyer, INEL

Effect of Aging on Component Function	Contrib to Failure	Reported progs	Rel.progs	Report Recommendations	Page No.	Item
Failure to operate - the circuit breaker does not function properly, either fails to open or fails to close on demand.	Rare	Not discussed in report	IEEE 741-1986 Section 7	Not stated	F-88	62
Failure to operate - the circuit breaker does not function properly, either fails to open or fails to close on demand.	Rare	Not discussed in report	IEEE 741-1986 Section 7	Not stated	F-88	63
Failure to operate - the circuit breaker does not function properly, either fails to open or fails to close on demand.	Occasional	Not discussed in report	IEEE 741-1986 Section 7	Not stated	F-88	64
Premature open - the opening of the circuit breaker prior to demand.	Rare	Not discussed in report	IEEE 741-1986 Section 7	Not stated	F-88	65
Failure to operate due to being out of calibration (aging related).	Occasional	Not discussed in report	IEEE 338-1987, RG 1.118	Not stated	F-89	66
Erroneous or erratic signals	Rare	Not discussed in report	IEEE 338-1987, RG 1.118	Not stated	F-89	67
Erroneous or erratic signals due to set point drift, insulation breakdown or out of calibration.	Frequent	Not discussed in report	IEEE 338-1987, RG 1.118	Not stated	F-90	68
Erroneous or erratic signals	Rare	Not discussed in report	IEEE 338-1987, RG 1.118	Not stated	F-104	69
Erroneous or erratic signals because of being out of calibraton.	Rare	Not discussed in report	IEEE 338-1987, RG 1.118	Not stated	F-104	70

Document: NUREG/CR-4819 V1, Aging and Service Wear of Solenoid-Operated Valves Used in Safety Systems of Nuclear Power Plants
Reviewed by: E. W. Roberts, INEL

Effect of Aging on Component Function	Contrib to Failure	Reported progs	Rel.progs	Report Recommendations	Page No.	Item
Valve does not operate	Occasional	Not discussed in report	Vendor specific programs	R&D to develope test methods. Testing of proposed monitoring techniques. Develope baseline data. Evaluation of failures [4]	25-26. 34-35. 41-43. 54	1
Partial/full failure of valve to change position	Occasional	Not discussed in report	Vendor specific programs	R&D to develope test methods. Testing of proposed monitoring techniques. Develope baseline data. Evaluation of failures [4]	25-26. 34-35. 41-43. 54	2
Valve fails to operate	Not stated	Not discussed in report	Vendor specific programs	R&D to develope test methods. Testing of proposed monitoring techniques. Develope baseline data. Evaluation of failures [4]	25-26. 34-35. 41-43. 54	3
Valve fails to operate as required	Not stated	Not discussed in report	Vendor specific programs	R&D to develope test methods. Testing of proposed monitoring techniques. Develope baseline data. Evaluation of failures [4]	25-26. 34-35. 41-43. 54	4
Seat leakage	Not stated	Not discussed in report	Vendor specific programs	R&D to develope test methods. Testing of proposed monitoring techniques. Develope baseline data. Evaluation of failures [4]	25-26. 34-35. 41-43. 54	5
Seat leakage	Not stated	Not discussed in report	Vendor specific programs	R&D to develope test methods. Testing of proposed monitoring techniques. Develope baseline data. Evaluation of failures [4]	25-26. 34-35. 41-43. 54	6
Valve fails to operate	Not stated	Not discussed in report	Vendor specific programs	R&D to develope test methods. Testing of proposed monitoring techniques. Develope baseline data. Evaluation of failures [4]	25-26. 34. 36. 41-43. 54	7
Valve fails to operate	Not stated	Not discussed in report	Vendor specific programs	R&D to develope test methods. Testing of proposed monitoring techniques. Develope baseline data. Evaluation of failures [4]	25-26. 34. 36. 41-43. 54	8
Valve fails to operate as required	Not stated	Not discussed in report	Vendor specific programs	R&D to develope test methods. Testing of proposed monitoring techniques. Develope baseline data. Evaluation of failures [4]	25-26. 34. 36. 41-43. 54	9

Table A.2 Gall Report for NPAR Reports

Document: NUREG/CR-4819 V1, Aging and Service Wear of Solenoid-Operated Valves Used in Safety Systems of Nuclear Power Plants
Reviewed by: E. W. Roberts, INEL

Item	System	Structure/Comp	Subcomponent	Materials	Manufacturer	ARD mechanism	ARD effects
10		SOV	Disc Holder Spring	Steel	ASCO	CORR	Spring relaxation or failure
11		SOV	Pressure Diaphragm Bleed Hole		ASCO	CONTAM	Blocked bleeder hole
12		SOV	Exhaust Diaphragm Bleed Hold		ASCO	CONTAM	Blocked bleeder hole
13		SOV	Core Spring	Stainless steel	ASCO	CORR	Spring failure
14		SOV	Disc Holder Assy Seat	EPDM	ASCO	CONTAM ELETEMP	Seat degradation
15		SOV	Pressure Diaphragm	EPDM OR Nomex fabric	ASCO	CONTAM ELETEMP	Continuous exhaust
16		SOV	Exhaust Diaphragm	EPDM OR Nomex fabric	ASCO	CONTAM ELETEMP	Leakage through exhaust port
17		SOV 2-Way Direct Operating	Coil	Class H insulation	Valcore	ELETEMP CURSTR VOLSTR	Insulation failure short/open conductors
18		SOV 2-Way Direct Operating	Coil	Not stated	Valcore	ELETEMP CURSTR VOLSTR	Insulation failure short/open conductors
19		SOV 2-Way Direct Operating	Plunger Spring	Stainless steel	Valcore	CONTAM CORR	Binding in guide. spring breakage
20		SOV 2-Way Direct Operating	Plunger Spring	Stainless steel	Valcore	CONTAM CORR	Binding in guide. spring breakage
21		SOV 2-Way Direct Operating	Pilot Spring	Not stated	Valcore	CORR	Spring failure
22		SOV 2-Way Direct Operating	Plunger	Stainless steel	Valcore	CONTAM	Binding in guide tube
23		SOV 2-Way Direct Operating	Plunger	Stainless steel	Valcore	CONTAM	Binding in guide tube
24		SOV 2-Way Direct Operating	Pilot Spring	Stainless steel	Valcore	CORR	Spring failure
25		SOV 2-Way Direct Operating	Position Reed	Not stated	Valcore	Not stated	Contact failure
26		SOV 2-Way Direct Operating	Poppet Seat	Elastomers	Valcore	ELETEMP CONTAM	Eroded seat

Table A.2 Gall Report for NPAR Reports

Document: NUREG/CR-4819 V1, Aging and Service Wear of Solenoid-Operated Valves Used in Safety Systems of Nuclear Power Plants
Reviewed by: E. W. Roberts, INEL

Effect of Aging on Component Function	Contrib to Failure	Reported progs	Rel.progs	Report Recommendations	Page No.	Item
Valve fails to operate as required	Not stated	Not discussed in report	Vendor specific programs	R&D to develope test methods. Testing of proposed monitoring techniques. Develope baseline data. Evaluation of failures [4]	25-26. 34. 36. 41-43. 54	10
Valve slow to respond	Not stated	Not discussed in report	Vendor specific programs	R&D to develope test methods. Testing of proposed monitoring techniques. Develope baseline data. Evaluation of failures [4]	25-26. 34. 36. 41-43. 54	11
Valve fails to operate as required	Not stated	Not discussed in report	Vendor specific programs	R&D to develope test methods. Testing of proposed monitoring techniques. Develope baseline data. Evaluation of failures [4]	25-26. 34. 36. 41-43. 54	12
Valve leakage	Not stated	Not discussed in report	Vendor specific programs	R&D to develope test methods. Testing of proposed monitoring techniques. Develope baseline data. Evaluation of failures [4]	25-26. 34. 36. 41-43. 54	13
Valve leakage	Not stated	Not discussed in report	Vendor specific programs	R&D to develope test methods. Testing of proposed monitoring techniques. Develope baseline data. Evaluation of failures [4]	25-26. 34. 36. 41-43. 54	14
Valve leakage - valve failure to operate as required	Not stated	Not discussed in report	Vendor specific programs	R&D to develope test methods. Testing of proposed monitoring techniques. Develope baseline data. Evaluation of failures [4]	25-26. 34. 36. 41-43. 54	15
Valve leakage - valve failure to operate as required	Not stated	Not discussed in report	Vendor specific programs	R&D to develope test methods. Testing of proposed monitoring techniques. Develope baseline data. Evaluation of failures [4]	25-26. 34. 36. 41-43. 54	16
Valve fails to operate	Not stated	Not discussed in report	Vendor specific programs	R&D to develope test methods. Testing of proposed monitoring techniques. Develope baseline data. Evaluation of failures [4]	16. 25-28. 34. 37. 41-43. 54	17
Valve fails to operate	Not stated	Not discussed in report	Vendor specific programs	R&D to develope test methods. Testing of proposed monitoring techniques. Develope baseline data. Evaluation of failures [4]	19. 25-28. 34. 38. 41-43. 54	18
Valve fails to operate	Not stated	Not discussed in report	Vendor specific programs	R&D to develope test methods. Testing of proposed monitoring techniques. Develope baseline data. Evaluation of failures [4]	16. 25-28. 34. 37. 41-43. 54	19
Valve fails to operate	Not stated	Not discussed in report	Vendor specific programs	R&D to develope test methods. Testing of proposed monitoring techniques. Develope baseline data. Evaluation of failures [4]	19. 25-28. 34. 38. 41-43. 54	20
Valve fails to operate	Not stated	Not discussed in report	Vendor specific programs	R&D to develope test methods. Testing of proposed monitoring techniques. Develope baseline data. Evaluation of failures [4]	19. 25-28. 34. 38. 41-43. 54	21
Valve sluggish or not operational	Not stated	Not discussed in report	Vendor specific programs	R&D to develope test methods. Testing of proposed monitoring techniques. Develope baseline data. Evaluation of failures [4]	16. 25-28. 34. 37. 41-43. 54	22
Valve sluggish or no operation	Not stated	Not discussed in report	Vendor specific programs	R&D to develope test methods. Testing of proposed monitoring techniques. Develope baseline data. Evaluation of failures [4]	19. 25-28. 34. 38. 41-43. 54	23
Slow valve closure	Not stated	Not discussed in report	Vendor specific programs	R&D to develope test methods. Testing of proposed monitoring techniques. Develope baseline data. Evaluation of failures [4]	19. 25-28. 34. 38. 41-43. 54	24
No or constant position indication	Not stated	Not discussed in report	Vendor specific programs	R&D to develope test methods. Testing of proposed monitoring techniques. Develope baseline data. Evaluation of failures [4]	19. 25-28. 34. 38. 41-43. 54	25
Valve leakage	Not stated	Not discussed in report	Vendor specific programs	R&D to develope test methods. Testing of proposed monitoring techniques. Develope baseline data. Evaluation of failures [4]	16. 25-28. 34. 37. 41-43. 54	26

Document: NUREG/CR-4819 V1, Aging and Service Wear of Solenoid-Operated Valves Used in Safety Systems of Nuclear Power Plants
Reviewed by: E. W. Roberts, INEL

Item	System	Structure/Comp	Subcomponent	Materials	Manufacturer	ARD mechanism	ARD effects
27		SOV 2-Way Direct Operating	Poppet Seat	EPDM	Valcore	ELETEMP CONTAM	Eroded seat
28		SOV 2-Way Direct Operating	Pilot Seat Seal	EPDM	Valcore	ELETEMP CONTAM	Eroded seat
29		SOV 2-Way Direct Operating	Coil	Class H insulation	TRC	ELETEMP CURSTR VOLSTR	Insulation failure and short/open conductor
30		SOV	Coil Diode	Not stated	TRC	Not stated	Open diode
31		SOV	Core	Not stated	TRC	CONTAM	Binding in core tube
32		SOV	Pilot Disc Seat	Stainless steel	TRC	ELETEMP CONTAM	Degradation of elastomers
33		SOV	Main Disc	Stainless steel	TRC	CONTAM	Jammed disc
34		SOV	Position Switch	Not stated	TRC	WEAR	Contact failure
35		SOV	Position Relay	Not stated	TRC	Not stated	Coil conductor short/open
36		SOV	Return Spring	Stainless steel	TRC	CORR	Spring breakage
37		SOV	Main Disc Seat	Stainless steel	TRC	WEAR	Seat degradation

Document: NUREG/CR-4819 V2, Aging and Service Wear of Solenoid-Operated Valves Used in Safety Systems of Nuclear Power Plants, Vol. 2
Reviewed by: L. C. Meyer, INEL

Item	System	Structure/Comp	Subcomponent	Materials	Manufacturer	ARD mechanism	ARD effects
1		Solenoid-Operated Valves	Core Seat & Seals (Elastomeric Components)	Not stated	ASCO AND Skinner	THERM & AGR-CHEM	Prolonged temperatures degrades seals, chem attack by oils
2		Solenoid-Operated Valves	Solenoid Coil Insulation	Not stated	Not stated	THERM	Degraded insulation
3		Solenoid-Operated Valves	Core Spring	Not stated	Not stated	WEAR & CORR	Changes in mechanical propeties. binding or corrsion contar
4		Solenoid-Operated Valves	Sliding Surfaces	Not stated	Not stated	WEAR & CORR	Loss of materiai, crud buidup

Table A.2 Gall Report for NPAR Reports

Document: NUREG/CR-4819 V1, Aging and Service Wear of Solenoid-Operated Valves Used in Safety Systems of Nuclear Power Plants
Reviewed by: E. W. Roberts, INEL

Effect of Aging on Component Function	Contrib to Failure	Reported progs	Rel.progs	Report Recommendations	Page No.	Item
Valve leakage	Not stated	Not discussed in report	Vendor specific programs	R&D to develope test methods. Testing of proposed monitoring techniques. Develope baseline data. Evaluation of failures [4]	19. 25-28. 34. 38. 41-43. 54	27
Valve leakage	Not stated	Not discussed in report	Vendor specific programs	R&D to develope test methods. Testing of proposed monitoring techniques. Develope baseline data. Evaluation of failures [4]	19. 25-28. 34. 38. 41-43. 54	28
Valve fails to operate	Not stated	Not discussed in report	Vendor specific programs	R&D to develope test methods. Testing of proposed monitoring techniques. Develope baseline data. Evaluation of failures [4]	21. 25-28. 34. 39. 41-43. 54	29
Valve fails closed	Not stated	Not discussed in report	Vendor specific programs	R&D to develope test methods. Testing of proposed monitoring techniques. Develope baseline data. Evaluation of failures [4]	21. 25-28. 34. 39. 41-43. 54	30
Valve fails to operate	Not stated	Not discussed in report	Vendor specific programs	R&D to develope test methods. Testing of proposed monitoring techniques. Develope baseline data. Evaluation of failures [4]	21. 25-28. 34. 39. 41-43. 54	31
Valve fails to operate	Not stated	Not discussed in report	Vendor specific programs	R&D to develope test methods. Testing of proposed monitoring techniques. Develope baseline data. Evaluation of failures [4]	21. 25-28. 34. 39. 41-43. 54	32
Valve fails to operate	Not stated	Not discussed in report	Vendor specific programs	R&D to develope test methods. Testing of proposed monitoring techniques. Develope baseline data. Evaluation of failures [4]	21. 25-28. 34. 39. 41-43. 54	33
Loss of position indication	Not stated	Not discussed in report	Vendor specific programs	R&D to develope test methods. Testing of proposed monitoring techniques. Develope baseline data. Evaluation of failures [4]	21. 25-28. 34. 39. 41-43. 54	34
Position indication does not change	Not stated	Not discussed in report	Vendor specific programs	R&D to develope test methods. Testing of proposed monitoring techniques. Develope baseline data. Evaluation of failures [4]	21. 25-28. 34. 39. 41-43. 54	35
Valve remains open	Not stated	Not discussed in report	Vendor specific programs	R&D to develope test methods. Testing of proposed monitoring techniques. Develope baseline data. Evaluation of failures [4]	21. 25-28. 34. 39. 41-43. 54	36
Valve does not have a tight shutoff	Not stated	Not discussed in report	Vendor specific programs	R&D to develope test methods. Testing of proposed monitoring techniques. Develope baseline data. Evaluation of failures [4]	21. 25-28. 34. 39. 41-43. 54	37

Document: NUREG/CR-4819 V2, Aging and Service Wear of Solenoid-Operated Valves Used in Safety Systems of Nuclear Power Plants, Vol. 2
Reviewed by: L. C. Meyer, INEL

Effect of Aging on Component Function	Contrib to Failure	Reported progs	Rel.progs	Report Recommendations	Page No.	Item
Chemical attack of elastomers by oil and degradation of elastomers resulting from prolonged operation at excessively high temperatures resulting in failure to operate.	Rare	Not discussed in report	Vendor specific programs	Determine the sensitivity with which degraded elastomeric valve seats can be determined from electrical measurements [2]	5, 7, 8, 11, & 44	1
Electrical failure of solenoid coil, caused by high-voltage turn-off transients in combination with insulation weakened by prolonged operation at high temperatures, electrical failure due to short circuit, conductor burnout.	Occasional	Not discussed in report	Vendor specific programs	Visual inspections and electrical resistance tests [2]	5, 7, 8, 11, & 44	2
Changes in mechanical properties of materials, binding in operation, hum or chatter, worn spring, & wear, change in valve operating time or in rush current.	Rare	Not discussed in report	Vendor specific programs	Visual inspections and electrical characterization of inrush currents [2]	5, 7, 8, 11, & 44	3
Mechanical binding and sluggish shifting caused by worn or improper parts or the presence of foreign materials inside the valve, increase in frictional force	Occasional	Not discussed in report	Vendor specific programs	Visual inspections and electrical characterization of inrush currents and valve actuation times. [2]	5, 7, 8, 11, & 44	4

Table A.2 Gall Report for NPAR Reports

Document: NUREG/CR-4928, Degradation of Nuclear Plant Temperature Sensors
Reviewed by: L. C. Meyer, INEL

Item	System	Structure/Comp	Subcomponent	Materials	Manufacturer	ARD mechanism	ARD effects
1		Temperature Sensors	RTD Sensing Wire or Film	Platinum	Not stated	OXIDAT, VIB, CONTAM, & ELE-TEMP	Platininum oxide build up, fat, ion migration, & strain
2		Temperature Sensors	RTD Insulation	Powder or cement (material not identified in report)	Not stated	MOIST-EL	Moisture decreases resistance
3		Temperature Sensors	RTD Sheath	Stainless steel	Not stated	VIB	Cold working in metals

Document: NUREG/CR-4939 V1, Improving Motor Reliability in Nuclear Power Plants - Performance Evaluation and Maintenance Practices
Reviewed by: Jerry Edson, INEL

Item	System	Structure/Comp	Subcomponent	Materials	Manufacturer	ARD mechanism	ARD effects
1		Electric Motors	Dielectric, Rotational, Mechanical	Not stated	Not stated	Not stated	Insulation is most affected by aging mechanisms

Document: NUREG/CR-4939 V2, Improving Motor Reliability in Nuclear Power Plants
Reviewed by: E. W. Roberts, INEL

Item	System	Structure/Comp	Subcomponent	Materials	Manufacturer	ARD mechanism	ARD effects
1		Motor	Insulation	Glass, mylar, dacron w/poly binder, epoxy, poly fibers & poly varnish	Westinghouse	ELETEMP	Slot wedge developed hole(s), arcing to ground
2		Motor	Bearing	Not stated	Westinghouse	ELETEMP WEAR	Bearing failure

Document: NUREG/CR-4939 V3, Failure Analysis and Diagnostic Tests on A Naturally Aged Large Electric Motor
Reviewed by: E. W. Roberts, INEL

Item	System	Structure/Comp	Subcomponent	Materials	Manufacturer	ARD mechanism	ARD effects
1			400HP, 2400 V Motor	Not stated	Not stated	VOLSTR	Insulation breakdown

Document: NUREG/CR-4967, Nuclear Plant Aging Research on High Pressure Injection Systems
Reviewed by: L. C. Meyer, INEL

Item	System	Structure/Comp	Subcomponent	Materials	Manufacturer	ARD mechanism	ARD effects
15	PWR high pressure injection system	Air Operated Valves		Not stated	Not stated	CONTAM	Parts degrade from oil in air supply
16	PWR high pressure injection system	HPI Nozzles and Thermal Sleeve		Stainless steel	Not stated	THERM FAT	Crack initiation and propagation
17	PWR high pressure injection system	I & C Electronics	Small Electronic Components	Not stated	Not stated	CORR	Opens, shorts, and loose connections
18	PWR high pressure injection system	PIPING		Stainless steel	Not stated	THERM FAT, WEAR, VIB, & MECHSTR	Cracking & abrasive wear
19	PWR high pressure injection system	Valve		Stainless steel	Not stated	WEAR & CONTAM	Leakage, blockage, & mechanical linkage faults
20	PWR high pressure injection system	Pump		Stainless steel	Not stated	THERM-CY, WEAR, VIB, & FAT	Wear on parts and seal leaks
21	PWR high pressure injection system	Pipe Supports		Not stated	Not stated	VIB AND FAT	Loosening of connections or breaking loose
22	PWR high pressure injection system	Motor Operated Valve		Stainless steel	Not stated	WEAR AND VOLSTR	Loose connections, wear on moving parts, motor failure

Table A.2 Gall Report for NPAR Reports

Document: NUREG/CR-4928, Degradation of Nuclear Plant Temperature Sensors
Reviewed by: L. C. Meyer, INEL

Effect of Aging on Component Function	Contrib to Failure	Reported progs	Rel.progs	Report Recommendations	Page No.	Item
Changes in resistance causes calibration changes	Not stated	Not discussed in report	RG 1.118, IEEE 338-1987	Burn-in program for new sensors, develop a data base for degradation mechanisms, and simple tests to check sensor prob. [2]	A-9, and A-31 to A-36	1
Shunting of sensing element occurs when insulating powder gets wet. moisture intrusion occurs when the seals dry out, shrink, crack, or leak resulting in calibration shift or failure to function.	Not stated	Not discussed in report	No specific program	Burn-in program for new sensors, develop a data base for degradation mechanisms, and simple tests to check sensor prob. [2]	A-9, and A-31 to A-36	2
Mechanical shock and vibration can cause cold working in metal that leads to failure of the sheath and moisture intrusion.	Not stated	Not discussed in report	No specific program	Burn-in program for new sensors, develop a data base for degradation mechanisms, and simple tests to check sensor prob. [2]	A-9, and A-31 to A-36	3

Document: NUREG/CR-4939 V1, Improving Motor Reliability in Nuclear Power Plants - Performance Evaluation and Maintenance Practices
Reviewed by: Jerry Edson, INEL

Effect of Aging on Component Function	Contrib to Failure	Reported progs	Rel.progs	Report Recommendations	Page No.	Item
This report references a phase I study that investigated aging effects. This report only addresses motor evaluation and maintenance practices	Not stated	EPRI; IEEE 4,43,85,95,112,117, 286,429,432,522	EPRI; IEEE 4, 43, 85, 95, 112, 117, 286, 429,	Motors important to safety should undergo cost-effective PM programs [2]	1-6; 2-7; 4-1; 5-9,10,11,& 12; 7-1	1

Document: NUREG/CR-4939 V2, Improving Motor Reliability in Nuclear Power Plants
Reviewed by: E. W. Roberts, INEL

Effect of Aging on Component Function	Contrib to Failure	Reported progs	Rel.progs	Report Recommendations	Page No.	Item
Motor failure	Not stated	Not discussed in report	IEEE 334-1974 Section 14.2.3	The "plug reversal life test" is recommended for motor qualification. [2]	2-1, 6-1	1
Motor failure	Not stated	Not discussed in report	IEEE 334-1974 Section 14.2.3	Not stated	4-1, 5-1, 6-1	2

Document: NUREG/CR-4939 V3, Failure Analysis and Diagnostic Tests on A Naturally Aged Large Electric Motor
Reviewed by: E. W. Roberts, INEL

Effect of Aging on Component Function	Contrib to Failure	Reported progs	Rel.progs	Report Recommendations	Page No.	Item
Motor failure	Frequent	DC insulation &/or polarization tests	IEEE 334-1974 Section 14.2.3	Install effective grnd or grnd detectors on 3 Ph "capacitance" grnded (delta) PWR syst. [2]	3-4	1

Document: NUREG/CR-4967, Nuclear Plant Aging Research on High Pressure Injection Systems
Reviewed by: L. C. Meyer, INEL

Effect of Aging on Component Function	Contrib to Failure	Reported progs	Rel.progs	Report Recommendations	Page No.	Item
Fail to operate	Rare	Not discussed in report	Vendor specific program. Tech Spec surveill.	Not stated	36	15
Nozzle leaks and loose parts resulting in degraded HPI system	Rare	Not discussed in report	Dye penetrant, ultrasonic, radiography	Not stated	36 & 53	16
Failure to operate	Occasional	Not discussed in report	IEEE 338-1987	Not stated	36	17
Through the pipe wall leakage resulting in HPIS degraded operation or failure to function.	Rare	Not discussed in report	Dye penentant, ultrasonic, radiography	Not stated	36 & 53	18
Failure to operate resulting in HPIS failure. Valve failure allowes cold water to flow back into primary system resulting piping cracks.	Rare	Not discussed in report	Vendor specific programs	Not stated	36 & 53	19
Fail to start or run	Rare	Not discussed in report	Vendor specific programs	Not stated	36	20
Lose of pipe supports stresses piping leading to potential pipe failure and HPIS failure.	Rare	Not discussed in report	Plant specific program	Not stated	36	21
Valve failure to operate results in HPIS failure.	Rare	Not discussed in report	Vendor specific programs	Not stated	36	22

Table A.2 Gall Report for NPAR Reports

Document: NUREG/CR-4992 V1, Aging and Servcie Wear of Multistage Switches Used in Safety Systems of Nuclear Power Plants
Reviewed by: Jerry Edson, INEL

Item	System	Structure/Comp	Subcomponent	Materials	Manufacturer	ARD mechanism	ARD effects
1		Multistage Switches	General		GE, Westinghouse, Electro., Micro		
2		Multistage Switches	Cam Shaft	Steel, Al, brass	GE, Westinghouse, Electro., Micro	EXFORCE, WEAR	Bent or twisted shaft
3		Multistage Switches	Cam Shaft	Steel, Al, brass	GE, Westinghouse, Electro., Micro	MECHSTR, WEAR	Broken camshaft
4		Multistage Switches	Contacts	Silver or silver alloy	GE, Westinghouse, Electro., Micro	CORR, FAT, FAT/THERM, VIBR, CONTAM, ELETEMP, WEAR	Broken or distorted contact, sticking, loose contact
5		Multistage Switches	Contacts	Silver or silver alloy	GE, Westinghouse, Electro., Micro	ELETEMP, CURSTR, VOLSTR,	Pitted, worn, or welded contact
6		Multistage Switches	Contact Block	Phenolic	GE, Westinghouse, Electro., Micro	VIBR	Loose contact bank
7		Multistage Switches	Moving Contact Spring	Steel, Al, brass	GE, Westinghouse, Electro., Micro	FAT	Spring breaks
8		Multistage Switches	Moving contact Assembly	Not stated	GE, Westinghouse, Electro., Micro	FAT	Gear breaks
9		Multistage Switches	Moving Contact Pin	Not stated	GE, Westinghouse, Electro., Micro	ELETEMP, FAT, THERM-CY	Pin breaks
10		Multistage Switches	Cams	Polyphenylene oxide, acetal, phenolic	GE, Westinghouse, Electro., Micro	ELETEMP, RAD, THERM-CY, WEAR	Closing or opening cam failure
11		Multistage Switches	Cam Follower	Polycarbonate	GE, Westinghouse, Electro., Micro	ELETEMP, RAD, VIBR	Broken or warped follower
12		Multistage Switches	Cam Follower	Polycarbonate	GE, Westinghouse, Electro., Micro	WEAR	Slipping of cam follower
13		Multistage Switches	Switch Handle	Polycarbonate	GE, Westinghouse, Electro., Micro	VIBR	Broken or loose set screws
14		Multistage Switches	Shaft Bearings	Not stated	GE, Westinghouse, Electro., Micro	LOSLUB, WEAR, CONTAM	Bearing freezes up
15		Multistage Switches	Gear	Not stated	GE, Westinghouse, Electro., Micro	FAT, WEAR	Gear failure
16		Multistage Switches	Detent Mechanism	Steel, Al, brass, vulcanized fiber	GE, Westinghouse, Electro., Micro	FAT, WEAR	Worn detent mechanism, loose detent roller pin
17		Multistage Switches	Detent Stop Arm	Steel, Al, brass	GE, Westinghouse, Electro., Micro	EXFORCE	Bent stop arm

Document: NUREG/CR-5008, Development of A Testing and Analysis Methodology to Determine the Functional Condition of Solenoid Operated Valves
Reviewed by: Jerry Edson, INEL

Item	System	Structure/Comp	Subcomponent	Materials	Manufacturer	ARD mechanism	ARD effects
1		Solenoid Valves	General		Not stated		
2		Solenoid Valves	Spring	Not stated	Not stated	Not stated	Weakened spring
3		Solenoid Valves	Valve Seat	Not stated	Not stated	CONTAM	Not stated
4		Solenoid Valves	Plunger	Not stated	Not stated	Not stated	Sticking plunger

Document: NUREG/CR-5051, Detecting and Mitigating Battery Charger and Inverter Aging
Reviewed by: L. C. Meyer, INEL

Item	System	Structure/Comp	Subcomponent	Materials	Manufacturer	ARD mechanism	ARD effects
1		Inverter	Automatic Transfer Switch (Two Pairs of SCR's)	Not stated	Not stated	ELETEMP & CURSTR	Degraded component or burn out
2		Battery	Electrolytic Capacitors	Not stated	Not stated	ELETEMP	Reduced capacitor life
3		Battery	Semi-Conductors		Not stated	VIB, THERM, & CURSTR	Vibration loosens connections & heat degrades operation
4		Battery	Magnetics - Transformers	High permeability alloys, copper windings, & insulation	Not stated	ELETEMP AND CURSTR	Aging degradation resulting from over heating & elec. stress
5		Battery	Complete Assembly	Enclosures and electrical components	Seven listed	ELETEMP & CURSTR,	Overheating & electrical transients from stresses

Document: NUREG/CR-5053, Operating Experience and Aging Assessment of Motor Control Centers
Reviewed by: Jerry Edson, INEL

Item	System	Structure/Comp	Subcomponent	Materials	Manufacturer	ARD mechanism	ARD effects
1		Motor Control Center	General				
2		Motor Control Center	Molded Case Circuit Breakers	Lubr., adhes., neoprene, silicone, polyester, phenolic, rubber, silver alloy, copper, stainless steel	Not stated	FAT, WEAR, CONTAM, CORR, CORR/PIT,	Mech. stress, sticking, surface deterioration, low torque
3		Motor Control Center	Molded Case Circuit Breakers	Lubr., adhes., neoprene, silicone, polyester, phenolic, rubber, silver alloy, copper, stainless steel	Not stated	WEAR,	Out of adjustment, defective latch, short/ground, stresses
4		Motor Control Center	Relay	Phenolic, vulcanized rubber, silver alloy, copper, steel	Not stated	ELETEMP, CORR, CORR/PIT	Breakdown of insulation, contact surface degradation
5		Motor Control Center	Relay	Phenolic, vulcanized rubber, silver alloy, copper, steel	Not stated	CONTAM, CORR, CORR/PIT, VIBR, FAT	Foreign mat'l accumulation, surface degradation, misalign.
6		Motor Control Center	Relay	Phenolic, vulcanized rubber, silver alloy, copper, steel	Not stated	WEAR	Out of calibration
7		Motor Control Center	Transformer	Phenolic, fiberglass, copper wire, teflon	Not stated	ELETEMP, CURSTR, VOLSTR	Overheating, deterioration and breakdown of insulation

Document: NUREG/CR-4992 V1, Aging and Servcie Wear of Multistage Switches Used in Safety Systems of Nuclear Power Plants
Reviewed by: Jerry Edson, INEL

Effect of Aging on Component Function	Contrib to Failure	Reported progs	Rel.progs	Report Recommendations	Page No.	Item
	Not stated	Not discussed in report	No specific/vendor specific programs	Operators provide feedback on problems, failures should be analyzed,no further consideraton by NPAR [2]	2, 10, 52	1
Bent or twisted shaft causes incorrect contact alignment and failure to operate as required	Not stated	General - none specifically for switches	No specific/vendor specific programs	Not stated	2, 10, 31-37, 41-44, 52	2
Switch will not change state resulting in failure to operate	Not stated	General - none specifically for switches	No specific/vendor specific programs	Not stated	2, 10, 31-37, 41-44, 52	3
Contacts do not close or change state, open or short circuit, high electrical resistnace resulting in failure to operate	Frequent	General - none specifically for switches	No specific/vendor specific programs	Not stated	2, 10, 31-37, 41-44, 52	4
High contact resistance resulting in failure to operate as required	Frequent	General - none specifically for switches	No specific/vendor specific programs	Not stated	2, 10, 31-37, 41-44, 52	5
Contacts do not mate properly resulting in failure to operate	Not stated	General - none specifically for switches	No specific/vendor specific programs	Not stated	2, 10, 31-37, 41-44, 52	6
No positive return of cam followers, contacts may open or close randomly resulting in failure to operate	Not stated	General - none specifically for switches	No specific/vendor specific programs	Not stated	2, 10, 31-37, 41-44, 52	7
Contacts to not change state resulting in failure to operate	Not stated	General - none specifically for switches	No specific/vendor specific programs	Not stated	2, 10, 31-37, 41-44, 52	8
Contacts will tend to remain closed during opening cam action resulting in failure to operate	Not stated	General - none specifically for switches	No specific/vendor specific programs	Not stated	2, 10, 31-37, 41-44, 52	9
Contacts to not change state resulting in failure to operate	Not stated	General - none specifically for switches	No specific/vendor specific programs	Not stated	2, 10, 31-37, 41-44, 52	10
Contacts do not change state resulting in failure to operate	Not stated	General - none specifically for switches	No specific/vendor specific programs	Not stated	2, 10, 31-37, 41-44, 52	11
Incomplete contact closure resulting in failure to operate as required	Not stated	General - none specifically for switches	No specific/vendor specific programs	Not stated	2, 10, 31-37, 41-44, 52	12
Switch will not change state resulting in failure to operate	Not stated	General - none specifically for switches	No specific/vendor specific programs	Not stated	2, 10, 31-37, 41-44, 52	13
Switch will not change state resulting in failure to operate	Not stated	General - none specifically for switches	No specific/vendor specific programs	Not stated	2, 10, 31-37, 41-44, 52	14
Switch will not maintain position resulting in failure to operate	Not stated	General - none specifically for switches	No specific/vendor specific programs	Not stated	2, 10, 31-37, 41-44, 52	15
False indication of position change, contacts do no properly line up resulting in failure to operate as required	Frequent	General - none specifically for switches	No specific/vendor specific programs	Not stated	2, 10, 31-37, 41-44, 52	16
Overtravel of cams at end stop resulting in failure to operate as required	Not stated	General - none specifically for switches	No specific/vendor specific programs	Not stated	2, 10, 31-37, 41-44, 52	17

Table A.2 Gall Report for NPAR Reports

Document: NUREG/CR-5008, Development of A Testing and Analysis Methodology to Determine the Functional Condition of Solenoid Operated Valves
Reviewed by: Jerry Edson, INEL

Effect of Aging on Component Function	Contrib to Failure	Reported progs	Rel.progs	Report Recommendations	Page No.	Item
This report is not an aging assessment of sovs. The report investigates testing and analysis methodologies.	Not stated	Not discussed in report	Vendor specific programs	Explore alternative analytical techniques. Further develop and validate coherency model [2]	23	1
Not stated	Not stated	Not discussed in report	Vendor specific programs	Not stated	13	2
Not stated	Not stated	Not discussed in report	Vendor specific programs	Not stated	13	3
Not stated	Not stated	Not discussed in report	Vendor specific programs	Not stated	13	4

Document: NUREG/CR-5051, Detecting and Mitigating Battery Charger and Inverter Aging
Reviewed by: L. C. Meyer, INEL

Effect of Aging on Component Function	Contrib to Failure	Reported progs	Rel.progs	Report Recommendations	Page No.	Item
Inverter fails and vital bus loads are automatically transferred to alternate source if failure occurs.	Not stated	Not discussed in report	Vendor specific programs	Not stated	3-15 TO 3-22	1
Aging due to high temperature leads to capacitor failure resulting in improper output.	Frequent	Not discussed in report	Vendor specific programs	Improve thermal efficiency by using forced air cooling. Manufacture improvements such as adding a fuse module. [2]	3-4 TO 3-6	2
Aging due to local heat buildup results in short circuit of the SCR and an inverter failure.	Occasional	Not discussed in report	Vendor specific programs	Improved maintenance and testing done more often. [2]	3-7, 4-13, & 5-7	3
Transformer aging caused by over heating, electrical transients, and personnel error results in charger/invertor failure.	Not stated	Not discussed in report	Vendor specific programs	Improved maintenance and testing done more often. [2]	XIII, 1-6, 3-9, & 5-6	4
Electrolytic capacitors, fuses, magnetics (inductors and transformers) and semiconductors failure results in charger/invertor failure.	Not stated	Plant maintenance	Vendor specific programs	Establish a comprehensive maintenance program that addresses inspection, testing, predictive and corrective maintenance [2]	XIII, 4-15, & 7-4	5

Document: NUREG/CR-5053, Operating Experience and Aging Assessment of Motor Control Centers
Reviewed by: Jerry Edson, INEL

Effect of Aging on Component Function	Contrib to Failure	Reported progs	Rel.progs	Report Recommendations	Page No.	Item
	Not stated	IEEE 308,279,317; RG 1.106,1.63; NEMA; UL	IEEE 308, 279, 317; RG 1.106, 1.63; NEMA; UL	Detailed survey of PM, surveillance techniques, and oper. exp. review maintenance data. PRA to determine importance [2]	5-1 thru 5-13, 6-5 thru 6-7	1
Failure to open or failure to close	Frequent	IEEE 308,279,317; RG 1.106,1.63; NEMA; UL	IEEE 308, 279, 317; RG 1.106, 1.63; NEMA; UL	Not stated	3-4, 4-6, 4-20, 4-21, 5-1 thru 5-13	2
Inadvertent trip, failure to trip	Occasional to Frequent	IEEE 308,279,317; RG 1.106,1.63; NEMA; UL	IEEE 308, 279, 317; RG 1.106, 1.63; NEMA; UL	Not stated	3-4, 4-6, 4-20, 4-21, 5-1 thru 5-13	3
Open circuits	Frequent	IEEE 308,279,317; RG 1.106,1.63; NEMA; UL	IEEE 308, 279, 317; RG 1.106, 1.63; NEMA; UL	Not stated	3-4, 4-6, 4-20, 4-21, 5-1 thru 5-13	4
Failure to open or failure to close	Occasional	IEEE 308,279,317; RG 1.106,1.63; NEMA; UL	IEEE 308, 279, 317; RG 1.106, 1.63; NEMA; UL	Not stated	3-4, 4-6, 4-20, 4-21, 5-1 thru 5-13	5
Response on incorrect signal	Frequent	IEEE 308,279,317; RG 1.106,1.63; NEMA; UL	IEEE 308, 279, 317; RG 1.106, 1.63; NEMA; UL	Not stated	3-4, 4-6, 4-20, 4-21, 5-1 thru 5-13	6
Open or short circuits	Occasional	IEEE 308,279,317; RG 1.106,1.63; NEMA; UL	IEEE 308, 279, 317; RG 1.106, 1.63; NEMA; UL	Not stated	3-4, 4-6, 4-22, 5-1 thru 5-13	7

Document: NUREG/CR-5053, Operating Experience and Aging Assessment of Motor Control Centers
Reviewed by: Jerry Edson, INEL

Item	System	Structure/Comp	Subcomponent	Materials	Manufacturer	ARD mechanism	ARD effects
8		Motor Control Center	TERMINAL BLOCK	Phenolic	Not stated	VIBR, WEAR	Mechanical stresses
9		Motor Control Center	Terminal Block	Phenolic	Not stated	ELETEMP	Conduction paths are formed
10		Motor Control Center	Thermal Overloads	Phenolic, silver plating, copper, vulcanized rubber	Not stated	ELETEMP, FAT	Overheating
11		Motor Control Center	Thermal Overloads	Phenolic, silver plating, copper, vulcanized rubber	Not stated	CORR, CORR/PIT	Surface degradation
12		Motor Control Center	Thermal Overloads	Phenolic, silver plating, copper, vulcanized rubber	Not stated	WEAR, CONTAM	Out of calibration, sticking
13		Motor Control Center	Starter/Contactor	Lubricant, adhesive, neoprene, silicone, polyester, phenolic, rubber, silver alloy, coppper, stainless steel	Not stated	FAT, CORR, CORR/PIT, CONTAM	Mech. stresses, surface degradation, foreign substance
14		Motor Control Center	Fuse	Not stated	Not stated	Not stated	Material degradation causes open circuits
15		Motor Control Center	Coils	Phenolic, fiberglass, copper wire, teflon	Not stated	CURSTR	Overcurrent causes overheating and insulation breakdown
16		Motor Control Center	Trip and Control	Not stated	Not stated	Not stated	Drifting of setpoint, out of calibration
17		Motor Control Center	Trip and Control	Not stated	Not stated	CONTAM	Degradation of contact surfaces, buildup of grease and dirt
18		Motor Control Center	Cabinets	Steel	Not stated	Not stated	Not stated

Document: NUREG/CR-5141, Aging and Qualification Research on Solenoid Operated Valves
Reviewed by: Jerry Edson, INEL

Item	System	Structure/Comp	Subcomponent	Materials	Manufacturer	ARD mechanism	ARD effects
1		SOV - ASCO	Coils	Elastomers	ASCO	MOIST-EL, ELETEMP	Decreased insulation and coil resistance
2		SOV - ASCO	Core Disc	Buna-N, EPDM	ASCO	ELETEMP, RAD	Hardening, decreased elongation
3		SOV - ASCO	Seat	Buna-N and nylon metal and EP	ASCO	ELETEMP, RAD	Hardening, decreased elongation
4		SOV - ASCO	Body O-Rings	Buna-N, EPDM	ASCO	ELETEMP, RAD	Hardening, decreased elongation

Document: NUREG/CR-5053, Operating Experience and Aging Assessment of Motor Control Centers
Reviewed by: Jerry Edson, INEL

Effect of Aging on Component Function	Contrib to Failure	Reported progs	Rel.progs	Report Recommendations	Page No.	Item
Poor connection/open circuit	Occasional	IEEE 308,279,317; RG 1.106,1.63; NEMA; UL	IEEE 308, 279, 317; RG 1.106, 1.63; NEMA; UL	Not stated	3-4, 4-6, 4-22, 5-1 thru 5-13	8
Ground/short	Occasional	IEEE 308,279,317; RG 1.106,1.63; NEMA; UL	IEEE 308, 279, 317; RG 1.106, 1.63; NEMA; UL	Not stated	3-4, 4-6, 4-22, 5-1 thru 5-13	9
Open circuit	Frequent	IEEE 308,279,317; RG 1.106,1.63; NEMA; UL	IEEE 308, 279, 317; RG 1.106, 1.63; NEMA; UL	Not stated	3-4, 4-6, 4-23, 4-24, 5-1 thru 5-13	10
Would not operate	Occasional	IEEE 308,279,317; RG 1.106,1.63; NEMA; UL	IEEE 308, 279, 317; RG 1.106, 1.63; NEMA; UL	Not stated	3-4, 4-6, 4-23, 4-24, 5-1 thru 5-13	11
Tripped and response on incorrect signal	Occasional	IEEE 308,279,317; RG 1.106,1.63; NEMA; UL	IEEE 308, 279, 317; RG 1.106, 1.63; NEMA; UL	Not stated	3-4, 4-6, 4-23, 4-24, 5-1 thru 5-13	12
Failure to open or close	Frequent	IEEE 308,279,317; RG 1.106,1.63; NEMA; UL	IEEE 308, 279, 317; RG 1.106, 1.63; NEMA; UL	Not stated	3-4, 4-6, 4-23, 4-24, 5-1 thru 5-13	13
Premature operation	Frequent	IEEE 308,279,317; RG 1.106,1.63; NEMA; UL	IEEE 308, 279, 317; RG 1.106, 1.63; NEMA; UL	Not stated	4-6, 4-23, 5-1 thru 5-13	14
Open circuit, short/ground	Occasional	IEEE 308,279,317; RG 1.106,1.63; NEMA; UL	IEEE 308, 279, 317; RG 1.106, 1.63; NEMA; UL	Not stated	3-4, 4-6, 4-24, 5-1 thru 5-13	15
Response on incorrect signal	Occasional	IEEE 308,279,317; RG 1.106,1.63; NEMA; UL	IEEE 308, 279, 317; RG 1.106, 1.63; NEMA; UL	Not stated	4-6, 4-24, 5-1 thru 5-13	16
Sticking and material degradation result in faiure to operate	Rare	IEEE 308,279,317; RG 1.106,1.63; NEMA; UL	IEEE 308, 279, 317; RG 1.106, 1.63; NEMA; UL	Not stated	4-6, 4-24, 5-1 thru 5-13	17
Not stated	Not stated	IEEE 308,279,317; RG 1.106,1.63; NEMA; UL	IEEE 308, 279, 317; RG 1.106, 1.63; NEMA; UL	Not stated	3-4, 5-1 thru 5-13	18

Document: NUREG/CR-5141, Aging and Qualification Research on Solenoid Operated Valves
Reviewed by: Jerry Edson, INEL

Effect of Aging on Component Function	Contrib to Failure	Reported progs	Rel.progs	Report Recommendations	Page No.	Item
Water enters during MSLB/LOCA conditions. Failure to operate	Frequent	Not discussed in report	10 CFR 50.49 if EQ'd, plant specific programs	Not stated	6-7, 9, 28-31, 41-48, 75-78	1
Leakage	Frequent	Not discussed in report	10 CFR 50.49 if EQ'd, plant specific programs	Not stated	6-7, 9, 28-31, 73, 75-78	2
Leakage. Laquer like organic deposits surrounding the metal to metal seats caused failure to transfer.	Frequent	Not discussed in report	10 CFR 50.49 if EQ'd, plant specific programs	Not stated	6-7, 9, 28-31, 75-78	3
Failure to transfer	Frequent	Not discussed in report	10 CFR 50.49 if EQ'd, plant specific programs	Not stated	6-7, 9, 28-31, 74, 75-78	4

Document: NUREG/CR-5141, Aging and Qualification Research on Solenoid Operated Valves
Reviewed by: Jerry Edson, INEL

Item	System	Structure/Comp	Subcomponent	Materials	Manufacturer	ARD mechanism	ARD effects
5		SOV - ASCO	Housings, Washers, Core Spring, Gaskets	Not stated	ASCO	Not stated	Not stated
6		SOV - VALCOR	Coils	Elastomers	Valcor	MOIST-EL, ELETEMP	Decreased coil and insulation resistance
7		SOV - VALCOR	Seats	EPR	Valcor	ELETEMP, RAD	Hardening and decreased elongation
8		SOV - VALCOR	Shaft Seal O-Ring	EPR	Valcor	ELETEMP, RAD	Hardening and decreased elongation
9		SOV - VALCOR	Upper Assembly Seal O-Ring	EPR	Valcor	ELETEMP, RAD	Hardening and decreased elongation
10		SOV - VALCOR	Shaft, Cage, Ports	Not stated	Valcor	Not stated	Not stated

Document: NUREG/CR-5181, Nuclear Plant Aging Research: The 1E Power System
Reviewed by: Jerry Edson, INEL

Item	System	Structure/Comp	Subcomponent	Materials	Manufacturer	ARD mechanism	ARD effects
1	1E Power	General					
2	1E Power	Transformer	General				
3	1E Power	Transformer	Insulating Oil	Mineral oil, systhetic chlorinated aromatic hydrocarbon	Not stated	MOIST-EL, ELETEMP	Degraded insulation value
4	1E Power	Transformer	Core (Magnetic Circuit and Windings)	Copper, aluminum, silicon steel, cellulose, phenolics, fiberglass, varnish, epoxy	Not stated	FAT, ELETEMP	Magnetic core deformation
5	1E Power	Transformer	Core (Magnetic Circuit and Windings)	Copper, aluminum, silicon steel, , cellulose, phenolics, fiberglass, varnish, epoxy	Not stated	ELETEMP, VIBR, MOIST-EL, VOLSTR, CURSTR, CORR/OX	Arcing, hot spots, winding insulation degradation
6	1E Power	Transformer	Case (Tank)	Structural steel, paints	Not stated	FAT	Failure of tank welds, moisture seal cracking
7	1E Power	Transformer	Insulating Gas	Nitrogen, air, flourocarbon	Not stated	MOIST-EL	Insulation breakdown
8	1E Power	Transformer	Core (Magnetic Circuit and Windings)	Copper, aluminum, silicon steel, cellulose, phenolics, figerglass, varnish, epoxy	Not stated	FAT, ELETEMP	Magnetic core deformation
9	1E Power	Transformer	Core (Magnetic Circuit and Windings)	Copper, aluminum, silicon steel, cellulose, phenolics, figerglass, varnish, epoxy	Not stated	MOIST-EL, ELETEMP, CORR/OX, CURSTR, VIBR, VOLSTR	Arcing, hot spots, winding insulation degradation
10	1E Power	Transformer	Case (Tank)	Structural steel, paint	Not stated	FAT	Failure of tank welds, moisture seal cracking

Table A.2 Gall Report for NPAR Reports

Document: NUREG/CR-5141, Aging and Qualification Research on Solenoid Operated Valves
Reviewed by: Jerry Edson, INEL

Effect of Aging on Component Function	Contrib to Failure	Reported progs	Rel.progs	Report Recommendations	Page No.	Item
Not stated	Not stated	Not discussed in report	10 CFR 50.49 if EQ'd, plant specific programs	Not stated	9	5
Water enters during MSLB/LOCA conditions. Failure to operate	Frequent	Not discussed in report	10 CFR 50.49 if EQ'd, plant specific programs	Not stated	6-7, 11, 20-28, 41-48, 75-78	6
Not stated	Frequent	Not discussed in report	10 CFR 50.49 if EQ'd, plant specific programs	Not stated	6-7, 11, 20-28, 41-48, 75-78	7
O-rings adhered to the guide tube - caused sticking and failure to transfer	Frequent	Not discussed in report	10 CFR 50.49 if EQ'd, plant specific programs	Not stated	6-7, 11, 20-28, 41-48, 73-78	8
O-rings adhered to seat - caused sticking and failure to transfer	Frequent	Not discussed in report	10 CFR 50.49 if EQ'd, plant specific programs	Not stated	6-7, 11, 20-28, 41-48, 73-78	9
Not stated	Not stated	Not discussed in report	10 CFR 50.49 if EQ'd, plant specific programs	Not stated	11	10

Document: NUREG/CR-5181, Nuclear Plant Aging Research: The 1E Power System
Reviewed by: Jerry Edson, INEL

Effect of Aging on Component Function	Contrib to Failure	Reported progs	Rel.progs	Report Recommendations	Page No.	Item
	Not stated	RG 1.118, IEEE-338, IEEE,943	RG 1.108, 1.118, 1.129; IEEE 338, 387, 450	Eval. surveillance & monitoring practices. Determine which components contribute most to system unavailability [4]	49, 51, 54, 71	1
	Not stated	Representative plant	Vendor specific programs	Industry continue developing monitoring techniques. Transf. and surge suppressor aging studies should be performed [4]	66, 70	2
Reduction in dielectric strength resulting in internal shorts and winding failures	Not stated	Not discussed in report	Vendor specific programs	Not stated	20, 21, 22	3
Vibration and excessive temperature cause the magnetic core circuit to become deformed and loosen and can result in failure of the windings	Not stated	Not discussed in report	Vendor specific programs	Not stated	20, 21, 22	4
Winding-to-winding short circuit, winding-to-case short circuit	Not stated	Not discussed in report	Vendor specific programs	Not stated	20, 21, 22	5
Leakage, moisture instrusion resulting in degradation of the insulating oil	Not stated	Not discussed in report	Vendor specific programs	Not stated	21, 22	6
Reduction in dielectric strength resulting in internal shorts and winding failures	Not stated	Not discussed in report	Vendor specific programs	Not stated	21, 22	7
Deformation and loosening of the magnetic core resulting in winding failures	Not stated	Not discussed in report	Vendor specific programs	Not stated	21, 22	8
Winding-to-winding short circuit, winding-to-case short circuits	Not stated	Not discussed in report	Vendor specific programs	Not stated	21, 22	9
Moisuture intrusion and leakage of the gas coolant/insulation resulting in failure of the winding insulation	Not stated	Not discussed in report	Vendor specific programs	Not stated	21, 22	10

Document: NUREG/CR-5181, Nuclear Plant Aging Research: The 1E Power System
Reviewed by: Jerry Edson, INEL

Item	System	Structure/Comp	Subcomponent	Materials	Manufacturer	ARD mechanism	ARD effects
11	1E Power	Cable	Insulation	XLPE, EPR, silicon or butyl rubber, Kapton, PE, PVC, teflon, CSP	Not stated	ELETEMP, RAD, MOIST-EL, AGRCHEM	Embrittlement of insulation, treeing
12	1E Power	Cable	Jacket	CSP	Not stated	ELETEMP, RAD, MOIST-EL, AGRCHEM	Embrittlement of insulation
13	1E Power	Connections and Terminations	Not stated	Not stated	Not stated	FAT	Cracking
14	1E Power	Electrical Cable	Cable Clamp	Stainless steel	Not stated	Not stated	Not stated
15	1E Power	Electrical Cable	Terminal Strip Assembly	Glass filled phenolic	Not stated	Not stated	Not stated
16	1E Power	Electrical Cable	Shrink Tubing	Polyolefin	Not stated	Not stated	Not stated
17	1E Power	Electrical Cable	Plug Sleeve and Coupling Ring	Bronze	Not stated	Not stated	Not stated
18	1E Power	Electrical Cable	O-Ring Seal	Elastomer	Not stated	Not stated	Not stated
19	1E Power	Electrical Cable	Contact Socket	Copper	Not stated	Not stated	Not stated
20	1E Power	Electrical Cable	Interfacial Seal	Dow Corning Sylgard	Not stated	Not stated	Cracking
21	1E Power	Electrical Cable	Insulator, Plug Skirt	Polysulfone	Not stated	Not stated	Cracking
22	1E Power	Electrical Cable	Washer	Stainless steel	Not stated	Not stated	Not stated
23	1E Power	Electrical Cable	Module Assembly	Brass	Not stated	Not stated	Not stated
24	1E Power	Circuit Breaker	Insulation	Polyester, glassfiber-filled epoxy resins, phenolic	Not stated	ELETEMP	Reduced insulation value
25	1E Power	Circuit Breaker	Contacts	Silver alloy in copper base	Not stated	CURSTR, VOLSTR	Poor electrical contact
26	1E Power	Circuit Breaker	Arc Chutes	Not stated	Not stated	ELETEMP	Structural damage to the arc chutes
27	1E Power	Circuit Breaker	Overload Mechanism	Not stated	Not stated	ELETEMP	Reduced overload rating
28	1E Power	Circuit Breaker	Connections	Not stated	Not stated	VIBR	Loose connections
29	1E Power	Circuit Breaker	Lubricant	Not stated	Not stated	ELETEMP, AGRCHEM, CONTAM	Hardening of the lubricant
30	1E Power	Circuit Breaker	Frame	Painted or electroplated steel	Not stated	Not stated	Not stated

Document: NUREG/CR-5181, Nuclear Plant Aging Research: The 1E Power System
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Effect of Aging on Component Function	Contrib to Failure	Reported progs	Rel.progs	Report Recommendations	Page No.	Item
Embrittlement results in cracking which permits moisture to enter and result in conductor-to-conductor and conductor-to-ground shorts. Treeing results in conductpr-to-conductor and conductor-to-ground shorts	Occasional	Not discussed in report	No specific program	Not stated	22, 23, 25, 41	11
Embrittlement results in cracking and moisture instrusion	Occasional	Not discussed in report	No specific program	Not stated	22, 23, 25, 41	12
Not stated	Not stated	Not discussed in report	Plant specific progarms	Not stated	23,24	13
Not stated	Not stated	RG 1.63, IEEE-317	10 CFR 50.49, Vendor specific programs	Not stated	22, 25, 49, 56	14
Not stated	Not stated	RG 1.63, IEEE-317	10 CFR 50.49, Vendor specific programs	Not stated	24, 25, 49, 56	15
Not stated	Not stated	RG 1.63, IEEE-317	10 CFR 50.49, Vendor specific programs	Not stated	24, 25, 49, 56	16
Not stated	Not stated	RG 1.63, IEEE-317	10 CFR 50.49, Vendor specific programs	Not stated	24, 25, 49, 56	17
Pressure leak	Not stated	RG 1.63, IEEE-317	10 CFR 50.49, Vendor specific programs	Not stated	24, 25, 49, 56	18
Not stated	Not stated	RG 1.63, IEEE-317	10 CFR 50.49, Vendor specific programs	Not stated	24, 25, 49, 56	19
Not stated	Not stated	RG 1.63, IEEE-317	10 CFR 50.49, Vendor specific programs	Not stated	24, 25, 49, 56	20
Not stated	Not stated	RG 1.63, IEEE-317	10 CFR 50.49, Vendor specific programs	Not stated	24, 25, 49, 56	21
Not stated	Not stated	RG 1.63, IEEE-317	10 CFR 50.49, Vendor specific programs	Not stated	24, 25, 49, 56	22
Not stated	Not stated	RG 1.63, IEEE-317	10 CFR 50.49, Vendor specific programs	Not stated	24, 25, 49, 56	23
Excessive temperature caused by poor contact, large currents, or elevated environment degrades the insulation resulting in shorts and arcing	Not stated	Not discussed in report	ANSI/IEEE 741-1986 Section 7, vendor specific	Not stated	25, 26, 27	24
Degraded/poor contacts result in degraded or open circuits	Not stated	Not discussed in report	ANSI/IEEE 741-1986 Section 7, vendor specific	Not stated	25, 26, 27	25
Flashover/arcing, failure to extinguish the arc	Not stated	Not discussed in report	ANSI/IEEE 741-1986 Section 7, vendor specific	Not stated	25, 26, 27	26
Premature trip at low current	Not stated	Not discussed in report	ANSI/IEEE 741-1986 Section 7, vendor specific	Not stated	25, 26, 27	27
Improper operation and open circuits	Not stated	Not discussed in report	ANSI/IEEE 741-1986 Section 7, vendor specific	Not stated	25, 26, 27	28
Improper operation, failure to open or close	Not stated	Not discussed in report	ANSI/IEEE 741-1986 Section 7, vendor specific	Not stated	25, 26, 27	29
Not stated	Not stated	Not discussed in report	ANSI/IEEE 741-1986 Section 7, vendor specific	Not stated	25, 26, 27	30

Document: NUREG/CR-5181, Nuclear Plant Aging Research: The 1E Power System
Reviewed by: Jerry Edson, INEL

Item	System	Structure/Comp	Subcomponent	Materials	Manufacturer	ARD mechanism	ARD effects
31	1E Power	Circuit Breaker	Housing, Doors	Painted sheet steel	Not stated	Not stated	Not stated
32	1E Power	Circuit Breaker	Mechanisms	Cast bronze and steel, stamped steel	Not stated	CORR, AGRCHEM, WEAR, VIBR, FAT, CONTAM	Reduced force, increased friction, embrittled mat.
33	1E Power	Relays	Coil Insulation	Not stated	Not stated	VOLSTR, ELETEMP	Reduced insulation value
34	1E Power	Relays	Moving Parts	Not stated	Not stated	WEAR, FAT	Increased friction, binding
35	1E Power	Relays	Contacts	Not stated	Not stated	WEAR, CORR, VIBR, CONTAM	Poor electrical contact
36	1E Power	Relays	Connections	Not stated	Not stated	VIBR, ELETEMP	Loose or poor electrical connections
37	1E Power	Relays	Coil Bobbin	Not stated	Not stated	ELETEMP	Accelerate aging
38	1E Power	Chargers and Inverters	Circuit Breaker	Not stated	Not stated	CONTAM, LOSLUB, WEAR, CORR/PIT	Increased friction, binding, loss of continuity
39	1E Power	Chargers and Inverters	Fuse	Not stated	Not stated	THERM-CY, FAT	Metal fatigue, melting of link
40	1E Power	Chargers and Inverters	Relay	Not stated	Not stated	CORR/PIT, CORR/OX	Loss of continuity
41	1E Power	Chargers and Inverters	Electrolytic Capacitors	Not stated	Not stated	ELETEMP, VIBR	Loss of electrolyte, failure of leads
42	1E Power	Chargers and Inverters	Oil Filled Capacitors	Not stated	Not stated	ELETEMP, VIBR	Dielectric breakdown, failure of leads
43	1E Power	Chargers and Inverters	Magnetics (Transformer, Inductor)	Not stated	Not stated	ELETEMP, LOW TEMP, VOLSTR, VIBR	Degraded insulation, cracked moisture seals, broken wires
44	1E Power	Chargers and Inverters	Silicon Controlled Rectifiers	Not stated	Not stated	ELETEMP	Over voltage or over current caused by transients
45	1E Power	Chargers and Inverters	Resistor	Not stated	Not stated	VIBR, ELETEMP	Decrease in resistance, lead fails
46	1E Power	Chargers and Inverters	Printed Circuit Boards	Not stated	Not stated	TEMP, THERM-CY, CORR, VIBR	Cracking of circuit lines, open circuits, loose connections

Table A.2 Gall Report for NPAR Reports

Document: NUREG/CR-5181, Nuclear Plant Aging Research: The 1E Power System
Reviewed by: Jerry Edson, INEL

Effect of Aging on Component Function	Contrib to Failure	Reported progs	Rel.progs	Report Recommendations	Page No.	Item
Not stated	Not stated	Not discussed in report	ANSI/IEEE 741-1986 Section 7, vendor specific	Not stated	25, 26, 27	31
Improper operation, failure to oper or close	Not stated	Not discussed in report	ANSI/IEEE 741-1986 Section 7, vendor specific	Not stated	25, 26, 27	32
Excessive temperture from ohmic heating or the environment causes insulation failure and results in failure of the relay to operate	Not stated	Not discussed in report	RG 1.118, IEEE 338-1987	Not stated	25, 26, 27, 28	33
Misopertion, failure to operte, slow or sluggish operation, inadvertant contact closure	Not stated	Not discussed in report	RG 1.118, IEEE 338-1987	Not stated	25, 26, 27, 28	34
Open circuit, failure to close, arcing, increased temperature due to ohmic heating	Not stated	Not discussed in report	RG 1.118, IEEE 338-1987	Not stated	25, 26, 27, 28	35
Open circuit, heating at the socket/pin interface	Not stated	Not discussed in report	RG 1.118, IEEE 338-1987	Not stated	25, 26, 27, 28	36
Coil failure	Not stated	Not discussed in report	RG 1.118, IEEE 338-1987	Not stated	25, 26, 27, 28	37
Failure to operate, failure to open	Occasional	IEEE-446, NEMA PE5, IEC 146-2, ANSI/IEEE-944	IEEE 446, NEMA PE5, IEC 146-2, ANSI/IEEE 944,	Not stated	29-36, 55, 60-64	38
Fails open (opens prematurely)	Occasional	IEEE-446, NEMA PE5, IEC 146-2, ANSI/IEEE-944	IEEE 446, NEMA PE5, IEC 146-2, ANSI/IEEE 944,	Not stated	29-36, 55, 60-64	39
Open circuit or coil, contacts open	Occasional	IEEE-446, NEMA PE5, IEC 146-2, ANSI/IEEE-944	IEEE 446, NEMA PE5, IEC 146-2, ANSI/IEEE 944,	Not stated	29-36, 55, 60-64	40
Loss of capacitance or open circuit causes the charger/inverter to have improper output	Frequent	IEEE-446, NEMA PE5, IEC 146-2, ANSI/IEEE-944	IEEE 446, NEMA PE5, IEC 146-2, ANSI/IEEE 944,	Not stated	29-36, 55, 60-64	41
Loss of capacitance or open circuit causes the charger/inverter to have improper output	Frequent	IEEE-446, NEMA PE5, IEC 146-2, ANSI/IEEE-944	IEEE 446, NEMA PE5, IEC 146-2, ANSI/IEEE 944,	Not stated	29-36, 55, 60-64	42
Failure of device due to short circuit (turn-to-turn or turn-to-ground) or change in inductance	Occasional	IEEE-446, NEMA PE5, IEC 146-2, ANSI/IEEE-944	IEEE 446, NEMA PE5, IEC 146-2, ANSI/IEEE 944,	Not stated	29-36, 55, 60-64	43
Failure of device due to open or short circuits	Occasional	IEEE-446, NEMA PE5, IEC 146-2, ANSI/IEEE-944	IEEE 446, NEMA PE5, IEC 146-2, ANSI/IEEE 944,	Not stated	29-36, 55, 60-64	44
Failure of device due to open circuit or change in value of resistor	Rare	IEEE-446, NEMA PE5, IEC 146-2, ANSI/IEEE-944	IEEE 446, NEMA PE5, IEC 146-2, ANSI/IEEE 944,	Not stated	29-36, 55, 60-64	45
Output changes from desired value	Frequent	IEEE-446, NEMA PE5, IEC 146-2, ANSI/IEEE-944	IEEE 446, NEMA PE5, IEC 146-2, ANSI/IEEE 944,	Not stated	29-36, 55, 60-64	46

Document: NUREG/CR-5181, Nuclear Plant Aging Research: The 1E Power System
Reviewed by: Jerry Edson, INEL

Item	System	Structure/Comp	Subcomponent	Materials	Manufacturer	ARD mechanism	ARD effects
47	1E Power	Chargers and Inverters	Surge Suppressor	Not stated	Not stated	VOLSTR, CURSTR	Semiconductor breakdown
48	1E Power	Chargers and Inverters	Connections	Not stated	Not stated	MECHSTR	Fatigue failure of wire at terminals
49	1E Power	Chargers and Inverters	Meters	Not stated	Not stated	CONTAM	Increase in bearing friction
50	1E Power	Chargers and Inverters	Switch	Not stated	Not stated	CORR, CORR/PIT	Loss of continuity across contacts
51	1E Power	Chargers and Inverters	Potentiometer	Not stated	Not stated	ELETEMP	Loss of continuity
52	1E Power	Batteries	Grids/Plates	Lead-calcium alloy	Not stated	OVERCHG, ELETEMP, CONTAM	Accelerates corrosion and oxidation
53	1E Power	Batteries	Active Material	Lead dioxide and lead sulfate	Not stated	GAS	Dislodges active material
54	1E Power	Batteries	Separator	Rubber/glass matt	Not stated	ELETEMP	Accelerates deterioration of electrical insulation
55	1E Power	Batteries	Electrolyte	Sulfuric acid and water	Not stated	CONTAM	Hydrolysis of the water and loss of electrolyte
56	1E Power	Batteries	Vent	Fused alumina	Not stated	MECHSTR	Vent breaks allowing contamination to enter
57	1E Power	Batteries	Top Connectors	Lead-calcium alloy	Not stated	ELETEMP, CORR, EMBR	Low electrolyte level causes corrosion and embrittlement
58	1E Power	Batteries	Terminals	Lead-calcium alloy	Not stated	CORR/OX, CORR	Poor electrical contact with external busses
59	1E Power	Batteries	Container and Top Cover	Polycarbonate, styrene acryolonitrile, acrylo-butadiene styrene	Not stated	MECHSTR, CORR/OX	Oxidation of lead causes plate growth

Document: NUREG/CR-5192, Testing of A Naturally Aged Nuclear Power Plant Inverter and Battery Charger
Reviewed by: L. C. Meyer, INEL

Item	System	Structure/Comp	Subcomponent	Materials	Manufacturer	ARD mechanism	ARD effects
1		Inverter	Resistors	Carbon conposition	Not stated	ELETEMP & MOIST	Ohms decrease - temperature, & ohms increase - moisture
2		Inverter	Wire	Not stated	Not stated	Not stated	Turns contact

Table A.2 Gall Report for NPAR Reports

Document: NUREG/CR-5181, Nuclear Plant Aging Research: The 1E Power System
Reviewed by: Jerry Edson, INEL

Effect of Aging on Component Function	Contrib to Failure	Reported progs	Rel.progs	Report Recommendations	Page No.	Item
Semiconductor breakdown due to overheating causes short circuits and improper output	Rare	IEEE-446, NEMA PE5, IEC 146-2, ANSI/IEEE-944	IEEE 446, NEMA PE5, IEC 146-2, ANSI/IEEE 944,	Not stated	29-36, 55, 60-64	47
Improper output due to open or short circuits	Occasional	IEEE-446, NEMA PE5, IEC 146-2, ANSI/IEEE-944	IEEE 446, NEMA PE5, IEC 146-2, ANSI/IEEE 944,	Not stated	29-36, 55, 60-64	48
Improper indication	Occasional	IEEE-446, NEMA PE5, IEC 146-2, ANSI/IEEE-944	IEEE 446, NEMA PE5, IEC 146-2, ANSI/IEEE 944	Not stated	29-36, 55, 60-64	49
Improper output due to switch failing open or closed	Occasional	IEEE-446, NEMA PE5, IEC 146-2, ANSI/IEEE-944	IEEE 446, NEMA PE5, IEC 146-2, ANSI/IEEE 944	Not stated	29-36, 55, 60-64	50
Improper output due to open or short circuit	Occasional	IEEE-446, NEMA PE5, IEC 146-2, ANSI/IEEE-944	IEEE 446, NEMA PE5, IEC 146-2, ANSI/IEEE 944	Not stated	29-36, 55, 60-64	51
Corrosion/oxidation causes plate growth resulting in reduced capacity and stresses the container	Frequent	RG 1.129, IEEE-450	RG 1.129, IEEE 450-1987, Tech Spec Surveil.	Not stated	30, 31, 36, 37, 38, 50, 54, 62-65	52
Dislodging active material from the plates causes loss of capacity	Not stated	RG 1.129, IEEE-450	RG 1.129, IEEE 450-1987, Tech Spec Surveil.	Not stated	30, 31, 36, 37, 38, 50, 54, 62-65	53
Loss of electrical insulation between plates causes short circuits and loss of capacity	Not stated	RG 1.129, IEEE-450	RG 1.129, IEEE 450-1987, Tech Spec Surveil.	Not stated	30, 31, 36, 37, 38, 50, 54, 62-65	54
Loss of electrolyte results in loss of capacity	Not stated	RG 1.129, IEEE-450	RG 1.129, IEEE 450-1987, Tech Spec Surveil.	Not stated	30, 31, 36, 37, 38, 50, 54, 62-65	55
Contaminates in the electrolyte result in reduced capacity	Not stated	RG 1.129, IEEE-450	RG 1.129, IEEE 450-1987, Tech Spec Surveil.	Not stated	30, 31, 36, 37, 38, 50, 54, 62-65	56
Embrittled top conductors are susceptible to breaking and causes loss of capacity	Frequent	RG 1.129, IEEE-450	RG 1.129, IEEE 450-1987, Tech Spec Surveil.	Not stated	30, 31, 36, 37, 38, 50, 54, 62-65	57
Poor electrical contact results in loss of capacity and may result in total battery failure	Not stated	RG 1.129, IEEE-450	RG 1.129, IEEE 450-1987, Tech Spec Surveil.	Not stated	30, 31, 36, 37, 38, 50, 54, 62-65	58
Plate growth and handling stresses results in cracked containers which allow electrolyte to escape resulting in reduced capacity or total failure	Frequent	RG 1.129, IEEE-450	RG 1.129, IEEE 450-1987, Tech Spec Surveil.	Not stated	30, 31, 36, 37, 38, 50, 54, 62-65	59

Document: NUREG/CR-5192, Testing of A Naturally Aged Nuclear Power Plant Inverter and Battery Charger
Reviewed by: L. C. Meyer, INEL

Effect of Aging on Component Function	Contrib to Failure	Reported progs	Rel.progs	Report Recommendations	Page No.	Item
Resistance change causes improper output.	Not stated	Not discussed in report	Vendor specific, Tech. Spec., IEEE 446, NEMA	Individual fusing of filter capacitors to preclude a capacitor failure in the short circuit mode [2]	3-23	1
When turns of wire in resisor make contact it decreases total resistance of resistor resulting in improper output.	Not stated	Not discussed in report	Vendor specific, Tech. Spec., IEEE 446, NEMA	Not stated	3-23	2

Document: NUREG/CR-5192, Testing of A Naturally Aged Nuclear Power Plant Inverter and Battery Charger
Reviewed by: L. C. Meyer, INEL

Item	System	Structure/Comp	Subcomponent	Materials	Manufacturer	ARD mechanism	ARD effects
3		Inverter	Electrolytic Capacitors	Not stated	Not stated	Not stated	Capacitance decreases with age
4		Inverter	Ceramic Capacitor	Not stated	Not stated	Not stated	Unstable capacitance value
5		Inverter	Silicon Controlled Rectifiers	Silicon	Not stated	ELETEMP	Deterioration of the thermal joint compound
6		Inverter	Various Electrical Components	Not stated	Not stated	Not stated	No aging effects noted for 12 year old equipment
7		Battery	Various Electrical Components	Not stated	Not stated	Not stated	No aging effects noted for 12 year old equipment

Document: NUREG/CR-5280 V1, Age-Related Degradation of Westinghouse 480-Volt Circuit Breakers
Reviewed by: L. C. Meyer, INEL

Item	System	Structure/Comp	Subcomponent	Materials	Manufacturer	ARD mechanism	ARD effects
1		DS-206/DS-416 Circuit Breakers	Power Operated Mechanisms	Spring steel	Westinghouse	WEAR, LOSLUB, CORR/UA	Wear out, loss of material, friction, & corr product buildup
2		DS-206/DS-416 Circuit Breakers	Contacts	Contacts mounted on high strenght insulating base and steel arm	Westinghouse	WEAR, CURSTR, & CORR/UA	Wear from operation, pitting, & erosion from arcs
3		DS-206/DS-416 Circuit Breakers	Arc Chutes	Steel and arc resisting plastic plates	Westinghouse	WEAR, & CURSTR	Erosion & burned splitter plates
4		DS-206/DS-416 Circuit Breakers	Amptector Trip Unit (Electronic Components)	Not stated	Westinghouse	VIB, CURSTR, & VOLSTR	Loose parts, component burn out or degraded operation
5		DS-206/DS-416 Circuit Breakers	Current Magnitude and Direction Sensors	Current transformers	Westinghouse	CURSTR, & VOLSTR	Dielectric properties degraded from electrical stresses
6		DS-206/DS-416 Circuit Breakers	Optional Accessories	Electro-mechanical devices, switch, and solid state device	Westinghouse	VIB, CURSTR, & VOLSTR	Not stated
7		DS-206/DS-416 Circuit Breakers	Electrical and Mechanical Components in General	Not stated	Westinghouse	VIB, CURSTR, VOLSTR, LOSLUB, & WEAR	Coil burnings, binding of linkage, wear, overheating, & dust

Document: NUREG/CR-5280 V2, Age-Related Degradation of Westinghouse 480-Volt Circuit Breakers (Mechanical Cycling)
Reviewed by: L. C. Meyer, INEL

Item	System	Structure/Comp	Subcomponent	Materials	Manufacturer	ARD mechanism	ARD effects
1		DS-416 Breaker/480 V	Structural Components	Steel	Westinghouse	VIB & CORR	Vibration will loosen parts, corrosion degrades metals
2		DS-416 Breaker/480 V	Contact Assembly	Insulating material and stainless steel	Westinghouse	WEAR & CURSTR	Wear & loss of material from arcing.

Document: NUREG/CR-5192, Testing of A Naturally Aged Nuclear Power Plant Inverter and Battery Charger
Reviewed by: L. C. Meyer, INEL

Effect of Aging on Component Function	Contrib to Failure	Reported progs	Rel.progs	Report Recommendations	Page No.	Item
Distortion of signals to SCRs may result in improper putput.	Not stated	Not discussed in report	Vendor specific, Tech. Spec., IEEE 446, NEMA	Not stated	3-23	3
Not stated	Not stated	Not discussed in report	Vendor specific, Tech. Spec., IEEE 446, NEMA	Not stated	3-23	4
Over heating of SCRs may result in SCR failure and loss of output.	Not stated	Not discussed in report	Vendor specific, Tech. Spec., IEEE 446, NEMA	Not stated	4-1	5
None	Not stated	Not discussed in report	Vendor specific, Tech. Spec., IEEE 446, NEMA	Not stated	4-3	6
None.	Not stated	Not discussed in report	Vendor specific progarm, Tech. Spec. Surveil.	Not stated	3-1, 4-1, & 4-3	7

Document: NUREG/CR-5280 V1, Age-Related Degradation of Westinghouse 480-Volt Circuit Breakers
Reviewed by: L. C. Meyer, INEL

Effect of Aging on Component Function	Contrib to Failure	Reported progs	Rel.progs	Report Recommendations	Page No.	Item
Excessive force or rubbing causes distortion & wear out, rust on pivotal parts & trip gears can cause hang up, hardened or improper lubricants or lubricant application can cause sluggish operation.	Occasional	Not discussed in report	Vendor specific , IEEE 741-1986 Section 7	Twelve recommendations given relating to three separate issues covering reliability, pole shaft welds, and maintenance. [2]	2-7, 6-2, & 7-4	1
Contacts wear from repeated operations, arcing causes pitting, contacts become mottled, dirty, and eroded due to arc burning. Contacts over heat from resistance due to weak springs.	Occasional	Maintenance per owner's group MPM WORGTSDS416	Vendor specific , IEEE 741-1986 Section 7	Filing or dressing with abrasive cloth is not recommended [2]	2-9, 6-2, & 7-6	2
Slots in arc chute gradually erode with arc interruptions, fault currents cause heavy erosion, and throat of the arc chute enclosure becomes burned and coated with soot from arc interruptions.	Frequent	Maintenance per owner's group MPM WORGTSDS416	Vendor specific , IEEE 741-1986 Section 7	Life of the DS-16 breaker should be 5000 cycles or 20 years. [2]	2-9, 6-3, & 7-6	3
Vibration may loosen parts, voltage and current stress may cause part burn out or insulation damage. Electrical stress reduces dielectric properties	Occasional	Maintenance per owner's group MPM WORGTSDS416	Vendor specific , IEEE 741-1986 Section 7	Life of the DS-16 breaker should be 5000 cycles or 20 years. [2]	2-9, 6-3, & 7-6	4
Not stated	Not stated	Maintenance per owner's group MPM WORGTSDS416	Vendor specific , IEEE 741-1986 Section 7	Not stated	2-12	5
Not stated	Not stated	Maintenance per owner's group MPM WORGTSDS416	Vendor specific , IEEE 741-1986 Section 7	Not stated	2-12 & 2-13	6
Most breaker problems result from control problems involving contacts, coil burnings, and trip device bindings, followed by operating mechanism problems. Loss of lubrication, erosion of contacts, burning of arc chutes, & loss of adjustment are from aging	Occasional	Owner's group recommended maintenance	Vendor specific , IEEE 741-1986 Section 7	Twelve recommendations given related to reliability, weld failures, and maintenance [2]	2-1, 7-1, & 7-4.	7

Document: NUREG/CR-5280 V2, Age-Related Degradation of Westinghouse 480-Volt Circuit Breakers (Mechanical Cycling)
Reviewed by: L. C. Meyer, INEL

Effect of Aging on Component Function	Contrib to Failure	Reported progs	Rel.progs	Report Recommendations	Page No.	Item
Failure to operate	Rare	Not discussed in report	Vendor specific , IEEE 741-1986 Section 7	Not stated	3-2 & 6-2	1
Unreliable contact	Not stated	Not discussed in report	Vendor specific , IEEE 741-1986 Section 7	Not stated	3-2 & 6-2	2

Document: NUREG/CR-5280 V2, Age-Related Degradation of Westinghouse 480-Volt Circuit Breakers (Mechanical Cycling)
Reviewed by: L. C. Meyer, INEL

Item	System	Structure/Comp	Subcomponent	Materials	Manufacturer	ARD mechanism	ARD effects
3		DS-416 Breaker/480 V	Power Operated Mechanism	Steel	Westinghouse	WEAR, FAT, & EX FORCE	Wear, fracture, and distortion.
4		DS-416 Breaker/480 V	Pole Shaft	Steel	Westinghouse	FAT. & EX FORCE	Cracking, misalignment, & binding due to poor welds
5		DS-416 Breaker/480 V	Charging System (Rachet, Motor, Brushes, Oscillator., Spring)	Steel, carbon brush in motor, insulation varnish on motor windings	Westinghouse	WEAR, FAT, & CURSTR	Wear on moving parts & electric motor burn out
6		DS-416 Breaker/480 V	Electrical Coils (UVTA, STA, AND Closing Coil)	Not stated	Westinghouse	CURSTR	Extended duration of current flow caused burn out
7		DS-416 Breaker/480 V	Sensors, Amptector Trip Unit, & Arc Chutes	Not stated	Westinghouse	Not stated	Extended energization of coils.

Document: NUREG/CR-5334, Severe Accident Testing of Electrical Penetration Assemblies
Reviewed by: L. C. Meyer, INEL

Item	System	Structure/Comp	Subcomponent	Materials	Manufacturer	ARD mechanism	ARD effects
1		D. G. O'Brien Electrical Penetration	SEALS	Silicon O-ring	D. G. O'Brien	ELETEMP, MOIST-EL, AND RAD	Seal cracks and moisture intrusion.
2		D. G. O'Brien Electrical Penetration	Electrical Components (Wire, Insulation, and Connectors)	Not stated	Not stated	ELETEMP. MOIST-EL, AND RAD	Moisture or contaminants caused electrical shorts to ground
3		Westinghouse Electrical Penetration	Seals	Silcion O-ring	Westinghouse	ELETEMP, MOIST-EL, AND RAD	Seal cracks and moisture intrusion
4		Westinghouse Electrical Penetration	Electrical Components (Wire, Insulation, and Connectors)	Not stated	Westinghouse	ELETEMP, MOIST-EL, AND RAD	Insulation degradation
5		CONAX Electrical Penetration	Seals	Viton O-rings	Conax	ELETEMP, MOIST-EL, AND RAD	Seal cracks and moisture intrusion
6		CONAX Electrical Penetration	Electrical Components (Wire, Insulation, and Connectors)	Not stated	Conax	THERM, MOIST-EL, AND RAD	Embrittlement and cracking

Document: NUREG/CR-5383, Effect of Aging on Response Time of Nuclear Plant Pressure Sensors
Reviewed by: E. W. Roberts, INEL

Item	System	Structure/Comp	Subcomponent	Materials	Manufacturer	ARD mechanism	ARD effects
1		Pressure Transmitter	Diaphragm	Not stated	Not stated	VIBR FAT PRESS	Deformation, cracking, and hysteresis of diaphragm
2		Pressure Transmitter	Mechanical Linkages	Not stated	Not stated	PRESS CORR CORR/OX	Changes in system restoration ability
3		Pressure Transmitter Electronics	Seals	Not stated	Not stated	EMBR	Moisture on electronics

Document: NUREG/CR-5280 V2, Age-Related Degradation of Westinghouse 480-Volt Circuit Breakers (Mechanical Cycling)
Reviewed by: L. C. Meyer, INEL

Effect of Aging on Component Function	Contrib to Failure	Reported progs	Rel.progs	Report Recommendations	Page No.	Item
Aging degradation in parts between the motor and the poles redistributes the force transmitted from the charging motor causing large unbalanced stresses in subcomponents & wear	Occasional	Not discussed in report	Vendor specific, IEEE 741-1986 Section 7	Monthly inspection and every 50 to 100 cycles inspect parts vulnerable to aging, maintenance & lubrication at 250 cycles [2]	6-2 & 6-5	3
Once cracks grow to a quarter the size of an effective weld the five levers connecting the pole contacts become misaligned and caused excesssive movement leading to fracture, binding and other problems.	Not stated	Not discussed in report	Vendor specific, IEEE 741-1986 Section 7	Monthly inspection and every 50 to 100 cycles inspect parts vulnerable to aging, maintenance & lubrication at 250 cycles [2]	6-2 & 6-5	4
Wear of ratchet wheel, holding pauls, motor crank, and handle dominated the aging of the charging system. Carbon brushes needed frequent maintenance.	Not stated	Not discussed in report	Vendor specific, IEEE 741-1986 Section 7	Assure design adequacy by inspection, enhanced inspections and maintenance & install cycle counter. [2]	6-2, 6-4	5
Sluggish operation, binding, failure to operate.	Freq when mechanism binding	Not discussed in report	Vendor specific, IEEE 741-1986 Section 7	Assure design adequacy by inspection, enhanced inspections and maintenance & install cycle counter. [2]	4-18	6
Not stated	Not stated	Not discussed in report	Vendor specific, IEEE 741-1986 Section 7	Not stated	3-2	7

Document: NUREG/CR-5334, Severe Accident Testing of Electrical Penetration Assemblies
Reviewed by: L. C. Meyer, INEL

Effect of Aging on Component Function	Contrib to Failure	Reported progs	Rel.progs	Report Recommendations	Page No.	Item
Cracks in the seals from high temperature and radiation allows moisture to leak into penetration resulting in electrical faults.	Rare	IEEE 317-1976 AND IEEE 323-1974 DESIGN STD	10 CFR 50.49, vendor specific	Each design should be tested. The leak potential is highly dependent on the temperatures to which the EPA is subject. [2]	4-1, 4-16, and 7-1	1
Short to ground and electrical faults due to moisture intrusion.	Not stated	IEEE 317-1976 AND IEEE 323-1974 DESIGN STD	10 CFR 50.49, vendor specific	Not stated	C-1, 4-16, and 7-1	2
Seal cracks allow moisture intrusion into penetration resulting in electrical faults.	Rare	IEEE 317-1976 AND IEEE 323-1974 DESIGN STD	10 CFR 50.49, vendor specific	Each design should be tested. The leak potential is highly dependent on the temperatures to which the EPA is subject. [2]	1-3, 5-1, 5-15, and 7-1	3
Decreased insulation resistance results in excessive leakage currents.	Rare	IEEE 317-1976 AND IEEE 323-1974 DESIGN STD	10 CFR 50.49, vendor specific	Not stated	4-1, 4-16, and 7-1	4
Seal cracks allow moisture intrusion resulting in electrical faults.	Rare	IEEE 317-1976 AND IEEE 323-1974 DESIGN STD	10 CFR 50.49, vendor specific	Each design should be tested. The leak potential is highly dependent on the temperatures to which the EPA is subject. [2]	6-1, 6-13, and 7-1	5
Electrical faults due to moisture intrusion through connectors.	Occasional	IEEE 317-1976 AND IEEE 323-1974 DESIGN STD	10 CFR 50.49, vendor specific	Look at types of cables and connectors rather than penetration design to improve future electrical penetrations. [2]	6-1, 6-13, and 7-1	6

Document: NUREG/CR-5383, Effect of Aging on Response Time of Nuclear Plant Pressure Sensors
Reviewed by: E. W. Roberts, INEL

Effect of Aging on Component Function	Contrib to Failure	Reported progs	Rel.progs	Report Recommendations	Page No.	Item
Response time degradation for pressure transmitter	Not stated	RG 1.118, IEEE 338, & ISA Standard 67.06	RG 1.118, IEEE 338, Tech Spec surveillance	Revise RG and standards to take into account recent advances in testing technology and other available information. [2]	23, 115	1
Response time degradation for pressure transmitter	Not stated	RG 1.118, IEEE 338, & ISA Standard 67.06	RG 1.118, IEEE 338, Tech Spec surveillance	Revise RG and standards to take into account recent advances in testing technology and other available information. [2]	23, 115	2
Response time degradation for pressure transmitter	Not stated	RG 1.118, IEEE 338, & ISA Standard 67.06	RG 1.118, IEEE 338, 10 CFR 50.49, Tech Specs	Revise RG and standards to take into account recent advances in testing technology and other available information. [2]	23, 115	3

Document: NUREG/CR-5383, Effect of Aging on Response Time of Nuclear Plant Pressure Sensors
Reviewed by: E. W. Roberts, INEL

Item	System	Structure/Comp	Subcomponent	Materials	Manufacturer	ARD mechanism	ARD effects
4		Pressure Transmitter Electronics	Electronic Components	Not stated	Not stated	ELETEMP RAD MOIST-EL	Changes in value of electronic components

Document: NUREG/CR-5448, AGING EVALUATION OF CLASS 1E BATTERIES: SEISMIC TESTING
Reviewed by: E. W. Roberts, INEL

Item	System	Structure/Comp	Subcomponent	Materials	Manufacturer	ARD mechanism	ARD effects
1			Batteries	Not stated	Not stated	SEISMIC	Plate movement or breakup

Document: NUREG/CR-5461, Aging of Cables, Connections, and Electrical Penetration Assemblies Used in Nuclear Power Plants
Reviewed by: L. C. Meyer, INEL

Item	System	Structure/Comp	Subcomponent	Materials	Manufacturer	ARD mechanism	ARD effects
1		Cable	Insulation	EPR, CSPE, EPDM, XLPE, silicon rubber, butyl rubber, polyethylene, and 13 others used less often	Ten manufactures listed	MOIST-EL, ELETEMP, AND RAD	Insulation degradation, short and open circuits
2		Cable	Jacket	Neoprene, hypalon, XLPO, CSPE, & CPE,	Ten manufactures listed	MOIST-EL, ELETEMP, AND RAD	Jacket degradation, cracks, and discoloration
3		Connections	Terminal Blocks	Phenolic with glass or cellulose filler with metal terminals	Seven listed	ELETEMP, RAD, & VIB	Loose connections, cracks and short circuits
4		Connections	Splices	Crimp type ring lugs, copper conductor, nylon or kynar insulation, and Raychem heat shrink tubing	Raychem	ELETEMP, VIB, AND RAD	Loose connections and loss of dielectric isolation
5		Connections	Coax Connectors	Metal with organic insulation such as teflon	Not stated	ELETEMP AND RAD	Insulation degradation
6		Electrical Penetrations	Seal Material	Steel tubes, seal materials are polysulfone, metal-glass, and epoxy	Conax, O'Brien, and Westinghouse	ELTEMP & RAD	Seal leaks and cracking
7		Electrical Penetrations	Electrical Wire or Cable	Insulations (XLPE, EPR, EPDM & Polymide) and jacket(CSPE, SPE, Hypalon, FR, and fiberglass)	Ten manufacturers listed	ELETEMP AND RAD	Change in dieletric properties, embrittlement, and cracking

Document: NUREG/CR-5546, An Investigation of The Effects of Thermal Aging on the Fire Damageability of Electric Cables
Reviewed by: L. C. Meyer, INEL

Item	System	Structure/Comp	Subcomponent	Materials	Manufacturer	ARD mechanism	ARD effects
1		Electrical Cables	Insulation	XPE, and interstitial material (Nylon & paper)	Rockbestos	ELETEMP	Not stated
2		Electrical Cables	Jacket	Neoprene	Rockbestos	ELETEMP	Embrittlement and cracking
3		Electrical Cables	Insulation	EPR, and interstitial material (Nylon & paper)	Boston Insulated Wire	ELETEMP	Not stated
4		Electrical Cables	Jacket	Hypalon	Boston Insulated Wire	ELETEMP	Embrittlement, dielectric loss and forms cracks

Document: NUREG/CR-5383, Effect of Aging on Response Time of Nuclear Plant Pressure Sensors
Reviewed by: E. W. Roberts, INEL

Effect of Aging on Component Function	Contrib to Failure	Reported progs	Rel.progs	Report Recommendations	Page No.	Item
Response time degradation for pressure transmitter	Not stated	RG 1.118, IEEE 338, & ISA Standard 67.06	RG 1.118, IEEE 338, Tech Spec surveillance	Revise RG and standards to take into account recent advances in testing technology and other available information. [2]	23, 115	4

Document: NUREG/CR-5448, AGING EVALUATION OF CLASS 1E BATTERIES: SEISMIC TESTING
Reviewed by: E. W. Roberts, INEL

Effect of Aging on Component Function	Contrib to Failure	Reported progs	Rel.progs	Report Recommendations	Page No.	Item
No effect on bat capability if maintained to IEEE Std 450, RG 1.1.29 and MFG recommendations	Not stated	IEEE STD 450, RG 1.129, & Mfg recommendations	RG 1.129, IEEE 450-1987, Tech Spec Surveil.	Batteries not maintained per IEEE 450, RG1.129, & MFG rec. need adv.monitoring tech. to determine seismic capability. [2]	35	1

Document: NUREG/CR-5461, Aging of Cables, Connections, and Electrical Penetration Assemblies Used in Nuclear Power Plants
Reviewed by: L. C. Meyer, INEL

Effect of Aging on Component Function	Contrib to Failure	Reported progs	Rel.progs	Report Recommendations	Page No.	Item
Thermal and radiation effects cause insulation degradation leading to cracking which allows moisture to intrude and then shorts or current leakage results. Jacket/insulation interaction effect was also noted.	Not stated	EQDB, IEEE 323-1974 & IEEE 383-1974 testing	No specific program	Not stated	8, 24, & 40	1
Thermal and radiation effects cause jacket material degradation leading to cracking which allows moisture to intrude into the insulation, jacket/insulation interaction effect was also noted in the sandia report.	Not stated	EQDB, IEEE 323-1974 & IEEE 383-1974 testing	No specific program	Not stated	8, 24, & 40	2
Loss of dielectric isolation or loose connections to disrupt a circuit, leakage paths through moisture films, and insulation resistance decrease in presents of steam.	Not stated	Not discussed in report	Plant specific programs	Not stated	11, 27, & 41	3
Insulaton vulnerable to aging, loss of dielectric isolation sufficient to disrupt a circuit, or loose connections	Not stated	Not discussed in report	10 CFR 50.49	Not stated	11, 27, & 42	4
Decreased insulation resistance results in excesive leakage current.	Not stated	Not discussed in report	Plant specific programs	Not stated	27	5
Seal cracks and leaks result in moisture intrusion and electrical faults.	Not stated	Not discussed in report	10 CFR 50.49, vendor specific program	Not stated	14, 28, & 42	6
Insulation degradation and jacket cracking leading to short or open circuits and degraded signals.	Not stated	Not discussed in report	10 CFR 50.49, vendor specific program	Not stated	14, 28, & 42	7

Document: NUREG/CR-5546, An Investigation of The Effects of Thermal Aging on the Fire Damageability of Electric Cables
Reviewed by: L. C. Meyer, INEL

Effect of Aging on Component Function	Contrib to Failure	Reported progs	Rel.progs	Report Recommendations	Page No.	Item
None	Not stated	Not discussed in report	No specific program	Not stated	10, 13, and 32	1
Failure to protect conductors and insulation.	Not stated	Not discussed in report	No specific program	Not stated	21, 24, and 32	2
Reduced the thermal damage threshold.	Not stated	Not discussed in report	No specific program	Not stated	21, 24, and 32	3
Reduced thermal damage threshold.	Not stated	Not discussed in report	No specific program	Not stated	21, 24, and 32	4

Document: NUREG/CR-5560, Aging of Nuclear Plant Resistance Temperature Detectors
Reviewed by: L. C. Meyer, INEL

Item	System	Structure/Comp	Subcomponent	Materials	Manufacturer	ARD mechanism	ARD effects
1		Resistance Temperature Detector (RTD)	Seal	Not stated	Five Companies Listed	ELETEMP, MOIST-EL, VIB, & THERM-CY	Dry out, shrink, & crack
2		Resistance Temperature Detector (RTD)	Insulation	MgO	Five Companies Listed	MOIST-EL	Moisture degrades insulation
3		Resistance Temperature Detector (RTD)	Sensing Element	Platinum	Five Companies Listed	ELETEMP, MOIST-EL, VIB, & THERM-CY	Noisy, cal shift, & degraded element
4		Resistance Temperature Detector (RTD)	Sheath	Stainless steel	Five Companies Listed	ELETEMP, VIB, & THERM-CY	Not stated

Document: NUREG/CR-5619, The Impact of Thermal Aging on the Flammability of Electric Cables
Reviewed by: E. W. Roberts, INEL

Item	System	Structure/Comp	Subcomponent	Materials	Manufacturer	ARD mechanism	ARD effects
1			Electric Cables	Neoprene jacket, cross-linked polyethylene (XPE) insulated	Rockbestos	ELETEMP	Not stated
2			Electric Cables	Hypalon jacket, ethylene-propylene rubber (EPR) insulated	Boston Insulated Wire	ELETEMP	Not stated

Document: NUREG/CR-5643, Insights Gained From Aging Research
Reviewed by: Jerry Edson, INEL

Item	System	Structure/Comp	Subcomponent	Materials	Manufacturer	ARD mechanism	ARD effects
1		Electrical Components					

Document: NUREG/CR-5655, Submergence and High Temperature Steam Testing of Class 1E Electrical Cables
Reviewed by: E. W. Roberts, INEL

Item	System	Structure/Comp	Subcomponent	Materials	Manufacturer	ARD mechanism	ARD effects
1			Electrical Cable	EPR, XLPO, silicone, kapton, kerite, coaxial	12 Mfg	ELETEMP RAD MOIST-EL	Insulation failure
2			Electrical Cable	EPR, XLPO, silicone, kapton, kerite, coaxial	12 Mfg	ELETEMP RAD MOIST-EL	Some insulation failure
3			Electrical Cable	EPR, XLPO, silicone, kapton, kerite, coaxial	12 Mfg	ELETEMP RAD MOIST-EL	Some insulation failure

Document: NUREG/CR-5700, Aging Assessment of Reactor Instrumentation and Protection System Components
Reviewed by: E. W. Roberts, INEL

Item	System	Structure/Comp	Subcomponent	Materials	Manufacturer	ARD mechanism	ARD effects
1		Instrumentation System	Indicator	Not stated	Not stated	ELETEMP VIBR	Indicator failure

Document: NUREG/CR-5560, Aging of Nuclear Plant Resistance Temperature Detectors
Reviewed by: L. C. Meyer, INEL

Effect of Aging on Component Function	Contrib to Failure	Reported progs	Rel.progs	Report Recommendations	Page No.	Item
Seal may dry out, shrink, or crack allowing moisture intrusion and degraded performance of RTD.	Occasional	Not discussed in report	IEEE 338-1987, RG 1.118, ISA 67.06, Tech Spec	Not stated	25, & 27	1
Moisure intrusion from a leaking seal will degrade the insulation.	Occasional	Not discussed in report	IEEE 338-1987, RG 1.118, ISA 67.06, Tech Spec	Not stated	28	2
Long term high temp exposure affects material properties, vibration may cause response time degradation, and therm-cy can cause calibration shift.	Occasional	Not discussed in report	IEEE 338-1987, RG 1.118, ISA 67.06, Tech Spec	Calibrate RTDs and perform response time tests prior to installation in a plant. [2]	28, 167, 180, and A8	3
Sheath not normally effected by aging during qualified life of RTD.	Rare	Not discussed in report	IEEE 338-1987, RG 1.118, ISA 67.06, Tech Spec	Not stated	15, 25 & 27	4

Document: NUREG/CR-5619, The Impact of Thermal Aging on the Flammability of Electric Cables
Reviewed by: E. W. Roberts, INEL

Effect of Aging on Component Function	Contrib to Failure	Reported progs	Rel.progs	Report Recommendations	Page No.	Item
Reduction in flammability	Not stated	Not discussed in report	No specific program	No further investigation needed	21	1
Reduction in flammability	Not stated	Not discussed in report	No specific program	No further investigation needed	21	2

Document: NUREG/CR-5643, Insights Gained From Aging Research
Reviewed by: Jerry Edson, INEL

Effect of Aging on Component Function	Contrib to Failure	Reported progs	Rel.progs	Report Recommendations	Page No.	Item
For electrical components, this report contains information identical to that in other NPAR reports. See the following NUREG/CR reports: 4457, 5448, 4564, 5051, 5192, 5461, 5655, 4156, 4939, 4234 v1 & v2, 5141, 4819 v1 & v2, 5181, 4747 v1, 4967, 4740	Not stated	Not discussed in report	Component specific programs	Not stated		1

Document: NUREG/CR-5655, Submergence and High Temperature Steam Testing of Class 1E Electrical Cables
Reviewed by: E. W. Roberts, INEL

Effect of Aging on Component Function	Contrib to Failure	Reported progs	Rel.progs	Report Recommendations	Page No.	Item
Not stated	Not stated	IEEE 383	No specific program	Not stated	2, 35	1
Not stated	Not stated	IEEE 383	No specific program	Not stated	2, 35	2
Not stated	Not stated	IEEE 383	No specific program	Not stated	2, 35	3

Document: NUREG/CR-5700, Aging Assessment of Reactor Instrumentation and Protection System Components
Reviewed by: E. W. Roberts, INEL

Effect of Aging on Component Function	Contrib to Failure	Reported progs	Rel.progs	Report Recommendations	Page No.	Item
Not stated	Frequent	Not discussed in report	RG 1.118, IEEE 338-1987, ISA 67.06, Tech Spec	Develop methods to prevent infant mortality. Testing for synergistic effects of aging. Develop industry wide data base [2]	11 ,24 ,38 ,65	1

Document: NUREG/CR-5700, Aging Assessment of Reactor Instrumentation and Protection System Components
Reviewed by: E. W. Roberts, INEL

Item	System	Structure/Comp	Subcomponent	Materials	Manufacturer	ARD mechanism	ARD effects
2		Instrumentation System	Sensor	Not stated	Not stated	ELETEMP VIBR PRESS-CY MOIST-EL	Sensor failure, response time degradation, drift
3		Instrumentation System	Controller	Not stated	Not stated	ELETEMP VIBR MOIST-EL	Failure, response time degradation, drift
4		Instrumentation System	Controller	Not stated	Not stated	ELETEMP VIBR MOIST-EL	Calibration shift slow responce time
5		Instrumentation System	Annunciators	Not stated	Not stated	ELETEMP VIBR MOIST-EL	Visual unit failure sound alarm failure
6		Instrumentation System	Recorders	Not stated	Not stated	ELETEMP VIBR MOIST-EL	Failure to record

Document: NUREG/CR-5762, Comprehensive Aging Assessment of Circuit Breakers and Relays
Reviewed by: E. W. Roberts, INEL

Item	System	Structure/Comp	Subcomponent	Materials	Manufacturer	ARD mechanism	ARD effects
1			Protective Relay - 10, 13, & 24 Years Old(GE)	Not stated	General Electric	Not stated	Oxidation on contacts, increased operating temperatures
2			Control Relay	Not stated	Klockner Moeller	Not stated	None
3			Control Relay - 2 & 12 Years Old	Not stated	Struthers Dunn	Not stated	Slight discoloration of armature and contact conn. fingers
4			Control Relay	Not stated	Westinghouse	Not stated	None
5			Electronic Relay	Not stated	Blaser Electric	Not stated	Not stated
6			Auxiliary Relay	Not stated	General Electric	Not stated	Worn contacts and dust inside case
7			Auxilliary Relay	Not stated	Westinghouse	Not stated	Contact worn, discolored and pitted with age
8			Timing Relay	Not stated	Agastat	Not stated	Increased pickup voltage and op. temp. with age
9			Molded Case Circuit Breakers	Not stated	Square D	Not stated	None - 6 year old
10			Molded Case Circuit Breakers	Not stated	Westinghouse	Not stated	None - 18 & 30 year old
11			Molded Case Circuit Breakers	Not stated	Klockner Moeller	Not stated	Overheating (discoloration) of case & spliting of tubing
12			Molded Case Circuit Breakers	Not stated	ITE	Not stated	Overheating/distortion/damage to thermal element & trip mec

Document: NUREG/CR-5700, Aging Assessment of Reactor Instrumentation and Protection System Components
Reviewed by: E. W. Roberts, INEL

Effect of Aging on Component Function	Contrib to Failure	Reported progs	Rel.progs	Report Recommendations	Page No.	Item
Not stated	Occasional	Not discussed in report	RG 1.118, IEEE 338-1987, ISA 67.06, Tech Spec	Develop methods to prevent infant mortality. Testing for synergistic effects of aging. Develop industry wide data base [2]	11, 13, 26 ,41 ,65	2
Not stated	Occasional	Not discussed in report	RG 1.118, IEEE 338-1987, ISA 67.06	Develop methods to prevent infant mortality. Testing for synergistic effects of aging. Develop industry wide data base [2]	11, 13, 26 ,43 ,65	3
Not stated	Occasional	Not discussed in report	RG 1.118, IEEE 338-1987, ISA 67.06, Tech Spec	Develop methods to prevent infant mortality. Testing for synergistic effects of aging. Develop industry wide data base [2]	11, 13, 26 ,47 ,65	4
Not stated	Frequent	Not discussed in report	RG 1.118, IEEE 338-1987, ISA 67.06	Develop methods to prevent infant mortality. Testing for synergistic effects of aging. Develop industry wide data base [2]	11, 13, 26 ,48 ,65	5
Not stated	Occasional	Not discussed in report	RG 1.118, IEEE 338-1987, ISA 67.06, Tech Spec	Develop methods to prevent infant mortality. Testing for synergistic effects of aging. Develop industry wide data base [2]	11, 13, 26 ,48 ,65	6

Document: NUREG/CR-5762, Comprehensive Aging Assessment of Circuit Breakers and Relays
Reviewed by: E. W. Roberts, INEL

Effect of Aging on Component Function	Contrib to Failure	Reported progs	Rel.progs	Report Recommendations	Page No.	Item
Higher contact resistance, differences in induction pickup, significant variation in time/current charateristic.	Frequent	Yes - not specifically identified	IEEE 741-1986 Section 7	Modify current practices to include the addition of infrared temperature measurement with cover off and relay energized. [2]	3-1 & 7-3	1
None	NONE	Yes - not specifically identified	IEEE 741-1986 Section 7	Modify current practices to include the addition of infrared temperature and vibration measurements. [2]	3-18 & 7-3	2
Contact resistance increased with age	Rare	Yes - not specifically identified	IEEE 741-1986 Section 7	Modify current practices to include the addition of infrared temperature and vibration measurements. [2]	3-18 & 7-3	3
None	Not stated	Yes - not specifically identified	IEEE 741-1986 Section 7	Modify current practices to include the addition of infrared temperature and vibration measurements. [2]	3-18 & 7-3	4
Not stated	Not stated	Yes - not specifically identified	IEEE 741-1986 Section 7	Not stated	3-32 & 7-3	5
Pickup voltage exceeded acceptance criteria	Not stated	Yes - not specifically identified	IEEE 741-1986 Section 7	Add infrared temperature measurement and vibration testing to current plant practices. [2]	3-36 & 7-3	6
Increased contact resistance	Not stated	Yes - not specifically identified	IEEE 741-1986 Section 7	Add infrared temperature measurement and vibration testing to current plant practices. [2]	3-36 & 7-3	7
Timing accuracy not within typical required accuracy	Not stated	Yes - not specifically identified	IEEE 741-1986 Section 7	Add infrared temperature measurement, inrush current and vibration testing to current plant practices. [2]	3-52 & 7-3	8
None	Not stated	Yes - not specifically identified	IEEE 741-1986 Section 7	Add infrared temperature measurement and vibration testing to current plant practices. modify instantaneous trip test. [2]	3-65 & 7-3	9
Exceeded typical accept. criteria for instantaneous trip (125%) time.	Rare	Yes - not specifically identified	IEEE 741-1986 Section 7	Add infrared temperature measurement and vibration testing to current plant practices. modify instantaneous trip test. [2]	3-65 & 7-3	10
300% overcurrent trip delay exceeded acceptance criteria. Damaged/misaligigned trip pin caused overheating and failure to perform instantaneous trip when required.	Occasional	Yes - not specifically identified	IEEE 741-1986 Section 7	Add infrared temperature measurement and vibration testing to current plant practices. modify instantaneous trip test. [2]	3-65 & 7-3	11
Instantaneous trip inoperable/out of tolerance on 2 phases. 300% overcurrent trip does not meet acceptance ctiteria.	Frequent	Yes - not specifically identified	IEEE 741-1986 Section 7	Add infrared temperature measurement and vibration testing to current plant practices. modify instantaneous trip test. [2]	3-65 & 7-3	12

Document: NUREG/CR-5762, Comprehensive Aging Assessment of Circuit Breakers and Relays
Reviewed by: E. W. Roberts, INEL

Item	System	Structure/Comp	Subcomponent	Materials	Manufacturer	ARD mechanism	ARD effects
13			Metal Clad Circuit Breakers	Not stated	Westinghouse	Not stated	Main/arcing contacts pitted, insulation split, damaged parts
14			Metal Clad Circuit Breakers		General Electric	Not stated	Back connections oxidized. binding of dashpot

Document: NUREG/CR-5772 V1, Aging, Condition Monitoring, and Loss-of-Coolant Accident (LOCA) Tests of Class 1E Electrical Cables
Reviewed by: L. C. Meyer, INEL

Item	System	Structure/Comp	Subcomponent	Materials	Manufacturer	ARD mechanism	ARD effects
1		600 V, Single Conductor Cables	Insulation	Cross linked polyethylene and cross linked polyolefin	Four Suppliers Listed	ELETEMP, RAD, AND OXIDAT	Changes in electrical property - insulation resistance (IR)
2		600 V, Single Conductor Cables	Insulation	Cross linked polyethylene and cross linked polyolefin	Four Suppliers Listed	ELETEMP, RAD, AND OXIDAT	Changes in electrical property - capacitance & diss. factor
3		600 V, Single Conductor Cables	Insulation	Cross linked polyethylene and cross linked polyolefin	Four Suppliers Listed	ELETEMP, RAD, AND OXIDAT	Changes in electrical property - polarization index
4		600 V, Single Conductor Cables	Insulation	Cross linked polyethylene and cross linked polyolefin	Four Suppliers Listed	ELETEMP, RAD, AND OXIDAT	Changes in mechanical property - elongation & tens. strength
5		600 V, Single Conductor Cables	Insulation	Cross linked polyethylene and cross linked polyolefin	Four Suppliers Listed	ELETEMP, RAD, AND OXIDAT	Changes in mechanical property - hardness
6		600 V, Single Conductor Cables	Insulation	Cross linked polyethylene and cross linked polyolefin	Four Suppliers Listed	ELETEMP, RAD, AND OXIDAT	Changes in mechanical property - indenter modulus
7		600 V, Single Conductor Cables	Insulation	Cross linked polyethylene and cross linked polyolefin	Four Suppliers Listed	ELETEMP, RAD, AND OXIDAT	Changes in mechanical property - bulk density
8		600 V, Single Conductor Cables	Insulation	Cross linked polyethylene and cross linked polyolefin	Four Suppliers Listed	ELETEMP, RAD, AND OXIDAT	Changes in mechanical property - mandrel bend test
9		600 V, Single Conductor Cables	Insulation	Cross linked polyethylene and cross linked polyolefin	Four Suppliers Listed	MOIST-EL	Moisture absorbed into a cable acts as a plasticizer
10		600 V, Single Conductor Cables	Jacket	Neoprene, chlorosulfonated polyethylene (CSPE), & CPE	Four Suppliers Listed	ELETEMP, RAD, & OXIDAT	Jacket - elongation & tensil strength
11		600 V, Single Conductor Cables	Jacket	Neoprene, chlorosulfonated polyethylene (CSPE), & CPE	Four Suppliers Listed	ELETEMP, RAD, & OXIDAT	Jacket - hardness and indenter modulus

Document: NUREG/CR-5772 V2, Aging, Condition Monitoring, and Loss-of-Coolant Accident (LOCA) Tests of Class 1E Electrical Cables
Reviewed by: L. C. Meyer, INEL

Item	System	Structure/Comp	Subcomponent	Materials	Manufacturer	ARD mechanism	ARD effects
1		600 V I&C Cables	Single and Multiconductor Cable Insulation	Ethylene propylene	Five Suppliers Listed	ELETEMP, RAD, AND OXIDAT	Changes in electrical property - insulation resistance (IR)
2		600 V I&C Cables	Single and Multiconductor Cable Insulation	Ethylene propylene	Five Suppliers Listed	ELETEMP, RAD, AND OXIDAT	Changes in electrical property - polarizaton index

Document: NUREG/CR-5762, Comprehensive Aging Assessment of Circuit Breakers and Relays
Reviewed by: E. W. Roberts, INEL

Effect of Aging on Component Function	Contrib to Failure	Reported progs	Rel.progs	Report Recommendations	Page No.	Item
Long time delay varied between 110% and 150% of setting	Rare	Yes - not specifically identified	IEEE 741-1986 Section 7	Add infrared temperature measurement and vibration testing to current plant practices. modify instantaneous trip test. [2]	3-89 & 7-3	13
One phase failed to trip on long time delay overcurrent. Short timedelay overcurrent trip not within acceptance criteria.	Frequent	Yes - not specifically identified	IEEE 741-1986 Section 7	Add infrared temperature measurement and vibration testing to current plant practices. modify instantaneous trip test. [2]	3-89 & 7-3	14

Document: NUREG/CR-5772 V1, Aging, Condition Monitoring, and Loss-of-Coolant Accident (LOCA) Tests of Class 1E Electrical Cables
Reviewed by: L. C. Meyer, INEL

Effect of Aging on Component Function	Contrib to Failure	Reported progs	Rel.progs	Report Recommendations	Page No.	Item
Not determined since report only addressed detection methods	Not stated	Not discussed in report	No specific program	Not stated	6, 27, 40, and App C	1
Not determined since report only addressed detection methods	Not stated	Not discussed in report	No specific program	Not stated	6, 28, & App D.	2
Not determined since report only addressed detection methods	Not stated	Not discussed in report	No specific program	Not stated	6, 28, and App C	3
Not determined since report only addressed detection methods	Not stated	Not discussed in report	No specific program	Not stated	6, 30-33, 39, and App E.	4
Not determined since report only addressed detection methods	Not stated	Not discussed in report	No specific program	Not stated	6, 34, 56, and App F.	5
Not determined since report only addressed detection methods	Not stated	Not discussed in report	No specific program	Not stated	33, 38, & 39	6
Not determined since report only addressed detection methods	Not stated	Not discussed in report	No specific program	Not stated	35 & 56	7
Not determined since report only addressed detection methods	Not stated	Testing per IEEE 383-1974	No specific program	Not stated	47 TO 54, & 57.	8
Not determined since report only addressed detection methods	Not stated	Testing per IEEE 383-1974	No specific program	Not stated	54 & 57	9
Not determined since report only addressed detection methods	Not stated	Testing per IEEE 383-1974	No specific program	Not stated	33, 39, & 56	10
Not determined since report only addressed detection methods	Not stated	Not discussed in report	No specific program	Not stated	39 & 56	11

Document: NUREG/CR-5772 V2, Aging, Condition Monitoring, and Loss-of-Coolant Accident (LOCA) Tests of Class 1E Electrical Cables
Reviewed by: L. C. Meyer, INEL

Effect of Aging on Component Function	Contrib to Failure	Reported progs	Rel.progs	Report Recommendations	Page No.	Item
Not determined since report only addressed detection methods.	Not stated	Not discussed in report	No specific program	Not stated	31, 32, 52 TO 58, 73, 74, & Appendix I	1
Not determined since report only addressed detection methods.	Not stated	Not discussed in report	No specific program	The electrical measurements were not effective for monitoring aging	13, 32, 46, & 73	2

Table A.2 Gall Report for NPAR Reports

Document: NUREG/CR-5772 V2, Aging, Condition Monitoring, and Loss-of-Coolant Accident (LOCA) Tests of Class 1E Electrical Cables
Reviewed by: L. C. Meyer, INEL

Item	System	Structure/Comp	Subcomponent	Materials	Manufacturer	ARD mechanism	ARD effects
3		600 V I&C Cables	Single and Multiconductor Cable Insulation	Ethylene propylene	Five Suppliers Listed	ELETEMP, RAD, AND OXIDAT	Aging effects on capacitance and dissipation factor
4		600 V I&C Cables	Insulation	Ethylene propylene	Five Suppliers Listed	ELETEMP, RAD, AND OXIDAT	Changes in mechanical property - elongation & tens. strength
5		600 V I&C Cables	Insulation	Ethylene propylene	Five Suppliers Listed	ELETEMP, RAD, AND OXIDAT	Changes in mechanical property - hardness
6		600 V I&C Cables	Insulation	Ethylene propylene	Five Suppliers Listed	ELETEMP, RAD, AND OXIDAT	Changes in mechanical property - indenter modulus
7		600 V I&C Cables	Insulation	Ethylene propylene	Five Suppliers Listed	ELETEMP, RAD, AND OXIDAT	Changes in mechanical property - bulk density
8		600 V I&C Cables	Insulation	Ethylene propylene	Five Suppliers Listed	ELETEMP, RAD, AND OXIDAT	Changes in mechanical property - cracking
9		600 V I&C Cables	Insulation	Ethylene propylene	Five Suppliers Listed	MOIST-EL	Moisture absorbed into a cable acts as a plasticizer
10		600 V I&C Cables	Jacket	CSPE and CPE	Five Suppliers Listed	ELETEMP, RAD, & OXIDAT	Jacket - elongation & tensil strength
11		600 V I&C Cables	Jacket	CSPE, & CPE	Five Suppliers Listed	ELETEMP, RAD, & OXIDAT	Jacket - hardness and indenter modulus

Document: NUREG/CR-5772 V3, Aging, Condition Monitoring, and Loss-of-Coolant Accident (LOCA) Tests of Class 1E Electrical Cables
Reviewed by: L. C. Meyer, INEL

Item	System	Structure/Comp	Subcomponent	Materials	Manufacturer	ARD mechanism	ARD effects
1		Miscellaneous Cable Types	Insulation	FR insulation, coax, silicon rubber, & polymide (Kapton)	Three Suppliers Listed	ELETEMP, RAD, AND OXIDAT	Changes in electrical property - insulation resistance (IR)
2		Miscellaneous Cable Types	Insulation	FR insulation, coax, silicon rubber, & polymide (Kapton)	Three Suppliers Listed	ELETEMP, RAD, AND OXIDAT	Changes in electrical property - capacitance & diss. factor
3		Miscellaneous Cable Types	Insulation	FR insulation, coax, silicon rubber, & polymide (Kapton)	Three Suppliers Listed	ELETEMP, RAD, AND OXIDAT	Changes in electrical property - polarization index
4		Miscellaneous Cable Types	Insulation	FR insulation, coax, silicon rubber, & polymide (Kapton)	Three Suppliers Listed	ELETEMP, RAD, AND OXIDAT	Changes in mechanical property - elongation & tens. strength
5		Miscellaneous Cable Types	Insulation	FR insulation, coax, silicon rubber, & polymide (Kapton)	Three Suppliers Listed	ELETEMP, RAD, AND OXIDAT	Changes in mechanical property - hardness
6		Miscellaneous Cable Types	Insulation	FR insulation, coax, silicon rubber, & polymide (Kapton)	Three Suppliers Listed	ELETEMP, RAD, AND OXIDAT	Changes in mechanical property - indenter modulus
7		Miscellaneous Cable Types	Insulation	FR insulation, coax, silicon rubber, & polymide (Kapton)	Three Suppliers Listed	ELETEMP, RAD, AND OXIDAT	Changes in mechanical property - bulk density
8		Miscellaneous Cable Types	Insulation	FR insulation, coax, silicon rubber, & polymide (Kapton)	Three Suppliers Listed	ELETEMP, RAD, AND OXIDAT	Changes in mechanical property - brittleness
9		Miscellaneous Cable Types	Insulation	FR insulation, coax, silicon rubber, & polymide (Kapton)	Three Suppliers Listed	MOIST-EL	Moisture absorbe[illegible] decreases insula[illegible] resistance
10		Miscellaneous Cable Types	Jacket	FR & fiberglass braided	Three Suppliers Listed	ELETEMP, RAD, & OXIDAT	Jacket - elongation & tensil strength
11		Miscellaneous Cable Types	Jacket	FR & fiberglass braided	Three Suppliers Listed	ELETEMP, RAD, & OXIDAT	Jacket - hardness and indenter modulus

Document: NUREG/CR-5772 V2, Aging, Condition Monitoring, and Loss-of-Coolant Accident (LOCA) Tests of Class 1E Electrical Cables
Reviewed by: L. C. Meyer, INEL

Effect of Aging on Component Function	Contrib to Failure	Reported progs	Rel.progs	Report Recommendations	Page No.	Item
Not determined since report only addressed detection methods.	Not stated	Not discussed in report	No specific program	Not stated	33, 36, & 46	3
Not determined since report only addressed detection methods.	Not stated	Not discussed in report	No specific program	Not stated	36 TO 41, & 46	4
Not determined since report only addressed detection methods.	Not stated	Not discussed in report	No specific program	Not stated	43, 46, and Appendix F	5
Not determined since report only addressed detection methods.	Not stated	Not discussed in report	No specific program	The Franklin indenter is recommended because it is a good indicator of aging for jacket and EPR materials. [4]	17, 42, & 46	6
Not determined since report only addressed detection methods.	Not stated	Not discussed in report	No specific program	Not stated	43, 46, & Appendix F	7
Not determined since report only addressed detection methods.	Not stated	Testing per IEEE 383-1974	No specific program	Follow IEEE 383-1974 requirements. [4]	66, 74, & 75	8
Not determined since report only addressed detection methods.	Not stated	Not discussed in report	No specific program	Not stated	58 & 74	9
Not determined since report only addressed detection methods.	Not stated	Not discussed in report	No specific program	Not stated	73 & 75	10
Not determined since report only addressed detection methods.	Not stated	Not discussed in report	No specific program	Not stated	46 & 73	11

Document: NUREG/CR-5772 V3, Aging, Condition Monitoring, and Loss-of-Coolant Accident (LOCA) Tests of Class 1E Electrical Cables
Reviewed by: L. C. Meyer, INEL

Effect of Aging on Component Function	Contrib to Failure	Reported progs	Rel.progs	Report Recommendations	Page No.	Item
Not determined since report only addressed detector methods.	Not stated	Not discussed in report	No specific program	Not stated	30, 38, 40, & 51	1
Not determined since report only addressed detector methods.	Not stated	Not discussed in report	No specific program	Not stated	32, 38, & Appendix D	2
Not determined since report only addressed detector methods.	Not stated	Not discussed in report	No specific program	Not stated	31, 38, & Appendix C.	3
Not determined since report only addressed detector methods.	Not stated	Not discussed in report	No specific program	Not stated	34, 35, & Appendix E	4
Not determined since report only addressed detector methods.	Not stated	Not discussed in report	No specific program	Not stated	36 & Appendix G	5
Not determined since report only addressed detector methods.	Not stated	Not discussed in report	No specific program	The indenter is a good indicator of aging for silicon rubber and Kerite jacket materials, but not for coax jackets [4]	36, & Appendix F	6
Not determined since report only addressed detector methods.	Not stated	Not discussed in report	No specific program	Not stated	36 & Appendix G	7
Not determined since report only addressed detector methods.	Not stated	Testing per IEEE 383-1974	No specific program	IEEE 383-1974 requirements. [4]	45 TO 48, & 52.	8
Not determined since report only addressed detector methods.	Not stated	Not discussed in report	No specific program	Not stated	52	9
Not determined since report only addressed detector methods.	Not stated	Not discussed in report	No specific program	Not stated	6, 13, & 35	10
Not determined since report only addressed detector methods.	Not stated	Not discussed in report	No specific program	Not stated	16 & 36	11

Document: NUREG/CR-6095, Aging, Loss-of-Coolant Accident (LOCA), and High Potential Testing of Damaged Cables
Reviewed by: L. C. Meyer, INEL

Item	System	Structure/Comp	Subcomponent	Materials	Manufacturer	ARD mechanism	ARD effects
1		#12 AWG, 1C, Cables	Insulation	Ethylene propylene	Okonite	RAD, ELTEMP, & MOIST-EL, & VOLTSTR	Cracks, degraded insulation resistance for damaged cable
2		#12 AWG, 1C, Cables	Jacket	Chlorosulfonated polyethylene (CSPE)	Okonite	RAD, ELTEMP, & MOIST-EL, & VOLTSTR	Cracks
3		#12 AWG, 1C, Cables	Insulation	Silicon rubber	Rockbestos	RAD, ELTEMP, & MOIST-EL, & VOLTSTR	Fragile & cracks
4		#12 AWG, 1C, Cables	Jacket	Figerglass braid	Rockbestos	RAD, ELTEMP, & MOIST-EL, & VOLTSTR	Not stated
5		#12 AWG, 1C, Cables	Insulation	Cross linked polyethylene with no jacket	Brand Rex	RAD, ELTEMP, & MOIST-EL, & VOLTSTR	Voltage breakdown and moisture and high temp degradation

Document: SAND--88-0754, Time-Temperature-Dose Rate Superpositions: A Methodology for Predicting Cable Degradation Under Ambient Nuclear Power Plant /
Reviewed by: L. C. Meyer, INEL

Item	System	Structure/Comp	Subcomponent	Materials	Manufacturer	ARD mechanism	ARD effects
1		Electrical Cable	Jacket	Neoprene	Not stated	THERM & RAD	Drop in elongation
2		Electrical Cable	Jacket	Hypalon	Not stated	THERM & RAD	Drop in elongation
3		Electrical Cable	Jacket	PVC	Not stated	THERM & RAD	Elongation reduced from initial value
4		Electrical Cable	Insulation	Low density polyethylene	Not stated	THERM & RAD	Embrittlement & discoloration
5		Electrical Cable	Insulation	Chemically Cross linked polyethylene	Not stated	THERM & RAD	Elongation decrease

Document: SAND93-7027, Aging Management Guideline for Commercial Nuclear Power Plants - Electrical Switchgear
Reviewed by: K. D. McCarthy, INEL

Item	System	Structure/Comp	Subcomponent	Materials	Manufacturer	ARD mechanism	ARD effects
1		Electrical Switchgear	Metal Housing System	Not stated	GE, Westinghouse, ITE/BB	FAT, MECHSTR	Cracked welds, deformation of circuit breaker rails
2		Electrical Switchgear	Metal Housing System	Not stated	GE, Westinghouse, ITE/BB	CONTAM, CORR	Rust, pitting, and corr of structural members and fasteners
3		Electrical Switchgear	Primary Insulating System	Not stated	GE, Westinghouse, ITE/BB	EMBR	Insulation failure
4		Electrical Switchgear	Primary Insulating System	Not stated	GE, Westinghouse, ITE/BB	CONTAM, EMBR	Decrease in surface resistance
5		Electrical Switchgear	Primary Insulating System	Not stated	GE, Westinghouse, ITE/BB	ELETEMP, CONTAM, EMBR	Decrease in volumetric and surface resistance
6		Electrical Switchgear	Horizontal Racking Mechanism	Not stated	GE, Westinghouse, ITE/BB	WEAR	Binding of drawout unit
7		Electrical Switchgear	Vertical Racking Mechanism	Not stated	GE, Westinghouse, ITE/BB	WEAR	Lifting motor failure

Table A.2 Gall Report for NPAR Reports

Document: NUREG/CR-6095, Aging, Loss-of-Coolant Accident (LOCA), and High Potential Testing of Damaged Cables
Reviewed by: L. C. Meyer, INEL

Effect of Aging on Component Function	Contrib to Failure	Reported progs	Rel.progs	Report Recommendations	Page No.	Item
Longitudinal cracks were through to conductor and adjacent to damaged area, insulaton resistance degrades until failure occurs.	Occasional	Not discussed in report	No specific program	Not stated	4, 5, 10, & 18	1
Jacket cracking can propagate to the insulation	OCASSIONAL	Not discussed in report	No specific program	Not stated	4, 5, 10, & 18	2
Some cables showed degradation during accident tests, on one cable a crack was found adjacent to the damaged area.	Rare	Not discussed in report	No specific program	Not stated	4 & 16	3
Not stated	Rare	Not discussed in report	No specific program	Not stated	4 & 16	4
No high potential effects found when insulation remaining was 7 mills, no cracks developed from aging. Failure of cables during LOCA testing were at damaged locations	Rare	Not discussed in report	No specific program	Not stated	4	5

Document: SAND--88-0754, Time-Temperature-Dose Rate Superpositions: A Methodology for Predicting Cable Degradation Under Ambient Nuclear Power Plant
Reviewed by: L. C. Meyer, INEL

Effect of Aging on Component Function	Contrib to Failure	Reported progs	Rel.progs	Report Recommendations	Page No.	Item
Jacket failed to provide protection from moisture.	Rare	Not discussed in report	No current programs	Not stated	28 to 34	1
Jacket failed to provide protection from moisture.	Rare	Not discussed in report	No current programs	Not stated	34 to 38	2
Jacket failed to provide protection from moisture.	Occasional	Not discussed in report	No current programs	Not stated	43	3
Embrittlement causes cracking and allows moisture intrusion resulting in failure to accurately transmit voltage or current.	Frequent (for 1960 cable)	Not discussed in report	No current programs	Not stated	44	4
Embrittlement causes cracking and allows moisture intrusion resulting in failure to accurately transmit voltage or current.	Rare	Not discussed in report	No current programs	Not stated	12 & 54	5

Document: SAND93-7027, Aging Management Guideline for Commercial Nuclear Power Plants - Electrical Switchgear
Reviewed by: K. D. McCarthy, INEL

Effect of Aging on Component Function	Contrib to Failure	Reported progs	Rel.progs	Report Recommendations	Page No.	Item
Structural degradation caused by material fatigue can lead to the loss of structural integrity.	Not stated	Various recommendations made for maintenance	No specific program for this subcomponent	Not stated	4-7	1
Contaminants and moisture can cause corrosion/rust of the metal housing system, resulting in a loss of structural integrity.	Not stated	Various recommendations made for maintenance	No specific program for this subcomponent	Not stated	4-7	2
Insulation deterioration results from ambient temperatures with ohmic heating and can result in a loss of insulating properties and flashover of insulation.	Not stated	Various recommendations made for maintenance	No specific program for this subcomponent	Not stated	4-7	3
Normal voltage in combination with humidity, dirt, and contaminants can lead to surface current tracking which can result in insulation failure and flashover	Not stated	Various recommendations made for maintenance	No specific program for this subcomponent	Not stated	4-7	4
Normal voltage in combination with thermal deterioration, humidity, dirt, and contaminants can lead to a decrease in volumetric and surface resistance which can result in bus insulation failure and flashover.	Not stated	Various recommendations made for maintenance	No specific program for this subcomponent	Not stated	4-7	5
Wear from many racking cycles can lead to a binding of the drawout unit which can result in the inability to connect the breaker for operation.	Not stated	Various recommendations made for maintenance	Vendor specific programs	Not stated	4-7	6
Wear from many racking cycles can lead to a lifting motor failure which can result in the breaker not being able to be connected for operation.	Not stated	Various recommendations made for maintenance	Vendor specific programs	Not stated	4-8	7

Table A.2 Gall Report for NPAR Reports

Document: SAND93-7027, Aging Management Guideline for Commercial Nuclear Power Plants - Electrical Switchgear
Reviewed by: K. D. McCarthy, INEL

Item	System	Structure/Comp	Subcomponent	Materials	Manufacturer	ARD mechanism	ARD effects
8		Electrical Switchgear	Arcing Contacts	Not stated	GE, Westinghouse, ITE/BB	CURSTR	Arcing contact burn up and vaporization
9		Electrical Switchgear	Main Contacts	Not stated	GE, Westinghouse, ITE/BB	CURSTR	Contact burning or welding
10		Electrical Switchgear	Main Contacts	Not stated	GE, Westinghouse, ITE/BB	VIBR, WEAR	Contact burning or welding
11		Electrical Switchgear	Stored Energy Spring and Solenoid Operated Mech	Not stated	GE, Westinghouse, ITE/BB	CONTAM, ENVIR	Deterioration of greases
12		Electrical Switchgear	Stored Energy Spring and Solenoid Operated Mech	Not stated	GE, Westinghouse, ITE/BB	ENVIR, MECHSTR, WEAR	High friction between moving parts
13		Electrical Switchgear	Stored Energy Spring and Solenoid Operated Mech	Not stated	GE, Westinghouse, ITE/BB	VIBR, WEAR	Movement of components and loss of tolerances
14		Electrical Switchgear	Stored Energy Spring and Solenoid Operated Mech	Not stated	GE, Westinghouse, ITE/BB	FAT, CONTAM	Broken welds
15		Electrical Switchgear	Stored Energy Spring and Solenoid Operated Mech	Not stated	GE, Westinghouse, ITE/BB	WEAR	Wear of spring charging mechanism components
16		Electrical Switchgear	Stored Energy Spring and Solenoid Operated Mech	Not stated	GE, Westinghouse, ITE/BB	ELETEMP	Trip or close coil burn out
17		Electrical Switchgear	Solenoid Operated Mechanism	Not stated	GE, Westinghouse, ITE/BB	ELETEMP	Solenoid coil burnout
18		Electrical Switchgear	Solenoid Operated Mechanism	Not stated	GE, Westinghouse, ITE/BB	CURSTR, ELETEMP	Insulation deterioration
19		Electrical Switchgear	Arc-Chute	Not stated	GE, Westinghouse, ITE/BB	ELETEMP, EMBR	Material degradation
20		Electrical Switchgear	Primary Disconnect	Not stated	GE, Westinghouse, ITE/BB	WEAR	Disconnect wear, spring relaxation
21		Electrical Switchgear	Secondary Disconnect	Not stated	GE, Westinghouse, ITE/BB	WEAR	Spring relaxation

Table A.2 Gall Report for NPAR Reports

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Effect of Aging on Component Function	Contrib to Failure	Reported progs	Rel.progs	Report Recommendations	Page No.	Item
Fault current operation can cause contact deterioration and lead to contact burn up and vaporization which degrades the breaker's function.	Not stated	Various recommendations made for maintenance	IEEE 308-1980 Section 7.4 & 7.5	Not stated	4-8	8
Fault current operation can lead to contact deterioration which can result in the breaker's function being degraded.	Not stated	Various recommendations made for maintenance	IEEE 308-1980 Section 7.4 & 7.5	Not stated	4-8	9
Movement of components and loss of tolerances from mechanical cycling can lead to high resistance at the contact interface which in turn can lead to contact burning or welding. This can result in degraded breaker function.	Not stated	Various recommendations made for maintenance	IEEE 308-1980 Section 7.4 & 7.5	Not stated	4-8	10
Ambient temperatures can cause greases to deteriorate leading to binding of latches and high friction in mechanism. These can result in slow or no open or close operation.	Not stated	Various recommendations made for maintenance	Vendor specific programs	Not stated	4-8	11
Mechanical cycling of the stored energy spring can cause mechanical wear of mechanism parts which leads to high friction between moving parts. This can result in binding of mechanism and latches, slow or no open or close operation.	Not stated	Various recommendations made for maintenance	Vendor specific programs	Not stated	4-8	12
Mechanical cycling can cause a loss of tolerances and movement of components. This can result in binding and/or failure to operate.	Not stated	Various recommendations made for maintenance	Vendor specific programs	Not stated	4-8	13
Mechanical cycling can lead to pole shaft weld fatigue which can lead to broken welds. This can result in jamming, slowing, or failure to operate.	Not stated	Various recommendations made for maintenance	Vendor specific programs	Not stated	4-9	14
Mechanical cycling can lead to wear of spring charging mechanism components which can result in failure to charge closing springs and failure to close.	Not stated	Various recommendations made for maintenance	Vendor specific programs	Not stated	4-9	15
Prolonged energization of the control coils can lead to elevated temperatures which can lead to trip or close coil burn out. This can result in failure to open, failure to close, or failure to operate.	Not stated	Various recommendations made for maintenance	No specific program for this sub component	Not stated	4-9	16
Prolonged energization of solenoid coil can cause elevated temperatures in the coil which can lead to solenoid coil burnout. This can result in the breaker failing to close.	Not stated	Various recommendations made for maintenance	No specific program for this sub component	Not stated	4-9	17
Electrical cycling can cause insulation deterioration which can lead to solenoid coil burn out. This can result in a failure to close.	Not stated	Various recommendations made for maintenance	No specific program for this sub component	Not stated	4-9	18
Fault current operation can cause elevated temperatures in the arc-chute which can lead to material degradation of the arc-chute. This can result in degraded function of the arc-chute.	Not stated	Various recommendations made for maintenance	Vendor specific programs	Not stated	4-9	19
Many racking cycles can cause disconnect wear and spring relaxation which can lead to high resistivity connections. This can result in degraded disconnect function.	Not stated	Various recommendations made for maintenance	No specific program for this mechanism	Not stated	4-9	20
Many racking cycles can cause spring relaxation which can lead to high resistivity connections. This can result in degraded disconnect function.	Not stated	Various recommendations made for maintenance	No specific program for this mechanism	Not stated	4-10	21

Document: SAND93-7027, Aging Management Guideline for Commercial Nuclear Power Plants - Electrical Switchgear
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Item	System	Structure/Comp	Subcomponent	Materials	Manufacturer	ARD mechanism	ARD effects
22		Electrical Switchgear	Mechanical Interlock	Not stated	GE, Westinghouse, ITE/BB	WEAR	Wear/damage of mechanical interlock
23		Electrical Switchgear	Auxiliary Switch	Not stated	GE, Westinghouse, ITE/BB	WEAR, MECHSTR	Burnt contacts
24		Electrical Switchgear	Current and Potential Transformers	Not stated	GE, Westinghouse, ITE/BB	EMBR, ELETEMP	Insulation deterioration
25		Electrical Switchgear	Undervoltage Trip Attachment	Not stated	GE, Westinghouse, ITE/BB	ELETEMP, EMBR	Insulation deterioration
26		Electrical Switchgear	Undervoltage Trip Attachment	Not stated	GE, Westinghouse, ITE/BB	WEAR	Wear of latch
27		Electrical Switchgear	Undervoltage Trip Attachment	Not stated	GE, Westinghouse, ITE/BB	WEAR	High friction between moving parts
28		Electrical Switchgear	Control Wiring	Not stated	GE, Westinghouse, ITE/BB	ELETEMP, MECHSTR, VIBR	Loss of electrical and mechanical properties
29		Electrical Switchgear	Shunt Trip Attachment	Not stated	GE, Westinghouse, ITE/BB	ELETEMP	Coil deterioration
30		Electrical Switchgear	Shunt Trip Attachment	Not stated	GE, Westinghouse, ITE/BB	VIBR, WEAR	Loss of tolerances
31		Electrical Switchgear	Overcurrent Trip Device (Electro-Mechanical)	Not stated	GE, Westinghouse, ITE/BB	WEAR, FAT	Spring relaxation
32		Electrical Switchgear	Overcurrent Trip Device (Electro-Mechanical)	Not stated	GE, Westinghouse, ITE/BB	WEAR, ENVIR	Armature mechanical wear
33		Electrical Switchgear	Overcurrent Trip Device (Electro-Mechanical)	Not stated	GE, Westinghouse, ITE/BB	CONTAM, MECHSTR	Seal degredation

Table A.2 Gall Report for NPAR Reports

Document: SAND93-7027, Aging Management Guideline for Commercial Nuclear Power Plants - Electrical Switchgear
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Effect of Aging on Component Function	Contrib to Failure	Reported progs	Rel.progs	Report Recommendations	Page No.	Item
Many racking cycles can cause wear/damage from friction. This can make it possible to remove or insert the cb into compartment with main contacts closed. This could jeopardize personnel safety.	Not stated	Various recommendations made for maintenance	Vendor specific - Mechanism not safety rel.	Not stated	4-10	22
Mechanical cycling of the auxiliary switch can cause contact deterioration which can lead to burnt contacts. This can result in contact failure.	Not stated	Various recommendations made for maintenance	Vendor specific - Mechanism not safety rel.	Not stated	4-10	23
Temperature and electrical cycling can cause insulation deterioration which can lead to shorted windings. This can result in degraded function of the transformer which can cause failure of undervoltage and control functions.	Not stated	Various recommendations made for maintenance	No specific program for this subcomponent	Not stated	4-10	24
Constant coil energization can cause elevated temperatures which can lead to insulation deterioration. This can result in the breaker tripping open due to coil failure.	Not stated	Various recommendations made for maintenance	Vendor specific programs	Not stated	4-10	25
Mechanical cycling can cause wear of latch which can lead to latch failure. This can result in a failure to trip on undervoltage condition.	Not stated	Various recommendations made for maintenance	Vendor specific programs	Not stated	4-10	26
Mechanical cycling can cause high friction between moving parts which can lead to a lack of adequate force to trip the breader in an undervoltage condition.	Not stated	Various recommendations made for maintenance	Vendor specific programs	Not stated	4-10	27
High resistance connections, damage due to maint, and vibr can cause a loss of elect and mech properties, leading to elevated temp and mech damage. This can result in insulation deterioration and short to ground resulting in failure to operate.	Not stated	Various recommendations made for maintenance	No specific program for this subcomponent	Not stated	4-10	28
Prolonged energization can cause elevated temperatures in the coil which can lead to coil deterioration. This can cause coil failure and result in a failure of the shunt trip to operate.	Not stated	Various recommendations made for maintenance	Vendor specific programs	Not stated	4-11	29
Cycling and vibration can cause a loss of tolerances on its mounting leading to loosening or misalignment. This could result in the device not actuating the trip mechanism.	Not stated	Various recommendations made for maintenance	Vendor specific programs	Not stated	4-11	30
Prolonged spring compression can cause spring relaxation leading to metal fatigue in the spring. This could result in setpoint/time delay drift which could cause the overcurrent trip device to have improper operation or failure to operate.	Not stated	Various recommendations made for maintenance	Vendor specific programs	Not stated	4-11	31
Mechanical cycling and elevated temperatures can cause friction or degraded lubricant which can lead to mechanical wear in the armature. This can result in setpoint/time delay drift with the potential loss of overcurrent protection.	Not stated	Various recommendations made for maintenance	Vendor specific programs	Not stated	4-11	32
Mechanical cycling in conjunction with dirt or contaminants can lead to seal degradation which can result in dashpot leakage and setpoint/time delay drift. This can result in the potential loss of overcurrent protection.	Not stated	Various recommendations made for maintenance	IEEE 308-1980 Sections 7.4 & 7.5	Not stated	4-11	33

Document: SAND93-7027, Aging Management Guideline for Commercial Nuclear Power Plants - Electrical Switchgear
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Item	System	Structure/Comp	Subcomponent	Materials	Manufacturer	ARD mechanism	ARD effects
34		Electrical Switchgear	Overcurrent Trip Device (Solid State)	Not stated	GE, Westinghouse, ITE/BB	ELETEMP, CURSTR, MECHSTR	Electrical component aging

Document: SAND93-7046, Aging Management Guideline for Commerical Nuclear Power Plants - Battery Chargers, Inverters and Uninteruptable Power Supplies
Reviewed by: Michael W. Vaughn, INEL

Item	System	Structure/Comp	Subcomponent	Materials	Manufacturer	ARD mechanism	ARD effects
1		Battery Chargers, Inverters, & UPS's	Circuit Breakers	Not stated	Not stated	CORR	Contact pitting
2		Battery Chargers, Inverters, & UPS's	Circuit Breakers	Not stated	Not stated	FAT	Cumulative fatigue damage
3		Battery Chargers, Inverters, & UPS's	Circuit Breakers	Not stated	Not stated	WEAR	Attrition
4		Battery Chargers, Inverters, & UPS's	Relay	Not stated	Not stated	ENVIR	Chemical or physical degradation
5		Battery Chargers, Inverters, & UPS's	Circuit Breakers	Not stated	Not stated	THERM-CY, ELETEMP,	Deterioration of insulation, chemical or physical degradatio
6		Battery Chargers, Inverters, & UPS's	Circuit Breakers	Not stated	Not stated	CURRSTR	Equip temp rise, equipment degradation,
7		Battery Chargers, Inverters, & UPS's	Relay	Not stated	Not stated	ELETEMP	Chemical or physical degradation
8		Battery Chargers, Inverters, & UPS's	Transformer	Not stated	Not stated	CORR	Loss of material; corrosion product buildup
9		Battery Chargers, Inverters, & UPS's	Circuit Boards	Not stated	Not stated	CORR	Loss of material; corrosion product buildup
10		Battery Chargers, Inverters, & UPS's	Switches	Not stated	Not stated	CORR	Contact pitting
11		Battery Chargers, Inverters, & UPS's	Relay	Not stated	Not stated	CORR	Contact pitting
12		Battery Chargers, Inverters, & UPS's	Potentiometer	Not stated	Not stated	CORR	Contact pitting
13		Battery Chargers, Inverters, & UPS's	Switches	Not stated	Not stated	FAT	Cumulative fatique damage

Document: SAND93-7027, Aging Management Guideline for Commercial Nuclear Power Plants - Electrical Switchgear
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Effect of Aging on Component Function	Contrib to Failure	Reported progs	Rel.progs	Report Recommendations	Page No.	Item
Elevated temperature, electrical transients and mechanical shock result in material degradation from component aging. This can result in erroneous solid-state device output/operation and potential loss of overcurrent protection.	Not stated	Various recommendations made for maintenance	IEEE 308-1980 Sections 7.4 & 7.5	Not stated	4-11	34

Document: SAND93-7046, Aging Management Guideline for Commerical Nuclear Power Plants - Battery Chargers, Inverters and Uninteruptable Power Supplies
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Effect of Aging on Component Function	Contrib to Failure	Reported progs	Rel.progs	Report Recommendations	Page No.	Item
Corrosion can result in high contact impeadance, heat build-up, and signal transmission failure.	Not stated	Cleaning, visual inspection, IR scanning	No specific program for this mechanism	Not stated	4-19, 5-15	1
Fatigue due to high cyclic operation and vibration, resulting in contact degradation, loose connections, reduced force output and component failure.	Not stated	Tactile inspection, vibration observation, IR scanning	No specific program for this mechanism	Not stated	4-20, 5-16	2
Physical deterioration due to the cyclic operation caused by routine operation and periodic testing and adjustment, results in rubbing surfaces, binding of linkages, erosion of contacts and metal surfaces, burning of arc chutes, and loss of adjustment.	Not stated	Tactile inspection	No specific program for this mechanism	Not stated	4-21, 5-16	3
Drifting of the electronic setpoint can cause misoperation or component failure.	Not stated	Calibration, operational surveillance	No specific program for this mechanism	Not stated	4-21, 5-14	4
Continuous load coupled with poor contact mating, and fault currents can cause deterioration of contact support insulation, and possible phase-to-ground faults	Not stated	Cleaning, visual inspection	Vendor specific programs	Not stated	4-22, 5-15	5
Damage to contacts and arc chutes occurs regularly due to normal fault interruption.	Not stated	Cleaning, visual inspection	Vendor specific programs	Not stated	4-22, 5-15	6
Coil heating due to continuous, long-term energizing of the coil, causing material degradation due to accelerated chemical reactions/reduced dielectric strength.	Not stated	Cleaning, visual inspection	Vendor specific programs	Not stated	4-22, 5-15	7
Temperature and moisture create environmental stresses on transformers which could result in corrosion of the windings. A reduction of the dielelctric strength or insulation resilience may occur, causing the transformer to ultimately fail.	Not stated	Visual inspection	Vendor specific programs	Not stated	4-19, 5-14	8
Temp and moisture create environmental stresses, and deposited contaminants may affect electronics such as printed circuit boards, resistors, and capacitiors, resulting in corrosion of these components, which may lead to open/short circuits at the termin	Not stated	visual inspection, on-line monitoring	Vendor specific programs	Not stated	4-19, 5-15	9
Corrosion can result in high contact impeadance, heat build-up, and signal transmission failure.	Not stated	Cleaning, visual inspection	No specific program	Not stated	4-19, 5-16	10
Corrosion can result in high contact impeadance, heat build-up, and signal transmission failure.	Not stated	Cleaning, visual inspection	No specific program	Not stated	4-19, 5-14	11
Corrosion can result in high contact impeadance, heat build-up, and signal transmission failure.	Not stated	Cleaning, visual inspection	No specific program	Not stated	4-19, 5-16	12
Fatigue due to high cyclic operation and vibration, resulting in contact degradation, loose connections, reduced force output and component failure.	Not stated	Tactile inspection, vibration observation, IR scan	Vendor specific surveillance	Not stated	4-20, 5-16	13

Document: SAND93-7046, Aging Management Guideline for Commerical Nuclear Power Plants - Battery Chargers, Inverters and Uninteruptable Power Supplies
Reviewed by: Michael W. Vaughn, INEL

Item	System	Structure/Comp	Subcomponent	Materials	Manufacturer	ARD mechanism	ARD effects
14		Battery Chargers, Inverters, & UPS's	Relay	Not stated	Not stated	FAT	Cumulative fatique damage
15		Battery Chargers, Inverters, & UPS's	Potentiometer	Not stated	Not stated	FAT	Cumulative fatique damage
16		Battery Chargers, Inverters, & UPS's	Switches	Not stated	Not stated	WEAR	Attrition
17		Battery Chargers, Inverters, & UPS's	Relay	Not stated	Not stated	WEAR	Attrition
18		Battery Chargers, Inverters, & UPS's	Potentiometer	Not stated	Not stated	WEAR	Attrition
19		Battery Chargers, Inverters, & UPS's	Potentiometer	Not stated	Not stated	ENVIRO	Chemical or physical degradation
20		Battery Chargers, Inverters, & UPS's	Surge Suppressors	Not stated	Not stated	ENVIRO	Chemical or physical degradation
21		Battery Chargers, Inverters, & UPS's	Circuit Boards	Not stated	Not stated	ENVIRO	Chemical or physical degradation
22		Battery Chargers, Inverters, & UPS's	Electronics	Not stated	Not stated	ENVIRO	Chemical or physical degradation
23		Battery Chargers, Inverters, & UPS's	Electronics	Not stated	Not stated	CORR	Loss of material; corrosion product buildup
24		Battery Chargers, Inverters, & UPS's	Wire	Not stated	Not stated	CORR	Loss of material; corrosion product buildup
25		Battery Chargers, Inverters, & UPS's	Cooling Fans and Cooling Fan Motors	Not stated	Not stated	CORR/OX	Loss of material; corrosion product buildup;interrial damage
26		Battery Chargers, Inverters, & UPS's	Cabinet	Not stated	Not stated	CORR/OX	Loss of material; corrosion product buildup;internal damage

Table A.2 Gall Report for NPAR Reports

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Effect of Aging on Component Function	Contrib to Failure	Reported progs	Rel.progs	Report Recommendations	Page No.	Item
Fatigue due to high cyclic operation and vibration, resulting in contact degradation, loose connections, reduced force output and component failure.	Not stated	Tactile inspection, vibration observation, IR scan	Vendor specific surveillance	Not stated	4-20, 5-14	14
Fatigue due to high cyclic operation and vibration, resulting in contact degradation, loose connections, reduced force output and component failure.	Not stated	Tactile inspection, vibration observation, IR scan	Vendor specific surveillance	Not stated	4-20, 5-16	15
Physical deterioration due to the cyclic operation caused by routine operation and periodic testing and adjustment, results in rubbing surfaces, binding of linkages, erosion of contacts and metal surfaces, burning of arc chutes, and loss of adjustment.	Not stated	Tactile inspection	No specific program	Not stated	4-21, 5-16	16
Physical deterioration due to the cyclic operation caused by routine operation and periodic testing and adjustment, results in rubbing surfaces, binding of linkages, erosion of contacts and metal surfaces, burning of arc chutes, and loss of adjustment.	Not stated	Tactile inspection	No specific program	Not stated	4-21, 5-14	17
Physical deterioration due to the cyclic operation caused by routine operation and periodic testing and adjustment, results in rubbing surfaces, binding of linkages, erosion of contacts and metal surfaces, burning of arc chutes, and loss of adjustment.	Not stated	Not discussed in report	No specific program	Not stated	4-21, 5-16	18
Drifting of the setpoint can cause misoperation or componenet failure.	Not stated	Calibration, Tech Spec, I/O logging, output	IEEE 308-1980 Section 7, Tech Spec surveil.	Not stated	4-21, 5-16	19
Drifting of the electronic setpoint can cause misoperation or componenet failure.	Not stated	Calibration	No specific program	Not stated	4-21, 5-15	20
Drifting of the electronic setpoint can cause misoperation or componenet failure.	Not stated	Calibration, Tech Spec, I/O logging, output	Tech Spec. required surveillance	Not stated	4-21, 5-15	21
Drifting of the electronic setpoint can cause misoperation or componenet failure.	Not stated	Calibration, Tech Spec, I/O logging, output	Tech Spec. required surveillance	Not stated	4-21, 5-15	22
Temp and moisture create environmental stresses, and deposited contaminants may affect electronics such as printed circuit boards, resistors and capacitors resulting in corrosion of the components, which may lead to open/short circuits at the terminals.	Not stated	Visual inspection, output	Vendor specific programs	Not stated	4-19, 5-15	23
Temp and moisture create environmental stresses, and deposited contaminants may corrode shields or conductor strands, terminations, etc. eventually causing failure of the circuit due to overheating or dielectric insulation breakdown.	Not stated	Visual inspection, output	No specific program	Not stated	4-19, 5-16	24
Temp and moisture create environmental stresses, and deposited contaminants may increase contact resistance. Vibration can promote loosening connectons resulting in localized heating and more oxidation.	Not stated	Visual inspection	IEEE 334-1974 Section 14.2.3	Not stated	4-19, 5-16	25
Temp and moisture create environmental stresses, and deposited contaminants may over time can degrade and give way to oxidation corrosion.	Not stated	Visual inspection	No specific program	Not stated	4-20, 5-17	26

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Document: SAND93-7046, Aging Management Guideline for Commerical Nuclear Power Plants - Battery Chargers, Inverters and Uninteruptable Power Supplies
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Item	System	Structure/Comp	Subcomponent	Materials	Manufacturer	ARD mechanism	ARD effects
27		Battery Chargers, Inverters, & UPS's	Transformer	Not stated	Not stated	FAT	Cumulative fatigue damage
28		Battery Chargers, Inverters, & UPS's	Inductors	Not stated	Not stated	FAT	Cumulative fatigue damage
29		Battery Chargers, Inverters, & UPS's	Capacitor	Not stated	Not stated	FAT	Cumulative fatigue damage
30		Battery Chargers, Inverters, & UPS's	SCR's	Not stated	Not stated	FAT	Cumulative fatigue damage
31		Battery Chargers, Inverters, & UPS's	Diodes	Not stated	Not stated	FAT	Cumulative fatigue damage
32		Battery Chargers, Inverters, & UPS's	Surge Suppressors	Not stated	Not stated	FAT	Cumulative fatigue damage
33		Battery Chargers, Inverters, & UPS's	Circuit Boards	Not stated	Not stated	FAT	Cumulative fatigue damage
34		Battery Chargers, Inverters, & UPS's	Electronics	Not stated	Not stated	FAT	Cumulative fatigue damage
35		Battery Chargers, Inverters, & UPS's	Wire	Not stated	Not stated	FAT	Cumulative fatigue damage
36		Battery Chargers, Inverters, & UPS's	Cooling Fans and Cooling Fan Motors	Not stated	Not stated	FAT	Cumulative fatigue damage

Table A.2 Gall Report for NPAR Reports

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Effect of Aging on Component Function	Contrib to Failure	Reported progs	Rel.progs	Report Recommendations	Page No.	Item
High frequency vibration caused by ferromagnetic resonance can cause fatigue resulting in loose parts, open circuits causing loss of signal or sporatic operation. Regular maint also moves/bends wires/connectors causing conductor or insulation failure.	Not stated	Tactile/audible inspection, vibration observation, IR scan	Vendor specific program	Not stated	4-20, 5-14	27
High frequency vibration caused by ferromagnetic resonance can cause fatigue resulting in loose parts, open circuits causing loss of signal or sporatic operation. Regular maint also moves/bends wires/connectors causing conductor or insulation failure.	Not stated	Tactile/audible inspection, vibration observation, IR scan	Vendor specific program	Not stated	4-20, 5-14	28
High frequency vibration caused by ferromagnetic resonance can cause fatigue resulting in loose parts, open circuits causing loss of signal or sporatic operation. Regular maint also moves/bends wires/connectors causing conductor or insulation failure.	Not stated	Tactile/audible inspection, vibration observation, IR scan	Vendor specific program	Not stated	4-20, 5-14	29
High frequency vibration caused by ferromagnetic resonance can cause fatigue resulting in loose parts, open circuits causing loss of signal or sporatic operation. Regular maint also moves/bends wires/connectors causing conductor or insulation failure.	Not stated	Tactile/audible inspection, vibration observation, IR scan	No specific program	Not stated	4-20, 5-15	30
High frequency vibration caused by ferromagnetic resonance can cause fatigue resulting in loose parts, open circuits causing loss of signal or sporatic operation. Regular maint also moves/bends wires/connectors causing conductor or insulation failure.	Not stated	Tactile/audible inspection, vibration observation, IR scan	No specific program	Not stated	4-20, 5-15	31
High frequency vibration caused by ferromagnetic resonance can cause fatigue resulting in loose parts, open circuits causing loss of signal or sporatic operation. Regular maint also moves/bends wires/connectors causing conductor or insulation failure.	Not stated	Tactile/audible inspection, vibration observation, IR scan	No specific program	Not stated	4-20, 5-15	32
High frequency vibration caused by ferromagnetic resonance can cause fatigue resulting in loose parts, open circuits causing loss of signal or sporatic operation. Regular maint also moves/bends wires/connectors causing conductor or insulation failure.	Not stated	Tactile/audible inspection, vibration observation, IR scan	Vendor specific program	Not stated	4-20, 5-15	33
High frequency vibration caused by ferromagnetic resonance can cause fatigue resulting in loose parts, open circuits causing loss of signal or sporatic operation. Regular maint also moves/bends wires/connectors causing conductor or insulation failure.	Not stated	Tactile/audible inspection, vibration observation, IR scan	Vendor specific program	Not stated	4-20, 5-15	34
High frequency vibration caused by ferromagnetic resonance can cause fatigue resulting in loose parts, open circuits causing loss of signal or sporatic operation. Regular maint also moves/bends wires/connectors causing conductor or insulation failure.	Not stated	Tactile/audible inspection, vibration observation, IR scan	No specific program	Not stated	4-20, 5-16	35
Vibration induced fatigue in motor mounts can occur due to improper sheave alignment and dynamic imbalances.	Not stated	Tactile/audible inspection, vibration observation, IR scan	IEEE 334-1974 Section 14.2.3	Not stated	4-20, 5-17	36

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Item	System	Structure/Comp	Subcomponent	Materials	Manufacturer	ARD mechanism	ARD effects
37		Battery Chargers, Inverters, & UPS's	Cooling Fans and Cooling Fan Motors	Not stated	Not stated	WEAR	Attrition
38		Battery Chargers, Inverters, & UPS's	Transformer	Not stated	Not stated	THERM-CY, ELETEMP, VOLSTR	Deterioration of insulation, chemical or physical changes
39		Battery Chargers, Inverters, & UPS's	Inductors	Not stated	Not stated	THERM-CY, ELETEMP, VOLSTR, CURSTR	Deterioration of insulation, chemical or physical changes
40		Battery Chargers, Inverters, & UPS's	Capacitor	Not stated	Not stated	THERM-CY, ELETEMP, VOLSTR, CURSTR	Deterioration of insulation, chemical or physical changes
41		Battery Chargers, Inverters, & UPS's	Diodes	Not stated	Not stated	THERM-CY, ELETEMP, VOLSTR, CURSTR	Deterioration of insulation, chemical or physical changes
42		Battery Chargers, Inverters, & UPS's	Surge Suppressors	Not stated	Not stated	THERM-CY, ELETEMP, VOLSTR, CURSTR	Deterioration of insulation, chemical or physical changes
43		Battery Chargers, Inverters, & UPS's	Circuit Boards	Not stated	Not stated	THERM-CY, ELETEMP, VOLSTR, CURSTR	Deterioration of insulation, chemical or physical changes
44		Battery Chargers, Inverters, & UPS's	Electronics	Not stated	Not stated	THERM-CY, ELETEMP, VOLSTR, CURSTR	Deterioration of insulation, chemical or physical changes
45		Battery Chargers, Inverters, & UPS's	SCR's	Not stated	Not stated	THERM-CY, ELETEMP, VOLSTR, CURSTR	Deterioration of insulation, chemical or physical changes
46		Battery Chargers, Inverters, & UPS's	Switches	Not stated	Not stated	THERM-CY, ELETEMP, VOLSTR, CURSTR	Deterioration of insulation, chemical or physical changes
47		Battery Chargers, Inverters, & UPS's	Wire	Not stated	Not stated	THERM-CY, ELETEMP, VOLSTR, CURSTR, EMBR	Deterioration of insulation, chemical or physical changes
48		Battery Chargers, Inverters, & UPS's	Cooling Fan Motors	Not stated	Not stated	THERM-CY, ELETEMP, VOLSTR, CURSTR, EMBR	Deterioration of insulation, chemical or physical changes
49		Battery Chargers, Inverters, & UPS's	Transformer	Not stated	Not stated	CONTAM	Buildup of deposits; loss of desired surface properties
50		Battery Chargers, Inverters, & UPS's	Inductors	Not stated	Not stated	CONTAM	Buildup of deposits; loss of desired surface properties
51		Battery Chargers, Inverters, & UPS's	SCR's	Not stated	Not stated	CONTAM	Buildup of deposits; loss of desired surface properties

Table A.2 Gall Report for NPAR Reports

Document: SAND93-7046, Aging Management Guideline for Commerical Nuclear Power Plants - Battery Chargers, Inverters and Uninteruptable Power Supplies
Reviewed by: Michael W. Vaughn, INEL

Effect of Aging on Component Function	Contrib to Failure	Reported progs	Rel.progs	Report Recommendations	Page No.	Item
Shafts and bearings are susceptible to normal wear, and wear due to misalignment, imbalances, and inherent eccentricity of the rotor. On dc motors, brushes and commutators are also subject to wear.	Not stated	Noise observation	IEEE 334-1974 Section 14.2.3	Not stated	4-21, 5-17	37
Overvoltage or turn-to-turn shorts can cause high internal tempreratures, causing insulation to fail, causing local heating and deterioration of material resulting in dielectric failure.	Not stated	Cleaning, visual/tactile/audible inpection	Vendor specific program	Not stated	4-22, 5-14	38
Overvoltage or turn-to-turn shorts can cause high internal tempreratures, causing insulation to fail, causing local heating and deterioration of material resulting in dielectric failure.	Not stated	Cleaning, visual/tactile/audible inpection	Vendor specific program	Not stated	4-22, 5-14	39
Overvoltage can cause voltage stress causing loss of capacitance, breakdown of dielectric.	Not stated	Cleaning, visual inspection, measuement, part replacement	Vendor specific program	Not stated	4-22, 5-14	40
Heat due to overcurrent conditions and internal stresses can cause dielectric breakdown resulting in change in output signal.	Not stated	Cleaning, visual inspection, temperature & input/output	Vendor specific program	Not stated	4-22, 5-15	41
Heat due to overcurrent conditions and internal stresses can cause dielectric breakdown and misoperation or failure of the device.	Not stated	Cleaning, visual inspection, temperature & input/output	No specific program	Not stated	4-22, 5-15	42
Heat due to overcurrent conditions and internal stresses can cause dielectric breakdown and misoperation or failure of components, open/shorts of circuits.	Not stated	Cleaning, visual inspection, temperature & input/output	Vendor specific program	Not stated	4-22, 5-15	43
Heat due to overcurrent conditions and internal stresses can cause dielectric breakdown and misoperation or failure of components, open/shorts of circuits.	Not stated	Cleaning, visual inspection, temperature & input/output	Vendor specific program	Not stated	4-22, 5-15	44
Heat due to overcurrent conditions and internal stresses can cause dielectric breakdown and misoperation or failure of components, open/shorts of circuits.	Not stated	Cleaning, visual inspection, temperature & input/output	Vendor specific program	Not stated	4-22, 5-15	45
Heat due to overcurrent conditions and normal operations, and due to contact resistance, can cause dielectric breakdown of supports and insulation, and misoperation or failure of components.	Not stated	Cleaning, visual inspection, temperature logging	No specific program	Not stated	4-23, 5-16	46
Thermal effects on wire and cable leading to embrittlement, and insulation failure. Ohmic heating and heat from surrounding environment degrades insulation, resulting in short circuits.	Not stated	Cleaning, visual inspection, temperature & input/output	No specific program	Not stated	4-23	47
Heat due to overcurrent conditions and normal operations, can cause dielectric breakdown and failure.	Not stated	Cleaning, visual inspection, temperature & input/output	IEEE 334-1974 Section 14.2.3	Not stated	4-23, 5-16	48
Fouling due to accumulation of insects, dirt, and dust, can reduce heat dissipation, cause overheating, and eventual failure of components.	Not stated	Cleaning, visual inspection	Vendor specific programs	Not stated	4-23, 5-14	49
Fouling due to accumulation of insects, dirt, and dust, can reduce heat dissipation, cause overheating, and eventual failure of components.	Not stated	Cleaning, visual inspection	Vendor specific programs	Not stated	4-23, 5-14	50
Fouling due to accumulation of insects, dirt, and dust, can reduce heat dissipation, cause overheating, and eventual failure of components.	Not stated	Cleaning, visual inspection	No specific programs	Not stated	4-23, 5-15	51

Document: SAND93-7046, Aging Management Guideline for Commerical Nuclear Power Plants - Battery Chargers, Inverters and Uninteruptable Power Supplies
Reviewed by: Michael W. Vaughn, INEL

Item	System	Structure/Comp	Subcomponent	Materials	Manufacturer	ARD mechanism	ARD effects
52		Battery Chargers, Inverters, & UPS's	Diodes	Not stated	Not stated	CONTAM	Buildup of deposits; loss of desired surface properties
53		Battery Chargers, Inverters, & UPS's	Capacitor	Not stated	Not stated	CONTAM	Buildup of deposits; loss of desired surface properties
54		Battery Chargers, Inverters, & UPS's	Surge Suppressors	Not stated	Not stated	CONTAM	Buildup of deposits; loss of desired surface properties
55		Battery Chargers, Inverters, & UPS's	Circuit Boards	Not stated	Not stated	CONTAM	Buildup of deposits; loss of desired surface properties
56		Battery Chargers, Inverters, & UPS's	Electronics	Not stated	Not stated	CONTAM	Buildup of deposits; loss of desired surface properties
57		Battery Chargers, Inverters, & UPS's	Wire	Not stated	Not stated	CONTAM	Buildup of deposits; loss of desired surface properties
58		Battery Chargers, Inverters, & UPS's	Relay	Not stated	Not stated	CONTAM	Buildup of deposits; loss of desired surface properties
59		Battery Chargers, Inverters, & UPS's	Circuit Breakers	Not stated	Not stated	CONTAM	Buildup of deposits; loss of desired surface properties
60		Battery Chargers, Inverters, & UPS's	Switches	Not stated	Not stated	CONTAM	Buildup of deposits; loss of desired surface properties
61		Battery Chargers, Inverters, & UPS's	Potentiometers	Not stated	Not stated	CONTAM	Buildup of deposits; loss of desired surface properties
62		Battery Chargers, Inverters, & UPS's	Cooling Fan Motoers	Not stated	Not stated	CONTAM	Buildup of deposits; loss of desired surface properties
63		Battery Chargers, Inverters, & UPS's	Relay	Not stated	Not stated	LOSLUB	Viscosity change, loss of lubricicty
64		Battery Chargers, Inverters, & UPS's	Circuit Breakers	Not stated	Not stated	LOSLUB	Viscosity change, loss of lubricicty

Document: SAND93-7068, Aging Management Guideline for Commercial Nuclear Power Plants - Power and Distribution Transformers
Reviewed by: Michael W. Vaughn, INEL

Item	System	Structure/Comp	Subcomponent	Materials	Manufacturer	ARD mechanism	ARD effects
1		Transformer	Metal Enclosure (Tank) and Cover	Low-alloy steel	Not stated	ENVIR	Chemical/physical degradation
2		Transformer	Metal Enclosure (Tank) and Cover	Low-alloy steel	Not stated	CORR	Loss of material; corrosion product buildup

Document: SAND93-7046, Aging Management Guideline for Commerical Nuclear Power Plants - Battery Chargers, Inverters and Uninteruptable Power Supplies
Reviewed by: Michael W. Vaughn, INEL

Effect of Aging on Component Function	Contrib to Failure	Reported progs	Rel.progs	Report Recommendations	Page No.	Item
Fouling due to accumulation of insects, dirt, and dust, can reduce heat dissipation, cause overheating, and eventual failure of components.	Not stated	Cleaning, visual inspection	No specific programs	Not stated	4-23, 5-15	52
Fouling due to accumulation of insects, dirt, and dust, can reduce heat dissipation, cause overheating, and eventual failure of components.	Not stated	Cleaning, visual inspection	Vendor specific programs	Not stated	4-23, 5-14	53
Fouling due to accumulation of insects, dirt, and dust, can reduce heat dissipation, cause overheating, and eventual failure of components.	Not stated	Cleaning, visual inspection	No specific programs	Not stated	4-23, 5-15	54
Fouling due to accumulation of insects, dirt, and dust, can reduce heat dissipation, cause overheating, and eventual failure of components.	Not stated	Cleaning, visual inspection	Vendor specific programs	Not stated	4-23, 5-15	55
Fouling due to accumulation of insects, dirt, and dust, can reduce heat dissipation, cause overheating, and eventual failure of components.	Not stated	Cleaning, visual inspection	No specific programs	Not stated	4-23, 5-15	56
Fouling due to accumulation of insects, dirt, and dust, can reduce heat dissipation, cause overheating, and eventual failure of components.	Not stated	Cleaning, visual inspection	No specific programs	Not stated	4-23, 5-16	57
Fouling due to accumulation of insects, dirt, and dust, can reduce heat dissipation, cause overheating, and eventual failure of components.	Not stated	Cleaning, visual inspection	Vendor specific programs	Not stated	4-23, 4-24, 5-14	58
Fouling due to accumulation of insects, dirt, and dust, can reduce heat dissipation, cause overheating, and eventual failure of components.	Not stated	Cleaning, visual inspection	Vendor specific programs	Not stated	4-23, 4-24, 5-15	59
Fouling due to accumulation of insects, dirt, and dust, can reduce heat dissipation, cause overheating, and eventual failure of components.	Not stated	Cleaning, visual inspection	No specific programs	Not stated	4-23, 4-24, 5-16	60
Fouling due to accumulation of insects, dirt, and dust, can reduce heat dissipation, cause overheating, and eventual failure of components.	Not stated	Cleaning, visual inspection	No specific programs	Not stated	4-23, 4-24, 5-16	61
Fouling due to accumulation of insects, dirt, and dust, can reduce heat dissipation, cause overheating, and eventual failure of components.	Not stated	Cleaning, visual inspection	IEEE 334-1974 SECTION 14.2.3	Not stated	4-24, 5-17	62
Material set occurs when the organic materials used as lubricants in those subconponents harden, gel, or adhere to adjacent materials, which can cause binding of the devices, resulting in faulty operation.	Not stated	Tactile inspection, operational	Vendor specific programs	Not stated	4-24, 5-14	63
Material set occurs when the organic materials used as lubricants in those subconponents harden, gel, or adhere to adjacent materials, which can cause binding of the devices, resulting in faulty operation.	Not stated	Tactile inspection, operational	Vendor specific programs	Not stated	4-24, 5-14	64

Document: SAND93-7068, Aging Management Guideline for Commercial Nuclear Power Plants - Power and Distribution Transformers
Reviewed by: Michael W. Vaughn, INEL

Effect of Aging on Component Function	Contrib to Failure	Reported progs	Rel.progs	Report Recommendations	Page No.	Item
Chipping, cracking, or peeling of the enclosure's protective coating	Not stated	Visual inspection, cleaning, pressure testing	Vendor specific surveillance, IEEE 308-1980	Not stated	4-7, 5-3, 5-15	1
Exposed metal develops rust and corrosion	Not stated	Visual inspection, cleaning, pressure testing	Vendor specific surveillance, IEEE 308-1980	Not stated	4-7, 5-3, 5-15	2

Table A.2 Gall Report for NPAR Reports

Document: SAND93-7068, Aging Management Guideline for Commercial Nuclear Power Plants - Power and Distribution Transformers
Reviewed by: Michael W. Vaughn, INEL

Item	System	Structure/Comp	Subcomponent	Materials	Manufacturer	ARD mechanism	ARD effects
3		Transformer	Metal Enclosure (Tank) and Cover	Low-alloy steel	Not stated	ENVIR, EMBR	Deterioration of organic components
4		Transformer	Metal Enclosure (Tank) and Cover	Low-alloy steel	Not stated	FAT	Cumulative damage from cyclic vibration or thermal stress
5		Transformer	Primary and Secondary Windings, Liquid-Immersed	Not stated	Not stated	ELETEMP	Chemical or physical degradation: thermal distortion
6		Transformer	Primary and Secondary Windings, Liquid-Immersed	Not stated	Not stated	VIBR, VOLSTR, EXFORCE	Loosening, reduced tolerances, distortion or bending
7		Transformer	Primary and Secondary Windings, Dry-Type	Not stated	Not stated	ELETEMP	Chemical or physical degradation; thermal distortion
8		Transformer	Primary and Secondary Windings, Dry-Type	Not stated	Not stated	VIBR, VOLSTR, EXFORCE	Loosening, reduced tolerances, distortion or bending
9		Transformer	Magnetic Core	Not stated	Not stated	VIBR, MECHSTR, EXFORCE	Loosening, distortion, deterioration of mech function
10		Transformer	Magnetic Core	Not stated	Not stated	EMBR/TE	Loss of fracture toughness
11		Transformer	Insulation	Not stated	Not stated	ELETEMP, VOLSTR	Chemical or physical degradation, degradation of insulation
12		Transformer	Insulation	Not stated	Not stated	MOIST-EL, CONTAM	Loss of dielectric properties, buildup of deposits
13		Transformer	Insulation	Not stated	Not stated	Not stated	High acidity resulting in more water retention
14		Transformer	Insulation	Not stated	Not stated	CORR/OX	Loss of material; corrosion product buildup;internal damage

Table A.2 Gall Report for NPAR Reports

Document: SAND93-7068, Aging Management Guideline for Commercial Nuclear Power Plants - Power and Distribution Transformers
Reviewed by: Michael W. Vaughn, INEL

Effect of Aging on Component Function	Contrib to Failure	Reported progs	Rel.progs	Report Recommendations	Page No.	Item
Gaskets and other organic seals used in construction of the enclosure degrade due to exposure to heat, ultraviolet radiation, moisture, or chemicals, while under mechanical stress or compression. polymeric seal materials embrittle and harden	Not stated	Visual inspection, cleaning	Vendor specific surveillance, IEEE 308-1980	Not stated	4-7, 5-15	3
Can affect areas of high local stress such a welds, tank edges, etc., resulting in tank leaks (oil or gas-filled units) and potentially a loss of structural intergrity.	Not stated	visual inspection, cleaning, pressure testing	Vendor specific surveillance, IEEE 308-1980	Not stated	4-7, 4-8, 5-3, 5-15	4
May induce accelerated degradiation of surrounding organic materials.	Not stated	Electrical testing, visual inspection, cleaning	Vendor specific surveillance, IEEE 308-1980	Not stated	4-8, 5-4, 5-15	5
Movement and vibration allow windings to change clearances/tolerances required for maintaining satisfactory dielectric strength, which can result in dielectric breakdown and localized discharge. Can cause mechanical stress on electrical connections	Not stated	Electrical testing, visual inspection, cleaning	Vendor specific surveillance, IEEE 308-1980	Not stated	4-9, 5-4, 5-15	6
May induce accelerated degradation of surrounding organic materials. Degradation of winding conductor connections due to high resistance connections causing localized heating.	Not stated	Electrical testing, visual inspection, cleaning	Vendor specific surveillance, IEEE 308-1980	Not stated	4-9, 5-4, 5-15	7
Movement and vibration allow winding to change clearances/tolerances required for maintaining satisfactory dielectric strength, which can result in deilectric breakdown and localized discharge. Can cause mechanical stress on electrical connections.	Not stated	Electrical testing, visual inspection, cleaning	Vendor specific surveillance, IEEE 308-1980	Not stated	4-9, 5-4, 5-15	8
Loosining of the core due to vibration, shock, or severe electrical transients, can cause wear or deterioration of the insulation once dislocation occurs may lead to sufficient insulation damage to allow electrical failure	Not stated	Electrical testing, visual inspection	Vendor specific surveillance, IEEE 308-1980	Not stated	4-10, 5-4, 5-15	9
A result of relatively high thermal exposure resulting from core and winding losses, causing weakening or failure of the laminations, causing increased eddy currents and core losses.	Not stated	Electrical testing, visual inspection	Vendor specific surveillance, IEEE 308-1980	Not stated	4-10, 4-11, 5-4, 5-15	10
Partial or localized breakdown of the dielectric capacity of the material, which may in turn produce other eleterious effects such as the formation of additional gaseous byproducts, decomposition of the surrounding insulating fluid.	Not stated	Sampling and analysis, cleaning, replacement	Vendor specific surveillance, IEEE 308-1980	Recommended laboratory and/or in-situ analysis to detect impending breakdown of dielectric [2]	4-11, 5-5, 5-15, 5-22	11
Particulates contaminants and moisture may result in blockage of passages leading to hot spots. Chemical contaminants may have adverse effects on the material properties, water reduces dielectric strength causing partial discharge or dielectric breakdown	Not stated	Sampling and analysis, cleaning, replacement	Vendor specific surveillance, IEEE 308-1980	Recommended laboratory and/or in-situ analysis to detect impending breakdown of dielectric [2]	4-12, 5-5, 5-16, 5-22	12
High acidity results in more water being held in solution and therefore reduced dielectric strength. Also affects the deterioration and decomposition of solid insulating materials reducing the dielectric strenth	Not stated	Sampling and analysis, cleaning, replacement	Vendor specific surveillance, IEEE 308-1980	Recommended laboratory and/or in-situ analysis to detect impending breakdown of dielectric [2]	4-12, 5-5, 5-16, 5-22	13
Formation of sludge which can impead circulation creating hot spots. Dielectric properties associated with the sludge may also differ. oxygen will also increase the acidity of the insulating fluid	Not stated	Sampling and analysis, cleaning, replacement	Vendor specific surveillance, IEEE 308-1980	Recommended laboratory and/or in-situ analysis to detect impending breakdown of dielectric [2]	4-12, 5-5, 5-16, 5-22	14

Document: SAND93-7068, Aging Management Guideline for Commercial Nuclear Power Plants - Power and Distribution Transformers
Reviewed by: Michael W. Vaughn, INEL

Item	System	Structure/Comp	Subcomponent	Materials	Manufacturer	ARD mechanism	ARD effects
15		Transformer	Insulation	Not stated	Not stated	ELETEMP	Chemical or physical degradation; thermal distortion
16		Transformer	Bushings	Not stated	Not stated	THERM-CY	Degradation due to exposure to elements and temp cycles
17		Transformer	Bushings	Not stated	Not stated	CONTAM	Buildup of deposits:loss of desired surface properties
18		Transformer	Bushings	Not stated	Not stated	ENVIRO	Chemical or physical degradation
19		Transformer	Bushings	Not stated	Not stated	VOLSTR	Dielectric stress causing degradation of insulation
20		Transformer	Cooling System, Liquid-Immersed and Dry-Type	Not stated	Not stated	FAT, WEAR	Attrition and cumulative fatigue damage over time
21		Transformer	Cooling System, Liquid-Immersed and Dry-Type	Not stated	Not stated	CONTAM	Buildup of deposits; loss of desired surface properties
22		Transformer	Oil Preservation and Sampling System	Not stated	Not stated	ENVIRO, ELETEMP	Chemical or physical degredation
23		Transformer	Oil Preservation and Sampling System	Not stated	Not stated	WEAR	Attrition
24		Transformer	Tap Changers	Not stated	Not stated	WEAR	Attrition
25		Transformer	Tap Changers	Not stated	Not stated	VIBR, MECHSTR	Loosening, deterioration of mechanical function
26		Transformer	Tap Changers	Not stated	Not stated	ELTEMP, THERM-CY	Chemical or physical degradation, insulation deterioration
27		Transformer	Protection and Monitoring Systems	Not stated	Not stated	ENVIRO, EMBR	Chemical or physical degradation, loss or fracture toughness
28		Transformer	Protection and Monitoring Systems	Not stated	Not stated	THERM-CY	Deterioration of insulation

Table A.2 Gall Report for NPAR Reports

Document: SAND93-7068, Aging Management Guideline for Commercial Nuclear Power Plants - Power and Distribution Transformers
Reviewed by: Michael W. Vaughn, INEL

Effect of Aging on Component Function	Contrib to Failure	Reported progs	Rel.progs	Report Recommendations	Page No.	Item
The elevated temperatures cause thermal deterioration and dielectric breakdown	Not stated	Visual inspection, insulation resistance testing, clean	Vendor specific surveillance, IEEE 308-1980	Not stated	4-13, 5-7, 5-16	15
Breakdown of gaskets and seals, and all organic materials due to heat caused by current in the conductor, solar radiation, etc.	Not stated	Visual inspection, power factor testing, cleaning	Vendor specific surveillance, IEEE 308-1980	Manage bushing flashover by controling airborne dust and/or salt spray accumulation in combination with rain/humidity [2]	4-14, 5-7, 5-16, 5-22	16
The combination of dirt, dust, salt, and other contaminants, alone or with water or other liquid can form a conductive path leading to flashover of the bushing.	Not stated	Visual inspection, power factor testing, cleaning	Vendor specific surveillance, IEEE 308-1980	Not stated	4-14, 5-7, 5-17	17
Factors such as ultraviolet radiation, humidity, etc. can cause degradation over time	Not stated	Visual inspection, power factor testing, cleaning	Vendor specific surveillance, IEEE 308-1980	Not stated	4-14, 5-7, 5-17	18
Improper storage or loss of insulating oil, or voltage transients, can degrade the dielectric properties. Dielectric stress from potential gradient between the central conductor and other surfaces.	Not stated	Visual inspection, power factor testing, cleaning	Vendor specific surveillance, IEEE 308-1980	Not stated	4-14, 5-7, 5-17	19
Bearings and other parts wear over time due to friction and other stresses placed on them. This is accelerated by such stresses as frequent motor starting and stopping, undue vibration or transverse/longitudinal load placed on the driven unit.	Not stated	Visual inspection, monitor, adjust, lubricate, clean	Vendor specific surveillance, IEEE 308-1980	Not stated	4-15, 5-8, 5-17	20
Fouling of heat transfer surfaces such as radiators due to dirt, debris, or other materials	Not stated	Visual inspection, monitor, clean	Vendor specific surveillance, IEEE 308-1980	Not stated	4-16, 5-8, 5-17	21
Elevated temperatures and exposure to the elements can cause thermal and wear degradation to components.	Not stated	Visual inspection, adjust, repair/replace, clean	Vendor specific surveillance, IEEE 308-1980	Not stated	4-16, 5-9, 5-17	22
Wear to components such as sampling and isolation valves, fittings, and pressure regulating valves, can result in leakage of fluids, binding and/or malfunctioning of devices.	Not stated	Visual inspection, adjust, repair/replace, clean	Vendor specific surveillance, IEEE 308-1980	Not stated	4-17, 5-9, 5-18	23
Wear to components due to friction.	Not stated	Visual inspection, adjust, repair/replace, lubricate, clean	Vendor specific surveillance, IEEE 308-1980	Not stated	4-18, 5-9, 5-18	24
Vibration and mencanical stresses can result in a loss of adjustment in parts	Not stated	Visual inspection, adjust, repair/replace, lubricate, clean	Vendor specific surveillance, IEEE 308-1980	Not stated	4-18, 5-10, 5-18	25
Degradation of organic insulating materials in motor windings, insulators on main contacts, and materials used in related electrical components which can reduce their dielectric as well as mechanical properties.	Not stated	Visual inspection, adjust, repair/replace, clean	Vendor specific surveillance, IEEE 308-1980	Not stated	4-18, 5-10, 5-18	26
Degradation of organic materials used to seal the relay, can embrittle and harden the gaskets allowing leakage, possibly leading to the component failure.	Not stated	Visual inspection, functional testing	Vendor specific surveillance, IEEE 308-1980	Not stated	4-19, 5-11, 5-18	27
Repeated heating and cooling of the temperature indicator elements due to load variation induces thermal stresses which may eventually result in open-circuit failure of the element.	Not stated	Visual inspection, functional testing	No specific program	Not stated	4-20, 5-10, 5-19	28

Document: SAND93-7069, Aging Management Guideline for Commercial Nuclear Power Plants - Power and Distribution Transformers
Reviewed by: K. D. McCarthy, INEL

Item	System	Structure/Comp	Subcomponent	Materials	Manufacturer	ARD mechanism	ARD effects
1		Motor Control Center	Motor	Not stated	GE, Westinghouse, C-H, KM	THEM-CY, EMBR	Loss of electrical and mechanical properties of insulator
2		Motor Control Center	Motor	Not stated	GE, Westinghouse, C-H, KM	MOIST-EL, CONTAM, ENVIR	Loss of surface insulating properties
3		Motor Control Center	Motor	Not stated	GE, Westinghouse, C-H, KM	MOIST-EL, CONTAM, ENVIR	Loss of volumetric insulating properties
4		Motor Control Center	Motor	Not stated	GE, Westinghouse, C-H, KM	WEAR, CORR/OX, CONTAM	High resistance electrical connections
5		Motor Control Center	Motor	Not stated	GE, Westinghouse, C-H, KM	MECHSTR, VIBR	Loosening/loss of fasteners
6		Motor Control Center	Molded-Case Circuit Breakers	Case-phenolic or glass polyester, contact- silver or tungsten	GE, Westinghouse, C-H, KM	CURSTR	Contact surface deterioration
7		Motor Control Center	Molded-Case Circuit Breakers	Case-phenolic or glass polyester, contact- silver or tungsten	GE, Westinghouse, C-H, KM	FAT, MECHSTR	Fatigue of various circuit breaker components
8		Motor Control Center	Molded-Case Circuit Breakers	Case-phenolic or glass polyester, contact- silver or tungsten	GE, Westinghouse, C-H, KM	WEAR, CONTAM	Wear of internal components
9		Motor Control Center	Molded-Case Circuit Breakers	Case-phenolic or glass polyester, contact- silver or tungsten	GE, Westinghouse, C-H, KM	ELETEMP, CORR/OX, VIBR	Loose or high resistance elect connections or terminations
10		Motor Control Center	Molded-Case Circuit Breakers	Case-phenolic or glass polyester, contact- silver or tungsten	GE, Westinghouse, C-H, KM	CURSTR	Thermal trip setpoint variations
11		Motor Control Center	Molded-Case Circuit Breakers	Case-phenolic or glass polyester, contact- silver or tungsten	GE, Westinghouse, C-H, KM	CONTAM, ENVIR	Deterioration of lubricants
12		Motor Control Center	Molded-Case Circuit Breakers	Case-phenolic or glass polyester, contact- silver or tungsten	GE, Westinghouse, C-H, KM	ENVIR	Current limiting fuse failure

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Effect of Aging on Component Function	Contrib to Failure	Reported progs	Rel.progs	Report Recommendations	Page No.	Item
Exposure to ambient temps and ohmic heating can lead to loss of insulating properties and thermally induced cracking. This has the potential of causing a flashover of the component insulation and loss of structural integrity.	Not stated	Various recommendations made for maintenance	Vendor specific programs	Not stated	4-4, 4-5, 5-15	1
Voltage and humidity can affect energized insulation that is dirty or deteriorated and cause surface tracking paths on the insulator. This can lead to flashover.	Not stated	Various recommendations made for maintenance	Vendor specific programs	Not stated	4-6, 4-7, 5-15	2
Simultaneous exposure of thermally deteriorated insulation to temp, voltage, humidity, dirt and contaminants can result in loss of volumetric insulating properties, leading to increased surface and volumetric leakage currents and possible flashover	Not stated	Various recommendations made for maintenance	No specific program for this subcomponent	Not stated	4-6, 4-7, 5-15	3
Poor mating surface contact or sharp bends/current flow restrictions near crimps or terminations can cause high resistance elec connections which can result in excessive heating and potentially fire.	Not stated	Various recommendations made for maintenance	Vendor specific program	Not stated	4-5, 4-8, 5-15	4
Over-torquing of fasteners, and fasteners loosened by various external stresses (non-seismic) could cause loss of structural integrity or affect electrical connections.	Not stated	Various recommendations made for maintenance	Vendor specific program	Not stated	4-8, 5-15	5
High temps that accompany fault currents may cause contact material to vaporize, inducing a loss of contact surface material and pitting. This could cause the contacts to burn or weld together and result in breaker failure.	Not stated	Various recommendations made for maintenance	No specific program for this subcomponent	Not stated	4-9, 5-15	6
Cyclic stress can cause fatigue failure of various circuit breaker components such as contact assemblies, operating mechanisms, breaker housing. Fatigue may be evidenced by progressive cracking and ultimate failure of the component.	Not stated	Various recommendations made for maintenance	No specific program for this subcomponent	Not stated	4-9, 5-15	7
Inadequate or degraded lubrication, normal component wear, or wear caused by contaminants (from other degraded material or from external sources) can cause the breaker to malfunction.	Not stated	Various recommendations made for maintenance	No specific program for this subcomponent	Not stated	4-9, 5-15	8
Operation of the breaker and non-seismic vibration cause loose connections. oxidation or contamination of contact surfaces and sharp bends in wiring near terminations can cause high resistance connections. These can cause excessive heating or fire.	Not stated	Various recommendations made for maintenance	No specific program for this subcomponent	Not stated	4-9, 5-15	9
Exposure to fault currents can cause variations in the thermal trip setpoint of a circuit breaker. This can cause the CB to trip at progressively lower current levels, potentially causing nuisance tripping.	Not stated	Various recommendations made for maintenance	No specific program for this subcomponent	Not stated	4-10, 5-15	10
Contamination, aging, evaporation, and ambient temperatures can cause lubricants to deteriorate. this can slow or completely prevent operation of a breaker.	Not stated	Various recommendations made for maintenance	No specific program for this subcomponent	Not stated	4-10, 5-15	11
Fuses degrade slowly over time until eventually the current-carrying capability of the fuse is reached during normal/transient load operation, resulting in nuisance current interruptions.	Not stated	Various recommendations made for maintenance	Replace when inoperative	Not stated	4-10, 5-15	12

Table A.2 Gall Report for NPAR Reports

Document: SAND93-7069, Aging Management Guideline for Commercial Nuclear Power Plants - Notor Control Centers
Reviewed by: K. D. McCarthy, INEL

Item	System	Structure/Comp	Subcomponent	Materials	Manufacturer	ARD mechanism	ARD effects
13		Motor Control Center	Molded-Case Circuit Breakers	Case-phenolic or glass polyester, contact- silver or tungsten	GE, Westinghouse, C-H, KM	CURSTR, CONTAM	Surface current tracking/loss of insulating properties
14		Motor Control Center	Molded-Case Circuit Breakers	Case-phenolic or glass polyester, contact- silver or tungsten	GE, Westinghouse, C-H, KM	CURSTR, ELETEMP	Thermally induced degradation
15		Motor Control Center	Magnetic Contactors/Starters	Not stated	GE, Westinghouse, C-H, KM	ELETEMP	Insulation deterioration
16		Motor Control Center	Magnetic Contactors/Starters	Not stated	GE, Westinghouse, C-H, KM	ELETEMP	Organic component breakdown
17		Motor Control Center	Magnetic Contactors/Starters	Not stated	GE, Westinghouse, C-H, KM	VIB, WEAR	Cyclic fatigue
18		Motor Control Center	Magnetic Contactors/Starters	Not stated	GE, Westinghouse, C-H, KM	WEAR, VIB, CONTAM	Wear of contactor and starter subcomponents
19		Motor Control Center	Magnetic Contactors/Starters	Not stated	GE, Westinghouse, C-H, KM	CONTAM	Contact surface degradation
20		Motor Control Center	Thermal Overload Relays	Not stated	GE, Westinghouse, C-H, KM	WEAR, CURSTR	Degradation of heater or bimetallic elements
21		Motor Control Center	Thermal Overload Relays	Not stated	GE, Westinghouse, C-H, KM	CONT, WEAR	Binding of mechanical components
22		Motor Control Center	Thermal Overload Relays	Not stated	GE, Westinghouse, C-H, KM	CONT	Contact surface degradation
23		Motor Control Center	Thermal Overload Relays	Not stated	GE, Westinghouse, C-H, KM	ELETEMP, EMBR	Thermal degradation of organic materials

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Effect of Aging on Component Function	Contrib to Failure	Reported progs	Rel.progs	Report Recommendations	Page No.	Item
Voltage and humidity can affect energized insulation that is dirty or deteriorated and cause surface tracking paths on the insulator. Breaker arc-chute insulation is especially susceptible to surface current tracking. This can lead to flashover.	Not stated	Various recommendations made for maintenance	No specific program for this subcomponent	Not stated	4-10, 5-15	13
Fault currents can produce high temperatures and currents that can rapidly damage contacts, arc-chute surfaces and other organic materials. Continuous load currents can produce ohmic heating in poor connections. These can cause cb failure.	Not stated	Various recommendations made for maintenance	No specific program for this subcomponent	Not stated	4-11, 5-15	14
During operation, the heat generated in the coil during energization could cause insulation deterioration of the coil itself. This can lead to coil failure.	Not stated	Various recommendations made for maintenance	Vendor specific program	Not stated	4-12, 5-16	15
Prolonged coninuous energization of the contactor coil could result in excessive temperatures that cause the organic compounds that encapsulate the contactor to degrade. This could shorten life and lead to coil burnout.	Not stated	Various recommendations made for maintenance	No specific program for this subcomponent	Not stated	4-12, 5-16	16
Cyclic fatigue can occur in magnetic contactors if subjected to extremely high cycle operation. This can lead to heat generation because of higher resistivity, misalignment of contact, binding of armature, preventing full contact mating and arcing.	Not stated	Various recommendations made for maintenance	Vendor specific program	Not stated	4-13, 5-16	17
Binding of the contactor assembly, binding of contactor armature, binding of the contactor mechanism are all caused by wear, vibration and contamination. These can result in poor contactor/starter operation and failure.	Not stated	Various recommendations made for maintenance	Vendor specific program, replace when failed	Not stated	4-13, 5-16	18
Dust, dirt, and foreign material can lead to coil burnout, pitting of contact surfaces, and breakdown of adhesives and lubricants. They can also prevent the contact from closing. All the above can cause the contactor or starter to fail.	Not stated	Various recommendations made for maintenance	Vendor specific program	Not stated	4-13, 5-16	19
In bimetallic devices, variations in the current flowing through the heater will result in variations in device setpoint. These variations may be caused by changes in the characteristics of the heater element	Not stated	Various recommendations made for maintenance	Vendor specific program, replace when failed	Not stated	4-14, 5-16	20
Mechanical interference, dirt and friction may cause mechanical interference resulting in binding of mechanical components.	Not stated	Various recommendations made for maintenance	Replace when failed	Not stated	4-14, 5-17	21
Dust, dirt, and foreign material can lead to coil burnout, pitting of contact surfaces, and breakdown of adhesives and lubricants. They can also prevent the contact from closing. All the above can cause the relay to fail.	Not stated	Various recommendations made for maintenance	Vendor specific program, replace when failed	Not stated	4-14, 5-17	22
Elevated temperatures caused by the heaters cause aging of the heater element support material. Failure of the support block results in possible failure of the overload relay to perform its required function.	Not stated	Various recommendations made for maintenance	Vendor specific program, replace when failed	Not stated	4-14, 5-17	23

Document: SAND93-7069, Aging Management Guideline for Commercial Nuclear Power Plants - Notor Control Centers
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Item	System	Structure/Comp	Subcomponent	Materials	Manufacturer	ARD mechanism	ARD effects
24		Motor Control Center	Thermal Overload Relays	Not stated	GE, Westinghouse, C-H, KM	ELETEMP, CORR/OX, VIBR	Loose or high resistance elec connections or terminations
25		Motor Control Center	Miscellaneous Relays	Not stated	GE, Westinghouse, C-H, KM	ELETEMP	Thermal breakdown of organic materials
26		Motor Control Center	Miscellaneous Relays	Not stated	GE, Westinghouse, C-H, KM	CONT	Contact surface degradation
27		Motor Control Center	Miscellaneous Relays	Not stated	GE, Westinghouse, C-H, KM	WEAR, VIBR	Wear of mechanical parts
28		Motor Control Center	Miscellaneous Relays	Not stated	GE, Westinghouse, C-H, KM	ELETEMP, CORR/OX, VIBR	Loose or high resistance elect connections or terminations
29		Motor Control Center	Miscellaneous Relays	Not stated	GE, Westinghouse, C-H, KM	VOLTSTR	Coil dielectric breakdown
30		Motor Control Center	Control Transformers	Not stated	GE, Westinghouse, C-H, KM	ELETEMP	Winding insulation degradation
31		Motor Control Center	Control Transformers	Not stated	GE, Westinghouse, C-H, KM	CURSTR	Winding conductor failure
32		Motor Control Center	Control Transformers	Not stated	GE, Westinghouse, C-H, KM	ELETEMP, CORR/OX, VIBR	Loose or high resistance elect connections or terminations
33		Motor Control Center	Terminal Blocks	Not stated	GE, Westinghouse, C-H, KM	ELETEMP, CORR/OX, VIBR	Loose or high resistance elect connections or terminations
34		Motor Control Center	Terminal Blocks	Not stated	GE, Westinghouse, C-H, KM	ELETEMP, EMBR, ENVIR	Degradation or organic materials

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Effect of Aging on Component Function	Contrib to Failure	Reported progs	Rel.progs	Report Recommendations	Page No.	Item
Operation of the relay and non-seismic vibration cause loose connections. Oxidation or contamination of contact surfaces and sharp bends in wiring near terminations can cause high resistance connections. These can cause excessive heating or fire.	Not stated	Various recommendations made for maintenance	Vendor specific program	Not stated	4-15, 5-17	24
Prolonged continuous energization of the relay could result in excessive temperatures that cause the organic compounds that encapsulate the contactor to degrade. This could shorten life and lead to coil burnout.	Not stated	Various recommendations made for maintenance	No specific program for this subcomponent	Not stated	4-12, 5-17	25
Dust, dirt, and foreign material can lead to coil burnout, pitting of contact surfaces, and breakdown of adhesives and lubricants. They can also prevent the contact from closing. All the above can cause the relay to fail.	Not stated	Various recommendations made for maintenance	No specific program for this subcomponent	Not stated	4-15, 5-17	26
Wear can lead to setpoint drift, mechanical fatigue, surface burning caused by arcing, and insulation deterioration. These can result in reduced mechanical tolerances, jamming and binding of moving parts.	Not stated	Various recommendations made for maintenance	No specific program for this subcomponent	Not stated	4-17, 5-17	27
Operation of the relay and non-seismic vibration cause loose connections. Oxidation or contamination of contact surfaces and sharp bends in wiring near terminations can cause high resistance connections. These can cause excessive heating or fire.	Not stated	Various recommendations made for maintenance	No specific program for this subcomponent	Not stated	4-17, 5-17	28
Inductive voltage surges resulting from current interruptions can stress the relay coil. The inductive surge may cause coil dielectric breakdown at the weak points in the insulation, which can rapidly lead to insulation failure.	Not stated	Various recommendations made for maintenance	No specific program for this subcomponent	Not stated	4-18, 5-17	29
Ohmic heating and breaker internal ambient conditions cause elevated temperatures which lead to winding insulation degradation. This can produce shorted transformer winding, resulting in faulty voltage/current transformation or open circuit conditions.	Not stated	Various recommendations made for maintenance	No specific program for this subcomponent	Not stated	4-18, 5-17	30
Primary or secondary winding failure can result from continuous use for extended periods or from excessive current drawn through the winding from attached control power loads.	Not stated	Various recommendations made for maintenance	No specific program for this subcomponent	Not stated	4-18, 5-17	31
Non-seismic vibration can cause loose connections. oxidation or contamination of contact surfaces and sharp bends in wiring near terminations can cause high resistance connections. These can cause excessive heating or fire.	Not stated	Various recommendations made for maintenance	No specific program for this subcomponent	Not stated	4-18, 5-17	32
Operation of motor control center components and non-seismic vibration cause loose connections. Oxidation or contamination of surfaces and sharp bends in wiring near terminations cause high resistance connections. These can lead to heating or fire.	Not stated	Various recommendations made for maintenance	No specific program for this subcomponent	Not stated	4-19, 5-17	33
Terminal blocks and the organic glue or agent used to mount them may degrade because of ohmic heating, ambient temperature, humidity and vibration. This can result in embrittlement of the terminal blocks and loosening from their mounting surfaces.	Not stated	Various recommendations made for maintenance	No specific program for this subcomponent	Not stated	4-19, 5-17	34

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Item	System	Structure/Comp	Subcomponent	Materials	Manufacturer	ARD mechanism	ARD effects
35		Motor Control Center	Terminal Blocks	Not stated	GE, Westinghouse, C-H, KM	EXFORCE, MECHSTR	Degradation of terminal block hardware
36		Motor Control Center	Terminal Blocks	Not stated	GE, Westinghouse, C-H, KM	MOIST-EL, CONTAM, ENVIR	Loss of surface insulating properties
37		Motor Control Center	Terminal Blocks	Not stated	GE, Westinghouse, C-H, KM	MOIST-EL, CONTAM, ENVIR	Loss of volumetric insulating properties
38		Motor Control Center	Control Wiring	Copper wire insulated by ethylene propylene rubber or X-linked poly	GE, Westinghouse, C-H, KM	ELETEMP, EMBR	Insulation degradation
39		Motor Control Center	Control Wiring	Copper wire insulated by ethylene propylene rubber or X-linked poly	GE, Westinghouse, C-H, KM	ELETEMP	Conductor degredation
40		Motor Control Center	Control Wiring	Copper wire insulated by ethylene propylene rubber or X-linked poly	GE, Westinghouse, C-H, KM	VIBR, CORR/OX, ELETEMP, CONT, EXFORCE	Loose or high resistance elect connections or terminations
41		Motor Control Center	Fuse	Not stated	GE, Westinghouse, C-H, KM	FAT	Cyclic failure
42		Motor Control Center	Fuse	Not stated	GE, Westinghouse, C-H, KM	CORR/OX, CONT	High resistance contact surfaces
43		Motor Control Center	Fuse	Not stated	GE, Westinghouse, C-H, KM	ELETEMP, CORR/OX, VIBR, CONT	Loose or high resistance elect connections or terminations

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Item	System	Structure/Comp	Subcomponent	Materials	Manufacturer	ARD mechanism	ARD effects
1		Battery	Container	Polycarbonate, styrene acrylonitrile, butadiene, styrene	C&D, GNB, Exide	CORR/SCC, ELOTEMP, FAT	Cracks in container
2		Battery	Electrolyte	Sulfuric acid and water	C&D, GNB, Exide	CONTAM	Electrolyte consumed, water loss

Table A.2 Gall Report for NPAR Reports

Document: SAND93-7069, Aging Management Guideline for Commercial Nuclear Power Plants - Notor Control Centers
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Effect of Aging on Component Function	Contrib to Failure	Reported progs	Rel.progs	Report Recommendations	Page No.	Item
Terminal block hardware degrades primarily as a result of stresses produced during normal use. Improper maintenance techniques exacerbates this degradation.	Not stated	Various recommendations made for maintenance	No specific program for this subcomponent	Not stated	4-19, 5-17	35
Voltage and humidity can affect energized insulation that is dirty or deteriorated and cause surface tracking paths on the insulator. This can lead to flashover.	Not stated	Various recommendations made for maintenance	No specific program for this subcomponent	Not stated	4-20, 5-17	36
Simultaneous exposure to thermally deteriorated insulation to temp, voltage, humidity, dirt and contaminants can result in loss of volumetric insulating properties, leading to increased surface and volumetric leakage currents and possible flashover.	Not stated	Various recommendations made for maintenance	No specific program for this subcomponent	Not stated	4-20, 5-17	37
Insulation degradation can occur with exposure to elevated ambient temperature, ohmic heating of the conductor, and excessive ohmic heating that accompanies high resistivity connections.	Not stated	Various recommendations made for maintenance	No specific program for this subcomponent	Not stated	4-20, 5-17	38
Conductor degradation may result from bending, pulling, or crimping of the conductor or from localized heating (either from an external heat source or ohmic heating within the wire).	Not stated	Various recommendations made for maintenance	No specific program for this subcomponent	Not stated	4-20, 5-17	39
Loose or high resistance connections or terminations may occur from bending or pulling on wire, vibration of components, inadequate torquing of fasteners, or oxidation/corrosion/contamination of contact surfaces.	Not stated	Various recommendations made for maintenance	No specific program for this subcomponent	Not stated	4-21, 5-17	40
Cyclic fatigue of the fuse holder is primarily associated with the installation or removal of fuse elements; usualy some sort of frictional arrangement is employed to keep the fuse secure and properly connected.	Not stated	Various recommendations made for maintenance	No specific program for this subcomponent	Not stated	4-21, 5-18	41
High resistance contact surfaces may result from corrosion, oxidation, or contamination of the surfaces in contact with the fuse element itself. This condition may result in a loss of continuity or increased localized heating.	Not stated	Various recommendations made for maintenance	Vendor specific programs	Not stated	4-21, 5-18	42
Loose or high resistance connections or terminations may occur from vibration of components, inadequate torquing of fasteners, or oxidation/corrosion/contamination of contact surfaces.	Not stated	Various recommendations made for maintenance	No specific program for this subcomponent	Not stated	4-21, 5-18	43

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Effect of Aging on Component Function	Contrib to Failure	Reported progs	Rel.progs	Report Recommendations	Page No.	Item
Cracks in container caused by mishandling during maintenance/installation, seismic events, plate growth and improper use of grease or cleaning solvents lead to electrolyte leakage resulting in reduced capacity.	Not stated	IEEE Std-450,535, 10 CFR 50.49,NMAC TR-100248	Tech Spec. surveillance, RG 1.129, IEEE 450	Not stated	4-17, 21, 25, 26	1
Sulfation caused by undercharging & impurities consume electrolyte and results in reduced capacity.	Not stated	IEEE Std-450,535, 10 CFR 50.49,NMAC TR-100248	Tech Spec. surveillance, RG 1.129, IEEE 450	Not stated	4-23	2

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Item	System	Structure/Comp	Subcomponent	Materials	Manufacturer	ARD mechanism	ARD effects
3		Battery	Electrolyte	Sulfuric acid and water	C&D, GNB, Exide	GAS, ELETEMP	Gassing causes water loss from electrolyte
4		Battery	Plates	Lead antimony, lead calcium, lead	C&D, GNB, Exide	FAT, ELETEMP, MECHSTR	Increased mechanical stres on plates
5		Battery	Plates	Lead antimony, lead calcium, lead	C&D, GNB, Exide	GAS	Active material shedding from plates
6		Battery	Plates	Lead antimony, lead calcium, lead	C&D, GNB, Exide	CORR/OX	Increase in battery internal resistance
7		Battery	Plates	Lead antimony, lead calcium, lead	C&D, GNB, Exide	CONTAM	Local action at plates
8		Battery	Cell Top Straps	Not stated	C&D, GNB, Exide	CORR/OX	Increased battery internal resistance
9		Battery	Cell Top Straps	Not stated	C&D, GNB, Exide	FAT	Increased mechanical stress on cell top stra[illegible]
10		Battery	Separators	Rubber/glass mat, polyethylene	C&D, GNB, Exide	Not stated	Hydration caused by electrolyte low specific gravity
11		Battery	Separators	Rubber/glass mat, polyethylene	C&D, GNB, Exide	ELETEMP	Thermal aging caused by excessive electrolyte temperature
12		Battery	Terminal Posts	Lead alloy, copper inserts	C&D, GNB, Exide	CORR	High connection resistance and embrittlement of material
13		Battery	Terminal Posts	Lead alloy, copper inserts	C&D, GNB, Exide	FAT	Cracked or broken terminal posts

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Effect of Aging on Component Function	Contrib to Failure	Reported progs	Rel.progs	Report Recommendations	Page No.	Item
Gassing and electrolyte evaporation occur from overcharging and excessive temperatures. Gassing and evaporation main cause of water loss in electrolyte. Results in reduced capacity.	Not stated	IEEE Std-450,535,10 CFR 50.49, NMAC TR-100248	Tech Spec. surveillance, RG 1.129, IEEE 450	Not stated	4-23	3
Repeated thermal and mechanical stresses from battery charge/discharge cycles and seismic events can cause loss of active material or loss of electrical continuity, resulting in reduced battery capacity or total loss of battery output.	Not stated	IEEE Std-450,535,10 CFR 50.49, NMAC TR-100248	Tech Spec. Surveillance, IEEE 450-1987	Not stated	4-22	4
Active material shedding from plates results in sediment buildup at the bottom of cell. this can cause short circuits between the positive and negative plates, resulting in reduced capacity and eventually the inability to hold a charge.	Not stated	IEEE Std-450,535,10 CFR 50.49, NMAC TR-100248	Tech Spec. Surveillance, IEEE 450-1987	Not stated	4-23	5
Corrosion caused by oxidizing environment that exists at the positive plates. Plates become brittle and break down, decreasing their cross sectional area and increasing resistance. This leads to seismic vulnerability and decreased battery capacity.	Not stated	IEEE Std-450,535,10 CFR 50.49, NMAC TR-100248	Tech Spec. Surveillance, IEEE 450-1987	Not stated	4-22	6
Electrochemical reactions due to impurities in the electrolyte cause local action at the plates resulting in decreased battery capacity and potential overcharging of the positive plates.	Not stated	IEEE Std-450,535,10 CFR 50.49, NMAC TR-100248	Tech Spec. Surveillance, IEEE 450-1987	Not stated	4-21	7
Corrosion caused by oxidizing environment that exists at the positive plates. Straps become brittle and break down, decreasing their cross sectional area and increasing resistance. This leads to seismic vulnerability and decreased battery capacity.	Not stated	IEEE Std-450,535,10 CFR 50.49, NMAC TR-100248	Tech Spec. Surveillance, IEEE 450-1987	Not stated	4-22	8
Repeated thermal and mechanical stresses from battery charge/discharge cycles and seismic events can cause fatigue failure. This can cause loss of electrical continuity, resulting in reduced battery capacity or total loss of output.	Not stated	IEEE Std-450,535,10 CFR 50.49, NMAC TR-100248	Tech Spec. Surveillance, IEEE 450-1987	Not stated	4-22	9
Hydration causes material chemical changes in separators. Formation of metallic lead on surface of separators builds numerous short circuit paths between pos & neg plates, resulting in inability to hold charge.	Not stated	IEEE Std-450,535,10 CFR 50.49, NMAC TR-100248	No program specific to this material	Not stated	4-21	10
Excessive electrolyte temp caused by overcharging or excessive ac ripple on the charger output reduces dielectric strength of separator mat'l and causes structural deterioration, resulting in reduced battery capacity or inability to hold charge.	Not stated	IEEE Std-450,535,10 CFR 50.49, NMAC TR-100248	No program specific to this material	Not stated	4-23	11
High connection resistance and embrittlement of material in terminal posts results in decreased battery output and overheating of the posts.	Not stated	IEEE Std-450,535,10 CFR 50.49, NMAC TR-100248	Tech. Spec. surveillance, IEEE 450-1987	Not stated	4-22	12
Repeated or improper torquing of connections during instal/maint can result in cracked or broken terminal posts. This results in increased connection resistance or loss of electrical continuity, resulting in reduced capacity or loss of battery output.	Not stated	IEEE Std-450,535,10 CFR 50.49, NMAC TR-100248	Tech. Spec. surveillance, IEEE 450-1987	Not stated	4-22	13

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Item	System	Structure/Comp	Subcomponent	Materials	Manufacturer	ARD mechanism	ARD effects
14		Battery	Terminal Posts	Lead alloy, copper inserts	C&D, GNB, Exide	CORR	Fouling of terminal posts
15		Battery	Intercell Connectors	Lead plated copper bars	C&D, GNB, Exide	CORR	High connection resistance, embrittlement
16		Battery	Intercell Connectors	Lead plated copper bars	C&D, GNB, Exide	FAT	Cracked or broken intercell connectors
17		Battery	Intercell Connectors	Lead plated copper bars	C&D, GNB, Exide	CORR	Fouling of intercell connectors
18		Battery	Terminal Post Seals	Not stated	C&D, GNB, Exide	FAT	Cracking of the terminal post seals
19		Battery	Battery Racks	Steel	Not stated	CORR, FAT	Rack structure weakened
20		Battery	Container	Polypropylene	C&D, GNB, Exide	CORR/SCC, FAT	Cracks in container
21		Battery	Container	Polypropylene	C&D, GNB, Exide	FAT	Fatigue cracking of cover
22		Battery	Electrolyte	Potassium Hydroxide	C&D, GNB, Exide	Not stated	Decreased conductivity of electrolyte
23		Battery	Electrolyte	Potassium Hydroxide	C&D, GNB, Exide	GAS	Gassing causes water loss from electrolyte
24		Battery	Plates	Nickel hydroxide, cadmium hydorxide	C&D, GNB, Exide	Not stated	Aging of active material

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Effect of Aging on Component Function	Contrib to Failure	Reported progs	Rel.progs	Report Recommendations	Page No.	Item
Fouling of terminal posts can occur due to accumulation of dirt, dust, and leaked electrolyte. This can cause corrosion at the electrical connections, short circuits, and battery grounding, resulting in degraded battery output, discharge or overheating.	Not stated	IEEE Std-450,535,10 CFR 50.49, NMAC TR-100248	Tech. Spec. surveillance, IEEE 450-1987	Not stated	4-24	14
Excessive ambient humidity, external dust and dirt, electrolyte leaks and spills can cause corrosion of connectors. This results in high connection resistance and embrittlement resulting in decreased battery output and overheating of connectors.	Not stated	IEEE Std-450,535,10 CFR 50.49, NMAC TR-100248	Tech. Spec. surveillance, IEEE 450-1987	Not stated	4-22	15
Repeated or improper torquing of connections during install/maint can result in cracked or broken intercell connectors. This results in increased connection resistance or loss of elec continuity, resulting in reduced capacity or loss of battery output.	Not stated	IEEE Std-450,535,10 CFR 50.49, NMAC TR-100248	Tech. Spec. surveillance, IEEE 450-1987	Not stated	4-22	16
Fouling of intercell connectors can occur due to accumulation of dirt, dust, and leaked electrolyte. This can cause corrosion at the electrical connections, short circuits, and battery grounding, resulting in degraded output, discharge or overheating.	Not stated	IEEE Std-450,535,10 CFR 50.49, NMAC TR-100248	Tech. Spec. surveillance, IEEE 450-1987	Not stated	4-24	17
Fatigue failures can occur in post seals due to improper handling, plate growth, excessive corrosion which stresses the seals and covers. This can cause a loss of electrolyte and venting of gases, resulting in reduced capacity or loss of output.	Not stated	IEEE Std-450,535,10 CFR 50.49, NMAC TR-100248	Tech. Spec. surveillance, IEEE 450-1987	Not stated	4-23	18
Electrolyte leaks or spills, humidity and high temp can cause corrosion of battery rack which can weaken the structure. This can cause structural failure and loss of supported battery.	Not stated	IEEE Std-450,535,10 CFR 50.49, NMAC TR-100248	Tech. Spec. surveillance, IEEE 450-1987	Not stated	4-22	19
Damage to container is caused by improper use of greases and cleaning solvents which react with container material or weaken the structure. This can lead to reduced capacity.	Not stated	IEEE Std-1106,10 CFR 50.49,EPRI NMAC TR-10248	Tech. Spec. surveillance, IEEE 1106-1987	Not stated	4-25	20
Thermal expansion and improper handling introduce stresses to container cover which can cause cracking. This can result in gas release, possible air intrussion, and loss of electrolyte which may result in conductive paths to ground and loss of capacity.	Not stated	IEEE Std-1106,10 CFR 50.49,EPRI NMAC TR-10248	Tech. Spec. surveillance, IEEE 1106-1987	Not stated	4-25	21
Material chemical changes occur due to carbonation of potassium hydroxide electrolyte when exposed to carbon dioxide in air, which decreases conductivity of electrolyte. This increases battery internal resistance and decreases capacity.	Not stated	IEEE Std-1106,10 CFR 50.49,EPRI NMAC TR-10248	Tech. Spec. surveillance, none for this comp.	Not stated	4-24	22
Gassing & electrolyte evaporation is due to overcharging and elevated temp. These cause electrolyte water loss, which will reduce battery capacity. Evaporation also contributes to water loss.	Not stated	IEEE Std-1106,10 CFR 50.49,EPRI NMAC TR-10248	Tech. Spec. surveillance, IEEE 1106-1987	Not stated	4-26	23
Recrystallization of the nickel hydroxide in the positive plates causes gradual aging of the active material. This results in reduced capacity.	Not stated	IEEE Std-1106,10 CFR 50.49,EPRI NMAC TR-10248	Tech. Spec. surveillance, none for this comp.	Not stated	4-24	24

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Item	System	Structure/Comp	Subcomponent	Materials	Manufacturer	ARD mechanism	ARD effects
25		Battery	Separators	Plastic	C&D, GNB, Exide	ELETEMP	Reduced delectric strength of separator material
26		Battery	Terminal Posts	Not stated	C&D, GNB, Exide	CORR	Failure of terminal posts
27		Battery	Terminal Posts	Not stated	C&D, GNB, Exide	FAT	Cracked or broken terminal posts
28		Battery	Terminal Posts	Not stated	C&D, GNB, Exide	CORR	Corrosion, short ckts and grounding caused by fouling
29		Battery	Intercell Connectors	Nickel-plated copper bars with stainless steel hardware	C&D, GNB, Exide	CORR	Failure of intercell connectors
30		Battery	Intercell Connectors	Nickel-plated copper bars with stainless steel hardware	C&D, GNB, Exide	FAT	Cracked or broken intercell connectors
31		Battery	Intercell Connectors	Nickel-plated copper bars with stainless steel hardware	C&D, GNB, Exide	CORR	Corrosion, short ckts, grounding caused by fouling
32		Battery	Terminal Post Seals	Not stated	C&D, GNB, Exide	FAT	Fatigue cracking of post seals
33		Battery	Battery Racks	Steel	Not stated	CORR, FAT	Rack structure weakened
34		Battery	Pressure Relier Valve	Not stated	Not stated	Not stated	Malfunction of valve
35		Battery	Electrolyte	Not stated	Not stated	Not stated	Dryout of electrolyte
36		Battery	Electrolyte	Not stated	Not stated	ELETEMP	Thermal runaway

Document: SAND93-7071, Aging Management Guideline for Commercial Nuclear Power Plants - Stationary Batteries
Reviewed by: K. D. McCarthy, INEL

Effect of Aging on Component Function	Contrib to Failure	Reported progs	Rel.progs	Report Recommendations	Page No.	Item
Overcharging or excessive ac ripple on charger output cause excessive electrolyte temp which reduces the dielectric strength of separator mat'l & deteriorates mech strength. This results in reduced capacity & eventual inability to hold charge.	Not stated	IEEE Std-1106,10 CFR 50.49,EPRI NMAC TR-10248	No program specific to this subcomponent	Not stated	4-26	25
Humidity, dust, and elevated temperatures can lead to corrosion of the terminal posts. This can lead to failure of terminal posts.	Not stated	IEEE Std-1106,10 CFR 50.49,EPRI NMAC TR-10248	Tech. Spec. required surveillance. IEEE 1106	Not stated	4-25	26
Repeated or improper torquing of connections can result in cracked or broken terminal posts. This results in increased connection resistance or loss of continuity. This results in reduced capacity or total loss of output.	Not stated	IEEE Std-1106,10 CFR 50.49,EPRI NMAC TR-10248	Tech. Spec. required surveillance. IEEE 1106	Not stated	2-25	27
Fouling of terminal posts caused by accumulation of dirt, dust, and leaked electrolyte can cause corrosion, short circuits between pos and neg posts, and battery grounding. This results in degraded output, batt discharge, or overheating of connections.	Not stated	IEEE Std-1106,10 CFR 50.49,EPRI NMAC TR-10248	Tech. Spec. required surveillance. IEEE 1106	Not stated	4-24	28
Humidity, dust, and temperature can lead to corrosion of intercell connectors. This can lead to failure of the intercell connectors.	Not stated	IEEE Std-1106,10 CFR 50.49,EPRI NMAC TR-10248	Tech. Spec. required surveillance. IEEE 1106	Not stated	4-25	29
Repeated or improper torquing of connections can result in cracked or broken intercell connectors. This results in increased connection resistance or loss of continuity which reduces battery capacity or results in total loss of battery output.	Not stated	IEEE Std-1106,10 CFR 50.49,EPRI NMAC TR-10248	Tech. Spec. required surveillance. IEEE 1106	Not stated	4-25	30
Dirt, dust, and leaked electrolyte cause fouling of intercell connectors. fouling coupled with moisture condensation leads to corrosion, which causes current paths to ground. This results in degraded batt output, discharge or overheating of connections.	Not stated	IEEE Std-1106,10 CFR 50.49,EPRI NMAC TR-10248	Tech. Spec. required surveillance. IEEE 1106	Not stated	4-26	31
Excessive stresses caused by thermal expansion, corrosion of terminal posts, and improper handling can lead to fatigue cracking of terminal post seals, leading to gas release, air intrusion, loss of electrolyte. Results in conductive paths to ground.	Not stated	IEEE Std-1106,10 CFR 50.49,EPRI NMAC TR-10248	Tech. Spec. required surveillance. IEEE 1106	Not stated	4-25	32
Humidity, dust accumulation, and temperature can lead to corrosion in the battery racks. This can cause structural failure and loss of supported battery.	Not stated	IEEE Std-1106,10 CFR 50.49,EPRI NMAC TR-10248	IEEE 1106-1987	Not stated	4-25	33
Wear occurs due to relative movement between contacting internal parts and can cause malfunction of valve. This can allow gases and vapors to escape, resulting in lowered gas recombination efficiency. This can lead to dryout.	Not stated	IEEE Std-1106,10 CFR 50.49,EPRI NMAC TR-10248	No program specific to this subcomponent	Not stated	4-27	34
Overcharging, elevated temperatures, failed pressure relief valve or cracked container or seal can lead to dryout of electrolyte. This can result in battery failure.	Not stated	IEEE PAR 1188, 10 CFR 50.49, NMAC TR-100248	Tech. Spec. surveillance, IEEE 450 & 1106	Not stated	4-27	35
Elevated temperature, improper (high) float voltage, or excessive ac ripple from battery charger can cause thermal runaway. This can result in battery failure.	Not stated	IEEE PAR 1188, 10 CFR 50.49, NMAC TR-100248	Tech. Spec. surveillance, IEEE 450-1987	Not stated	4-28	36

Document: SAND93-7071, Aging Management Guideline for Commercial Nuclear Power Plants - Stationary Batteries
Reviewed by: K. D. McCarthy, INEL

Item	System	Structure/Comp	Subcomponent	Materials	Manufacturer	ARD mechanism	ARD effects
37		Battery	Electrolyte	Not stated	Not stated	Not stated	Memory effect

Document: TIRGALEX, Plan for Integration of Aging and Life-Extension Activities
Reviewed by: L. C. Meyer, INEL

Item	System	Structure/Comp	Subcomponent	Materials	Manufacturer	ARD mechanism	ARD effects
1		Cable	Not stated	Not stated	Not stated	ELETEMP, RAD, MOIST-EL, & VIB.	Not stated
2		Conectors	Not stated	Not stated	Not stated	ELETEMP, RAD, MOIST-EL, & VIB.	Not stated
3		Switchgear	Not stated	Not stated	Not stated	WEAR & LOSLUB	Not stated
4		Relays	Not stated	Not stated	Not stated	CORR, WEAR, & ELETEMP	Not stated

Document: WYLE 60103-1, Test Plan of Molded Case Circuit Breakers for the Comprehensive Aging Assessment of Circuit Breakers and Relays for Nuclear Plant
Reviewed by: L. C. Meyer, INEL

Item	System	Structure/Comp	Subcomponent	Materials	Manufacturer	ARD mechanism	ARD effects
1		Molded Case Circuit Breakers	5 Relay Types and 3 Types of Circuit Breakers	Not stated	Three mfg. listed	Not stated	Not stated

Document: WYLE 60103-2, Test Plan of Metal Clad Circuit Breakers for the Comprehensive Aging Assessment of Circuit Breakers and Relays for —— NPAR Pro
Reviewed by: L. C. Meyer, INEL

Item	System	Structure/Comp	Subcomponent	Materials	Manufacturer	ARD mechanism	ARD effects
1		Metal Clad Circuit Breakers	Not stated	Not stated	GE & Westinghouse	Not stated	Not stated

Document: WYLE 60103-3, Test Plan of Auxiliary Relays for the Comprehensive Aging Assessment of Circuit Breakers and Relays for — (NPAR) Program Phase
Reviewed by: L. C. Meyer, INEL

Item	System	Structure/Comp	Subcomponent	Materials	Manufacturer	ARD mechanism	ARD effects
1		Auxiliary Relays	Not stated	Not stated	Westinghouse	Not stated	Not stated

Document: WYLE 60103-4, Test Plan of Control Relays for the Comprehensive Aging Assessment of Circuit Breakers and Relays for —— (NPAR) Program, Phas
Reviewed by: L. C. Meyer, INEL

Item	System	Structure/Comp	Subcomponent	Materials	Manufacturer	ARD mechanism	ARD effects
1		Control Relays	Not stated	Not stated	Three mfg.s listed	Not stated	Not stated

Document: WYLE 60103-5, Test Plan of Protective Relays for the Comprehensive Aging Assessment of Circuit Breakers and Relays for Nuclear Plant Aging Rese
Reviewed by: L. C. Meyer, INEL

Item	System	Structure/Comp	Subcomponent	Materials	Manufacturer	ARD mechanism	ARD effects
1		Protective Relays	Not stated	Not stated	GE & Westinghouse	Not stated	Not stated

Table A.2 Gall Report for NPAR Reports

Document: SAND93-7071, Aging Management Guideline for Commercial Nuclear Power Plants - Stationary Batteries
Reviewed by: K. D. McCarthy, INEL

Effect of Aging on Component Function	Contrib to Failure	Reported progs	Rel.progs	Report Recommendations	Page No.	Item
Successive small discharge cycles can lead to a memory effect in a sintered plate nickel-cadmium battery. This can result in reduced capacity.	Not stated	IEEE PAR 1188, 10 CFR 50.49, NMAC TR-100248	Tech. Spec. surveillance, IEEE 450-1987	Not stated	4-28	37

Document: TIRGALEX, Plan for Integration of Aging and Life-Extension Activities
Reviewed by: L. C. Meyer, INEL

Effect of Aging on Component Function	Contrib to Failure	Reported progs	Rel.progs	Report Recommendations	Page No.	Item
Not stated	Not stated	IBE79-01, NUREG-0588, 10CFR 50.49, & RG 1.89	No specific program	Five recommendations are given for resolving aging and life extension issues [4]	A31-A36	1
Not stated	Not stated	IBE79-01, NUREG-0588, 10CFR 50.49, & RG 1.89	No specific program	Five recommendations are given for resolving aging and life extension issues [1]	A31-A36	2
Not stated	Not stated	Generic Letter 83-28 concerns and Tech Specs	IEEE 741-1986 Section 7	Three issues requiring followup are listed. [1]	A51 & A53	3
Not stated	Not stated	Generic Letter 83-28 concerns and Tech Specs	Dependent upon type and function of the relay	Followup on calibration frequency for protective relays, seismic fragility, and effect of common mode failure on safety [1]	A52 & A53	4

Document: WYLE 60103-1, Test Plan of Molded Case Circuit Breakers for the Comprehensive Aging Assessment of Circuit Breakers and Relays for Nuclear Plan
Reviewed by: L. C. Meyer, INEL

Effect of Aging on Component Function	Contrib to Failure	Reported progs	Rel.progs	Report Recommendations	Page No.	Item
Not stated	Not stated	Not discussed in report	No specific program, application dependent	Not stated	1-1	1

Document: WYLE 60103-2, Test Plan of Metal Clad Circuit Breakers for the Comprehensive Aging Assessment of Circuit Breakers and Relays for —— NPAR Pro
Reviewed by: L. C. Meyer, INEL

Effect of Aging on Component Function	Contrib to Failure	Reported progs	Rel.progs	Report Recommendations	Page No.	Item
Not stated	Not stated	Not discussed in report	RG 1.118, IEEE 338-1987, TECH. SPEC. MAINT. &	Not stated	4-1	1

Document: WYLE 60103-3, Test Plan of Auxiliary Relays for the Comprehensive Aging Assessment of Circuit Breakers and Relays for — (NPAR) Program Phas
Reviewed by: L. C. Meyer, INEL

Effect of Aging on Component Function	Contrib to Failure	Reported progs	Rel.progs	Report Recommendations	Page No.	Item
Not stated	Not stated	Not discussed in report	Dependent upon application, Tech. Spec. maint	Not stated	1-1, 1-2, & 4-1	1

Document: WYLE 60103-4, Test Plan of Control Relays for the Comprehensive Aging Assessment of Circuit Breakers and Relays for —— (NPAR) Program, Pha
Reviewed by: L. C. Meyer, INEL

Effect of Aging on Component Function	Contrib to Failure	Reported progs	Rel.progs	Report Recommendations	Page No.	Item
Not stated	Not stated	Not discussed in report	No specific program	Not stated	3-1	1

Document: WYLE 60103-5, Test Plan of Protective Relays for the Comprehensive Aging Assessment of Circuit Breakers and Relays for Nuclear Plant Aging Rese
Reviewed by: L. C. Meyer, INEL

Effect of Aging on Component Function	Contrib to Failure	Reported progs	Rel.progs	Report Recommendations	Page No.	Item
Not stated	Not stated	Not discussed in report	Tech Spec surveillance	Not stated	4-1	1

Document: WYLE 60103-6, Test Plan of Timing Relays for the Comprehensive Aging Assessment of Circuit Breakers and Relays for Nuclear Plant Aging Researc
Reviewed by: L. C. Meyer, INEL

Item	System	Structure/Comp	Subcomponent	Materials	Manufacturer	ARD mechanism	ARD effects
1		Timing Relays	Not stated	Not stated	Agastat	OXIDAT	Degradation caused by oxidation surfaces

Document: WYLE 60103-7, Test Plan of Electronic Relays for the Comprehensive Aging Assessment of Circuit Breakers and Relays for Nuclear Plant Aging Rese
Reviewed by: L. C. Meyer, INEL

Item	System	Structure/Comp	Subcomponent	Materials	Manufacturer	ARD mechanism	ARD effects
1		Electronic Relays	Not stated	Not stated	Basler	Not stated	Not stated

Document: WYLE 60103-6, Test Plan of Timing Relays for the Comprehensive Aging Assessment of Circuit Breakers and Relays for Nuclear Plant Aging Researc
Reviewed by: L. C. Meyer, INEL

Effect of Aging on Component Function	Contrib to Failure	Reported progs	Rel.progs	Report Recommendations	Page No.	Item
Relay failure due to contact oxidation caused by low current application of silver alloy contacts.	Occasional	Not discussed in report	Application dependent, Tech Spec Surveill.	Not stated	4-1	1

Document: WYLE 60103-7, Test Plan of Electronic Relays for the Comprehensive Aging Assessment of Circuit Breakers and Relays for Nuclear Plant Aging Rese
Reviewed by: L. C. Meyer, INEL

Effect of Aging on Component Function	Contrib to Failure	Reported progs	Rel.progs	Report Recommendations	Page No.	Item
Not stated	Not stated	Not discussed in report	Application dependent, likely no program	Not stated	4-1	1

Table A.2 Gall Report for NRC Generic Letters

Document: GL 91-15, Operating Experience Feedback Report, Solenoid-Operated Valve Problems at U.S. Reactors
Reviewed by: E. W. Roberts, INEL

Item	System	Structure/Comp	Subcomponent	Materials	Manufacturer	ARD mechanism	ARD effects
1	Not stated	Not stated	Solenoid Operated Valves	Not stated	Not stated	Not stated	Not stated

Table A.2 Gall Report for NRC Generic Letters

Document: GL 91-15, Operating Experience Feedback Report, Solenoid-Operated Valve Problems at U.S. Reactors
Reviewed by: E. W. Roberts, INEL

Effect of Aging on Component Function	Contrib to Failure	Reported progs	Rel.progs	Report Recommendations	Page No.	Item
Reference to case report study NUREG-1275, volume 6, "Operating Experience Feedback Report--Solenoid-Operated Valve Problems," February 1991	Not stated	Not discussed in report	Vendor specific program	Review info and consider actions as appropriate [4]		1

Document: IN NO. 89-07, Failures of Small-Diameter Tubing in Control Air, Fuel Oil, and Lube Oil Systems Which Render Emergency Diesel Gener[illegible]rs Inoperativ
Reviewed by: E. W. Roberts, INEL

Item	System	Structure/Comp	Subcomponent	Materials	Manufacturer	ARD mechanism	ARD effects
1	Emergency diesel generators		Small Diameter Tubing	Stainless Steel	Not stated	VIBR	Cracks, breaks, & holes in tubing

Document: IN NO. 89-17, Contamination and Degradation of Safety-Related Battery Cells
Reviewed by: E. W. Roberts, INEL

Item	System	Structure/Comp	Subcomponent	Materials	Manufacturer	ARD mechanism	ARD effects
2			Battery Cells Connections	Copper	Not stated	CONTAM	Electrolytic transfer of copper to battery lead term/plates

Document: IN NO. 89-20, Weld Failures in A Pump of Byron-Jackson Design
Reviewed by: E. W. Roberts, INEL

Item	System	Structure/Comp	Subcomponent	Materials	Manufacturer	ARD mechanism	ARD effects
3		Pump	Welds	Not stated	Byron Jackson	VIBR	Weld cracks

Document: IN NO. 89-42, Failure of Rosemount Models 1153 and 1154 Transmitters
Reviewed by: E. W. Roberts, INEL

Item	System	Structure/Comp	Subcomponent	Materials	Manufacturer	ARD mechanism	ARD effects
4			Pressure Transmitters	Not stated	Rosemount	Not stated	Loss of oil from sensing module

Document: IN NO. 89-43, Permanent Deformation of Torque Switch Helical Springs in Limitorque SMA-Type Motor Operators
Reviewed by: E. W. Roberts, INEL

Item	System	Structure/Comp	Subcomponent	Materials	Manufacturer	ARD mechanism	ARD effects
5		Torque Switch	Helical Springs	Not stated	Limitorque	MECHSTR	Permnent deformation of helical spring

Document: IN NO. 89-64, Electrical Bus Bas Failures
Reviewed by: E. W. Roberts, INEL

Item	System	Structure/Comp	Subcomponent	Materials	Manufacturer	ARD mechanism	ARD effects
6		Electrical Bus	Noryl Insulation	Not stated	Not stated	CONTAM EMBR	Electrical ground fault, short to ground

Document: IN NO. 89-66, Qualification Life of Solenoid Valves
Reviewed by: E. W. Roberts, INEL

Item	System	Structure/Comp	Subcomponent	Materials	Manufacturer	ARD mechanism	ARD effects
7		Duel-Coil Solenoid Valve	Elastomer Seat	Ethylene Propylene Dimer (EPDM)	Automatic Switch Co.	CONTAM ELETEMP	Sticky and deformed seats

Document: IN NO. 89-79, Degraded Coatings and Corrosion of Steel Containment Vessels
Reviewed by: E. W. Roberts, INEL

Item	System	Structure/Comp	Subcomponent	Materials	Manufacturer	ARD mechanism	ARD effects
8		Containment Vessels	Coatings	Not stated	Not stated	MOIST-EL	Coating failure

Document: IN NO. 89-84, Failure of Ingersoll Rand Air Start Motors as A Result of Pinion Gear Assembly Fitting Problems
Reviewed by: E. W. Roberts, INEL

Item	System	Structure/Comp	Subcomponent	Materials	Manufacturer	ARD mechanism	ARD effects
9	Diesel Generator	Air Starter Pinion Gear	Tang and Retainer Bolts	Not stated	Ingersoll Rand	WEAR VIBR	Cracking of retainer ring and loosening of bolts

Document: IN NO. 89-07, Failures of Small-Diameter Tubing in Control Air, Fuel Oil, and Lube Oil Systems Which Render Emergency Diesel Generators Inoperati
Reviewed by: E. W. Roberts, INEL

Effect of Aging on Component Function	Contrib to Failure	Reported progs	Rel.progs	Report Recommendations	Page No.	Item
Inoperability of EDG	Not stated	Not discussed in report	Vendor specific, RG 1.108, IEEE 387, IEEE 749	Review info and take actions as appropriate. [4]		1

Document: IN NO. 89-17, Contamination and Degradation of Safety-Related Battery Cells
Reviewed by: E. W. Roberts, INEL

Effect of Aging on Component Function	Contrib to Failure	Reported progs	Rel.progs	Report Recommendations	Page No.	Item
Loss of battery capacity	Not stated	Tech. spec requires exam, clean, & test connections	Tech. Spec., RG 1.129, IEEE 450-1987	Review info and take actions as appropriate [4]		2

Document: IN NO. 89-20, Weld Failures in A Pump of Byron-Jackson Design
Reviewed by: E. W. Roberts, INEL

Effect of Aging on Component Function	Contrib to Failure	Reported progs	Rel.progs	Report Recommendations	Page No.	Item
Broken ring and impeller - fasteners in recirculation loop	Not stated	Not discussed in report	Vendor specific, may have Tech. Spec. surveil	Review info and take actions as appropriate [4]		3

Document: IN NO. 89-42, Failure of Rosemount Models 1153 and 1154 Transmitters
Reviewed by: E. W. Roberts, INEL

Effect of Aging on Component Function	Contrib to Failure	Reported progs	Rel.progs	Report Recommendations	Page No.	Item
Transmitter failure	Not stated	Not discussed in report	Bul 90-1 Suppl. 1	Review info and take actions as appropriate [4]		4

Document: IN NO. 89-43, Permanent Deformation of Torque Switch Helical Springs in Limitorque SMA-Type Motor Operators
Reviewed by: E. W. Roberts, INEL

Effect of Aging on Component Function	Contrib to Failure	Reported progs	Rel.progs	Report Recommendations	Page No.	Item
Operability problem with valve motor operator	Not stated	Not discussed in report	Vendor specific, NUREG-1352	Not stated		5

Document: IN NO. 89-64, Electrical Bus Bas Failures
Reviewed by: E. W. Roberts, INEL

Effect of Aging on Component Function	Contrib to Failure	Reported progs	Rel.progs	Report Recommendations	Page No.	Item
Inoperable electrical bus	Not stated	Not discussed in report	IEEE 338-1987, RG 1.118, IEEE 741-1986	Review info and take actions as appropriate [4]		6

Document: IN NO. 89-66, Qualification Life of Solenoid Valves
Reviewed by: E. W. Roberts, INEL

Effect of Aging on Component Function	Contrib to Failure	Reported progs	Rel.progs	Report Recommendations	Page No.	Item
Valves fail to operate as required	Frequent	Not discussed in report	Application dependent, may have Tech Spec req	Review info and take actions as appropriate [4]		7

Document: IN NO. 89-79, Degraded Coatings and Corrosion of Steel Containment Vessels
Reviewed by: E. W. Roberts, INEL

Effect of Aging on Component Function	Contrib to Failure	Reported progs	Rel.progs	Report Recommendations	Page No.	Item
Oxidation and pitting of steel tanks	Not stated	Not discussed in report	Vendor specific	Review info for applicability and take actions as appropriate [4]		8

Document: IN NO. 89-84, Failure of Ingersoll Rand Air Start Motors as A Result of Pinion Gear Assembly Fitting Problems
Reviewed by: E. W. Roberts, INEL

Effect of Aging on Component Function	Contrib to Failure	Reported progs	Rel.progs	Report Recommendations	Page No.	Item
Diesel generators would not start	Frequent	Not discussed in report	RG 1.108,IEEE 387,IEEE 749,Tech. Spec. maint.	Review info and consider actions as appropriate [4]		9

Table A.2 Gall Report for Information Notices

Document: IN NO. 90-41, Potential Failure of General Electric Magne-Blast Circuit Breakers and AK Circuit Breakers
Reviewed by: E. W. Roberts, INEL

Item	System	Structure/Comp	Subcomponent	Materials	Manufacturer	ARD mechanism	ARD effects
10		Circuit Breakers	Prop Reset Spring	Not stated	General Electric	FAT	Broken spring

Document: IN NO. 90-51, Failures of Voltage-Resistors in the Power Supply Circuitry of Electric Governor Systems
Reviewed by: E. W. Roberts, INEL

Item	System	Structure/Comp	Subcomponent	Materials	Manufacturer	ARD mechanism	ARD effects
11	Emergency Diesel Generator	Governor Control Power Supply	Voltage Dropping Resistor	Not stated	Pacific Resistor	ENVIR ELTEMP	Loss of resistance value

Document: IN NO. 90-51-01, Failures of Voltage-Resistors in the Power Supply Circuitry of Electric Governor Systems
Reviewed by: L. C. Meyer, INEL

Item	System	Structure/Comp	Subcomponent	Materials	Manufacturer	ARD mechanism	ARD effects
12	Emergency Diesel Generator	Governor Control Power Supply	Voltage Dropping Resistor	Not stated	Not stated	CURSTR & ELETEMP	Loss of resistance value

Document: IN NO. 90-80, Sand Intrusion Resulting in Two Diesel Generators Becoming Inoperable
Reviewed by: E. W. Roberts, INEL

Item	System	Structure/Comp	Subcomponent	Materials	Manufacturer	ARD mechanism	ARD effects
13	Diesel Generatrors	Cylinders	Liners and Piston Rings	Not stated	Not stated	CONTAM ADH	Scoring of liners and piston rings

Document: IN NO. 91-20, Electric Wire Insulation Degradation Caused Failure in A Safety-Related Motor Control Center
Reviewed by: E. W. Roberts, INEL

Item	System	Structure/Comp	Subcomponent	Materials	Manufacturer	ARD mechanism	ARD effects
14		Motor Control Center	Wire	PCV - Vegatable oil plasticierR	Not stated	ELTEMP	Cond cover emits liquid which hardens on electrical contact

Document: IN NO. 91-45, Possible Malfunction of Westinghouse ARD, BFD, and NBFD Relays, and A200 DC and DPC 250 Magnetic Contactors
Reviewed by: E. W. Roberts, INEL

Item	System	Structure/Comp	Subcomponent	Materials	Manufacturer	ARD mechanism	ARD effects
15		Relays	Coils	Epoxy	Westinghouse	ELTEMP	Epoxy becomes fluid when coil is energized for ext period

Document: IN NO. 91-46, Degradation of Emergency Diesel Generator Fuel Oil Delivery Systems
Reviewed by: E. W. Roberts, INEL

Item	System	Structure/Comp	Subcomponent	Materials	Manufacturer	ARD mechanism	ARD effects
16	Diesel Generators		Filters and Injectors	Not stated	Not stated	CONTAM	Excessive particulate, fouled filters and injectors

Document: IN NO. 91-62, Diesel Enging Damage Caused by Hydraulic Lockup Resulting From Fluid Leakage Into Cylinders
Reviewed by: E. W. Roberts, INEL

Item	System	Structure/Comp	Subcomponent	Materials	Manufacturer	ARD mechanism	ARD effects
17	Emergency Diesel Generator	Diesel Engine	Head Gasket	Not stated	Not stated	Not stated	Water leaks into cylinder

Document: IN NO. 91-78, Status Indication of Control Power for Circuit Breakers Used in Safety-Related Applications
Reviewed by: E. W. Roberts, INEL

Item	System	Structure/Comp	Subcomponent	Materials	Manufacturer	ARD mechanism	ARD effects
18		Indicator Lights	Fuse Holders	Not stated	Not stated	FAT	Fuse holder fingers deformed resulting in poor elect contact

Document: IN NO. 90-41, Potential Failure of General Electric Magne-Blast Circuit Breakers and AK Circuit Breakers
Reviewed by: E. W. Roberts, INEL

Effect of Aging on Component Function	Contrib to Failure	Reported progs	Rel.progs	Report Recommendations	Page No.	Item
Breaker would attempt to close but would trip free	Frequent	Not discussed in report	RG 1.108,IEEE 387,IEEE 749,Tech. Spec. maint	Review info and consider actions as appropriate [4]		10

Document: IN NO. 90-51, Failures of Voltage-Resistors in the Power Supply Circuitry of Electric Governor Systems
Reviewed by: E. W. Roberts, INEL

Effect of Aging on Component Function	Contrib to Failure	Reported progs	Rel.progs	Report Recommendations	Page No.	Item
Edg loses speed control	Frequent	Scheduled Replacement	RG 1.108, IEEE 387, IEEE 749	Review info and consider actions if applicable [4]		11

Document: IN NO. 90-51-01, Failures of Voltage-Resistors in the Power Supply Circuitry of Electric Governor Systems
Reviewed by: L. C. Meyer, INEL

Effect of Aging on Component Function	Contrib to Failure	Reported progs	Rel.progs	Report Recommendations	Page No.	Item
Failure of resistor leads to governor power supply. Failure in original design. resistor failure in new replacement assembly results in a backup mechanical governor taking control of speed.	Frequent - old; Rare - new	Scheduled Replacement	RG 1.108, IEEE 387, IEEE 749	Review info and consider actions if applicable [4]	1 & 2	12

Document: IN NO. 90-80, Sand Intrusion Resulting in Two Diesel Generators Becoming Inoperable
Reviewed by: E. W. Roberts, INEL

Effect of Aging on Component Function	Contrib to Failure	Reported progs	Rel.progs	Report Recommendations	Page No.	Item
Inoperable diesel generators - maintenance activity introduced sand into diesel cylinders	Not stated	Not discussed in report	No specific program	Review info and consider actions if applicable [4]		13

Document: IN NO. 91-20, Electric Wire Insulation Degradation Caused Failure in A Safety-Related Motor Control Center
Reviewed by: E. W. Roberts, INEL

Effect of Aging on Component Function	Contrib to Failure	Reported progs	Rel.progs	Report Recommendations	Page No.	Item
Insulates electrical contacts	Not stated	Not discussed in report	No specific program	Review info and consider actions as appropriate [4]		14

Document: IN NO. 91-45, Possible Malfunction of Westinghouse ARD, BFD, and NBFD Relays, and A200 DC and DPC 250 Magnetic Contactors
Reviewed by: E. W. Roberts, INEL

Effect of Aging on Component Function	Contrib to Failure	Reported progs	Rel.progs	Report Recommendations	Page No.	Item
Degrades or delays relay function	Not stated	Not discussed in report	No specific program	Review info and consider actions if applicable [4]		15

Document: IN NO. 91-46, Degradation of Emergency Diesel Generator Fuel Oil Delivery Systems
Reviewed by: E. W. Roberts, INEL

Effect of Aging on Component Function	Contrib to Failure	Reported progs	Rel.progs	Report Recommendations	Page No.	Item
Inoperable diesel generator	Not stated	Not discussed in report	No specific program	Review info and consider actions as appropriate [4]		16

Document: IN NO. 91-62, Diesel Enging Damage Caused by Hydraulic Lockup Resulting From Fluid Leakage Into Cylinders
Reviewed by: E. W. Roberts, INEL

Effect of Aging on Component Function	Contrib to Failure	Reported progs	Rel.progs	Report Recommendations	Page No.	Item
Damage to engine will cause EDG failure	Not stated	Not discussed in report	Vendor specific program	Review info and consider actions as appropriate [4]		17

Document: IN NO. 91-78, Status Indication of Control Power for Circuit Breakers Used in Safety-Related Applications
Reviewed by: E. W. Roberts, INEL

Effect of Aging on Component Function	Contrib to Failure	Reported progs	Rel.progs	Report Recommendations	Page No.	Item
Improper indication of motor operation	Not stated	Not discussed in report	Vendor specific program	Review info and consider actions as appropriate [4]		18

Document: IN NO. 91-81, Switchyard Problems That Contribute to Loss of Offsite Power
Reviewed by: E. W. Roberts, INEL

Item	System	Structure/Comp	Subcomponent	Materials	Manufacturer	ARD mechanism	ARD effects
19		Swithcyard Control System	Zener Diodes	Not stated	Not stated	VOLSTR	Zenor diode failure

Document: IN NO. 91-83, Solenoid-Operated Valve Failures Resulted in Turbing Overspeed
Reviewed by: E. W. Roberts, INEL

Item	System	Structure/Comp	Subcomponent	Materials	Manufacturer	ARD mechanism	ARD effects
20	Turbine		Soleniod- Operated Valves	Not stated	Parker Hannifin	Not stated	Pilot valve assy mechanically bound

Document: IN NO. 91-85, Potential Failures of Thermostatic Control Valves for Diesel Generator Jacket Cooling Water
Reviewed by: E. W. Roberts, INEL

Item	System	Structure/Comp	Subcomponent	Materials	Manufacturer	ARD mechanism	ARD effects
21	Diesel Generator	Cooling Water System	Thermostatic Control Valve	Not stated	Not stated	Not stated	Valve failure

Document: IN NO. 91-87, Hydrogen Embrittlement of Raychem Cryofit Couplings
Reviewed by: L. C. Meyer, INEL

Item	System	Structure/Comp	Subcomponent	Materials	Manufacturer	ARD mechanism	ARD effects
22		Gas Space Sampling Line	Cryofit Coupling	Tinel (50% Titanium and 50% Nickel)	Raychem	EMBR/HY & ELETEMP	Circumferential fracture at the midpoint of coupling

Document: IN NO. 92-04, Potter & Brumfield Model MDR Rotary Relay Failures
Reviewed by: E. W. Roberts, INEL

Item	System	Structure/Comp	Subcomponent	Materials	Manufacturer	ARD mechanism	ARD effects
23		Rotary Relay	Rotor Coil	Varnish	Potter & Brumfield	CORR	Deposits on rotor

Document: IN NO. 92-27, Thermally Induced Accelerated Aging and Failure of ITE/GOULD A.C. Relaty Used in Safety-Related Applications
Reviewed by: E. W. Roberts, INEL

Item	System	Structure/Comp	Subcomponent	Materials	Manufacturer	ARD mechanism	ARD effects
24		Relay	Plastic Armature Carrier and Coil Insulation	Not stated	ITE/Gould	ELETEMP	Brittleness and cracking

Document: IN NO. 92-44, Problems With Westinghouse DS-206 Type Circuit Breakers
Reviewed by: E. W. Roberts, INEL

Item	System	Structure/Comp	Subcomponent	Materials	Manufacturer	ARD mechanism	ARD effects
25		Circuit Breaker	Reset Spring	Not stated	Westinghouse	FAT	Weakened spring

Document: IN NO. 92-48, Failure of Exide Batteries
Reviewed by: E. W. Roberts, INEL

Item	System	Structure/Comp	Subcomponent	Materials	Manufacturer	ARD mechanism	ARD effects
26		DC Power	Battery cells	Not stated	Exide	CORR	Cracking of battery face

Document: IN NO. 92-78, Piston to Cylinder Liner Tin Smearing On Cooper=Bessemer KSV Diesel Engines
Reviewed by: E. W. Roberts, INEL

Item	System	Structure/Comp	Subcomponent	Materials	Manufacturer	ARD mechanism	ARD effects
27	Diesel Generator	Cylinders	Walls	Not stated	Cooper Bessemer KSV	CORR	Transfer of tin from cyl. walls and breakdown of lubrication

Table A.2 Gall Report for Information Notices

Document: IN NO. 91-81, Switchyard Problems That Contribute to Loss of Offsite Power
Reviewed by: E. W. Roberts, INEL

Effect of Aging on Component Function	Contrib to Failure	Reported progs	Rel.progs	Report Recommendations	Page No.	Item
Loss of switchyard control	Not stated	Not discussed in report	RG 1.118, IEEE 741-1986 Section 7	Review info and consider actions as appropriate [4]		19

Document: IN NO. 91-83, Solenoid-Operated Valve Failures Resulted in Turbing Overspeed
Reviewed by: E. W. Roberts, INEL

Effect of Aging on Component Function	Contrib to Failure	Reported progs	Rel.progs	Report Recommendations	Page No.	Item
Valves failed to close allowing steam to cause turbine overspeed	Not stated	Not discussed in report	Vendor specific program	Review info and consider actions as appropriate [4]		20

Document: IN NO. 91-85, Potential Failures of Thermostatic Control Valves for Diesel Generator Jacket Cooling Water
Reviewed by: E. W. Roberts, INEL

Effect of Aging on Component Function	Contrib to Failure	Reported progs	Rel.progs	Report Recommendations	Page No.	Item
Overheating of diesel generator	Not stated	Not discussed in report	Vendor specific program	Review info and consider actions as appropriate [4]		21

Document: IN NO. 91-87, Hydrogen Embrittlement of Raychem Cryofit Couplings
Reviewed by: L. C. Meyer, INEL

Effect of Aging on Component Function	Contrib to Failure	Reported progs	Rel.progs	Report Recommendations	Page No.	Item
The fractured coupling allowed a reactor coolant system leak that exceded the 1.0 gpm technical specification limit.	Rare	Not discussed in report	No specific program	Not stated	1 & 2	22

Document: IN NO. 92-04, Potter & Brumfield Model MDR Rotary Relay Failures
Reviewed by: E. W. Roberts, INEL

Effect of Aging on Component Function	Contrib to Failure	Reported progs	Rel.progs	Report Recommendations	Page No.	Item
Mechanical binding of rotor and failure of relay to operate properly within 2 to 5 years after installation	Not stated	Not discussed in report	Vendor specific program	Review info and consider actions as applicable [4]		23

Document: IN NO. 92-27, Thermally Induced Accelerated Aging and Failure of ITE/GOULD A.C. Relaty Used in Safety-Related Applications
Reviewed by: E. W. Roberts, INEL

Effect of Aging on Component Function	Contrib to Failure	Reported progs	Rel.progs	Report Recommendations	Page No.	Item
Coil shorts and relay fails to operate	Not stated	Not discussed in report	Vendor specific program	Review info and consider actions as appropriate [4]		24

Document: IN NO. 92-44, Problems With Westinghouse DS-206 Type Circuit Breakers
Reviewed by: E. W. Roberts, INEL

Effect of Aging on Component Function	Contrib to Failure	Reported progs	Rel.progs	Report Recommendations	Page No.	Item
Breaker fails to open when required	Not stated	Not discussed in report	Vendor specific program	Review info and consider action as appropriate [4]		25

Document: IN NO. 92-48, Failure of Exide Batteries
Reviewed by: E. W. Roberts, INEL

Effect of Aging on Component Function	Contrib to Failure	Reported progs	Rel.progs	Report Recommendations	Page No.	Item
Leakage of electrolytic and battery cell failure	Not stated	Not discussed in report	RG 1.129, IEEE 450-1987, Tech. Spec. Surveil.	Review info and consider action as applicable [4]		26

Document: IN NO. 92-78, Piston to Cylinder Liner Tin Smearing On Cooper=Bessemer KSV Diesel Engines
Reviewed by: E. W. Roberts, INEL

Effect of Aging on Component Function	Contrib to Failure	Reported progs	Rel.progs	Report Recommendations	Page No.	Item
Crankcase explosions and diesel failure	Not stated	Not discussed in report	No specific program	Review info and consider actions as appropriate [4]		27

Document: IN NO. 93-05, Storm-Related Loss of Offsite Power Events Due to Salt Buildup on Switchyard Insulators
Reviewed by: E. W. Roberts, INEL

Item	System	Structure/Comp	Subcomponent	Materials	Manufacturer	ARD mechanism	ARD effects
28		Switch Yard	Insulators	Not stated	Not stated	CONTAM	Arcing across salt-lading insulators

Document: IN NO. 93-22, Tripping of Klockner-Moeller Molded-Case Circuit Breakers due to Support Lever Failure
Reviewed by: E. W. Roberts, INEL

Item	System	Structure/Comp	Subcomponent	Materials	Manufacturer	ARD mechanism	ARD effects
29		Mold-Case Circuit Breakers	Support Lever (Spring Arm)	Polycarbonate & Glass fiber composite	Klockner Moeller	CORR FAT	Fractured support lever

Document: IN NO. 93-23, Weschler Instruments Model 252 Switchboard Meters
Reviewed by: E. W. Roberts, INEL

Item	System	Structure/Comp	Subcomponent	Materials	Manufacturer	ARD mechanism	ARD effects
30		Indicating Meters	Meter Movement	Not stated	Weschler	ADH	Sticking movement

Document: IN NO. 93-26, Grease Solidification Causes Molded-Case Circuit Breaker Failure to Close
Reviewed by: E. W. Roberts, INEL

Item	System	Structure/Comp	Subcomponent	Materials	Manufacturer	ARD mechanism	ARD effects
31		Mold-Case Circuit Breakers	Grease	Soap-based or clay-based grease	General Electric	ENVIR	Drying out of grease, friction, gouging of metal-to-metal

Document: IN NO. 93-33, Potential Deficiency of Certain Class 1E Instrumentation and Control Cables
Reviewed by: E. W. Roberts, INEL

Item	System	Structure/Comp	Subcomponent	Materials	Manufacturer	ARD mechanism	ARD effects
32			Cables	Not stated	Not stated	REFERENCE NUREG/CR-5772	Reference nureg/cr-5772

Document: IN NO. 93-64, Periodic Testing and Preventive Maintenance of Modled Case Circuit Breakers
Reviewed by: E. W. Roberts, INEL

Item	System	Structure/Comp	Subcomponent	Materials	Manufacturer	ARD mechanism	ARD effects
33			Circuit Breakers Type EB and EHB	Not stated	Westinghouse	Not stated	Thermal and instantaneous trip not within specifications

Document: IN NO. 94-04, Digital Integrated Circuit Sockets With Intermittent Contact
Reviewed by: E. W. Roberts, INEL

Item	System	Structure/Comp	Subcomponent	Materials	Manufacturer	ARD mechanism	ARD effects
34		Digital Board	Socket Contacts	Tin-lead	Augat	CORR/OX	Contact failure

Document: IN NO. 94-33, Capacitor Failures in Westonghouse Easge 21 Plant Protection Systems
Reviewed by: E. W. Roberts, INEL

Item	System	Structure/Comp	Subcomponent	Materials	Manufacturer	ARD mechanism	ARD effects
35	Westinghouse Eagle 21 plant protection system	ASTEC America DC Power Supply	Electrolytic Capacitors	Epoxy module	AVX	ELTEMP	Capacitor failure

Document: IN NO. 93-05, Storm-Related Loss of Offsite Power Events Due to Salt Buildup on Switchyard Insulators
Reviewed by: E. W. Roberts, INEL

Effect of Aging on Component Function	Contrib to Failure	Reported progs	Rel.progs	Report Recommendations	Page No.	Item
Loss of offsite ac power	Not stated	Not discussed in report	IEEE 765-1983, Plant specific program	Review info and consider actions as appropriate [4]		28

Document: IN NO. 93-22, Tripping of Klockner-Moeller Molded-Case Circuit Breakers due to Support Lever Failure
Reviewed by: E. W. Roberts, INEL

Effect of Aging on Component Function	Contrib to Failure	Reported progs	Rel.progs	Report Recommendations	Page No.	Item
Breakers tripped without cause	Not stated	Not discussed in report	No specific program	Review info and consider actions as appropriate [4]		29

Document: IN NO. 93-23, Weschler Instruments Model 252 Switchboard Meters
Reviewed by: E. W. Roberts, INEL

Effect of Aging on Component Function	Contrib to Failure	Reported progs	Rel.progs	Report Recommendations	Page No.	Item
Inaccurate meter indications	Not stated	Not discussed in report	No specific program	Review info and consider actions as appropriate [4]		30

Document: IN NO. 93-26, Grease Solidification Causes Molded-Case Circuit Breaker Failure to Close
Reviewed by: E. W. Roberts, INEL

Effect of Aging on Component Function	Contrib to Failure	Reported progs	Rel.progs	Report Recommendations	Page No.	Item
Breaker fails to close	Not stated	Not discussed in report	No specific program	Review info and consider actions as appropriate [4]		31

Document: IN NO. 93-33, Potential Deficiency of Certain Class 1E Instrumentation and Control Cables
Reviewed by: E. W. Roberts, INEL

Effect of Aging on Component Function	Contrib to Failure	Reported progs	Rel.progs	Report Recommendations	Page No.	Item
References the result of the NUREG report to evaluate plant cables	Not stated	Not discussed in report	No specific program	Review info and consider actions as appropriate [4]		32

Document: IN NO. 93-64, Periodic Testing and Preventive Maintenance of Modled Case Circuit Breakers
Reviewed by: E. W. Roberts, INEL

Effect of Aging on Component Function	Contrib to Failure	Reported progs	Rel.progs	Report Recommendations	Page No.	Item
Age, failure to excercise, and lack of maintenance caused breakers trips to go out of specifications	Not stated	Not discussed in report	Vendor specific program, Tech. Spec.	Review info and consider actions as appropriate [4]		33

Document: IN NO. 94-04, Digital Integrated Circuit Sockets With Intermittent Contact
Reviewed by: E. W. Roberts, INEL

Effect of Aging on Component Function	Contrib to Failure	Reported progs	Rel.progs	Report Recommendations	Page No.	Item
Not stated	Not stated	Not discussed in report	No specific program	Review info and consider action as appropriate [4]		34

Document: IN NO. 94-33, Capacitor Failures in Westonghouse Easge 21 Plant Protection Systems
Reviewed by: E. W. Roberts, INEL

Effect of Aging on Component Function	Contrib to Failure	Reported progs	Rel.progs	Report Recommendations	Page No.	Item
Power supply failure	Not stated	Not discussed in report	Vendor specific program	Review info and consider actions as appropriate [4]		35

Table A.2 Gall Report for Licensee Event Reports

Document: LER 88-011-282, Auto-Start of Train A of Auxiliary Building Special Ventilation System as a result of a Radiation Monitor Spike
Reviewed by: L. C. Meyer, INEL

Item	System	Structure/Comp	Subcomponent	Materials	Manufacturer	ARD mechanism	ARD effects
1	Ventilation System	Radiation Monitor	Not stated	Not stated	Not stated	Not stated	Rad monitor spike - attributed to age of rad mon equipment

Document: LER 88-033-02-327, Unplanned Reactor Trip Signal Due to a Reactor Protection System (RPS) Channel 1 Instrument Failure During RPS Channel 2 C
Reviewed by: L. C. Meyer, INEL

Item	System	Structure/Comp	Subcomponent	Materials	Manufacturer	ARD mechanism	ARD effects
2	Reactor Protection System	Not stated	Not stated	Not stated	Foxboro	Not stated	Two transistors shorted and bridge assembly open circuited

Document: LER 89-001-280, Unplanned Auto Start of #3 EDG Due to Failed Diode
Reviewed by: L. C. Meyer, INEL

Item	System	Structure/Comp	Subcomponent	Materials	Manufacturer	ARD mechanism	ARD effects
3	Diesel Generator	Control Circuit	Diode	Not stated	GM Electro-Motive Division	Not stated	Failed diode caused start relay to actuate

Document: LER 89-002-331, Age-Related Failure of a Governor Printed Circuit Board Results in High Pressure Coolant Injection System Inoperability
Reviewed by: L. C. Meyer, INEL

Item	System	Structure/Comp	Subcomponent	Materials	Manufacturer	ARD mechanism	ARD effects
4	High Pressure Injection System	Turbine Governor	Printed Circuit Board Component	Not stated	Woodward Governor Company	ELETEMP	Intermitant electronic componet output

Document: LER 89-003-263, Isolation of Reactor Water Cleanup System Due to Capacitor Failure in Filter/Demineralizer Inlet Temperature Indication Switch
Reviewed by: L. C. Meyer, INEL

Item	System	Structure/Comp	Subcomponent	Materials	Manufacturer	ARD mechanism	ARD effects
5	RWCU	Electronic Circuit Filter	Capacitor	Not stated	Seimans	Not stated	Capacitor failed

Document: LER 89-006-261, Reactor Trip Due to Loss of Turbine E-H Control Power Supplies
Reviewed by: L. C. Meyer, INEL

Item	System	Structure/Comp	Subcomponent	Materials	Manufacturer	ARD mechanism	ARD effects
6	Turbine Control	Power Supply	Transistor	Not stated	Solid State Controls Inc.	CURSTR & VOLSTR	Transistors developed leakage current

Document: LER 89-010-362, Fuel Handling Isolation System Train "A" Actuation Due to Power Supply Failure
Reviewed by: L. C. Meyer, INEL

Item	System	Structure/Comp	Subcomponent	Materials	Manufacturer	ARD mechanism	ARD effects
7	Fuel Handling Isolation System	Power Supply	Regulator	Not stated	Nuclear Meaurement Corp.	ELETEMP	Nylon screw broken due to thermal aging

Document: LER 88-011-282, Auto-Start of Train A of Auxiliary Building Special Ventilation System as a result of a Radiation Monitor Spike
Reviewed by: L. C. Meyer, INEL

Effect of Aging on Component Function	Contrib to Failure	Reported progs	Rel.progs	Report Recommendations	Page No.	Item
Auto-start of aux building ventilation system when not called for. The electronics was 16 years old. Root cause of spike unknown. rad monitor upgrade pursued.	Not stated	10 CFR 50.73	Vendor specific program	Not stated	1-3	1

Document: LER 88-033-02-327, Unplanned Reactor Trip Signal Due to a Reactor Protection System (RPS) Channel 1 Instrument Failure During RPS Channel 2 C
Reviewed by: L. C. Meyer, INEL

Effect of Aging on Component Function	Contrib to Failure	Reported progs	Rel.progs	Report Recommendations	Page No.	Item
Failure of a rcs channel 1 delta T/Tavg loop instrument caused an unplanned reactor trip signal. Component aging was referenced as a possible failure mechanism.	Not stated	10 CFR 50.73	Tech. Spec. surveillance, RG 1.118, IEEE 338	Not stated	1-4	2

Document: LER 89-001-280, Unplanned Auto Start of #3 EDG Due to Failed Diode
Reviewed by: L. C. Meyer, INEL

Effect of Aging on Component Function	Contrib to Failure	Reported progs	Rel.progs	Report Recommendations	Page No.	Item
The failure of the diode was attributed to normal aging. the start relay iniated the air start motors and started the diesel when no emergency existed.	Not stated	10 CFR 50.73	No specific surveillance for this component	Not stated	1-3	3

Document: LER 89-002-331, Age-Related Failure of a Governor Printed Circuit Board Results in High Pressure Coolant Injection System Inoperability
Reviewed by: L. C. Meyer, INEL

Effect of Aging on Component Function	Contrib to Failure	Reported progs	Rel.progs	Report Recommendations	Page No.	Item
Failure to operate, reason was unanticipated age-related response of the printed circuit board's components due to long term constant energization and possibly environmental factors. Vendor indicated that long term constant current flow could reduce life	Rare	10 CFR 50.73	Tech. Spec. Surveillance req'd for HPI	Change out the governor printed circuit boards every eight years [4]	1-4	4

Document: LER 89-003-263, Isolation of Reactor Water Cleanup System Due to Capacitor Failure in Filter/Demineralizer Inlet Temperature Indication Switch
Reviewed by: L. C. Meyer, INEL

Effect of Aging on Component Function	Contrib to Failure	Reported progs	Rel.progs	Report Recommendations	Page No.	Item
Unexpected capacitor failure caused circuit to actuate a portion of the ESF system. Aging was given as the cause of the capacitor failure	Rare	10 CFR 50.73	No specific surveillance for this component	Not stated	1-3	5

Document: LER 89-006-261, Reactor Trip Due to Loss of Turbine E-H Control Power Supplies
Reviewed by: L. C. Meyer, INEL

Effect of Aging on Component Function	Contrib to Failure	Reported progs	Rel.progs	Report Recommendations	Page No.	Item
Transistor leakage current caused increased gain resulting in higher voltage on the output stage of the power supply. the over voltage protective circuitry was triggered causing the fuse to blow. degraded transistors attributed to aging.	Rare	10 CFR 50.73	No specific surveillance for this component	Not stated	1-4	6

Document: LER 89-010-362, Fuel Handling Isolation System Train "A" Actuation Due to Power Supply Failure
Reviewed by: L. C. Meyer, INEL

Effect of Aging on Component Function	Contrib to Failure	Reported progs	Rel.progs	Report Recommendations	Page No.	Item
Lost power from the power supply when the regulator shifted due to the broken screw and allowed a burr on the metal heat sink to penetrate the mica insulation. a short circuit resulted blowing a fuse.	Rare	10 CFR 50.73	No specific surveillance for this component	Not stated	1-5	7

Table A.2 Gall Report for Licensee Event Reports

Document: LER 89-014-271, Reactor Core Isolation Cooling System Inoperable Due to Motor Burn Out
Reviewed by: L. C. Meyer, INEL

Item	System	Structure/Comp	Subcomponent	Materials	Manufacturer	ARD mechanism	ARD effects
8	Reactor Core Isolation Cooling System	Motor Operated Valve	Motor	Not stated	Not stated	CURSTR	Failed armature winding

Document: LER 89-015-327, Control Room Isolation Resulting From a Worn Set of Contacts in the 480V Motor Starter for a Main Control Room Ventilation Intake F
Reviewed by: L. C. Meyer, INEL

Item	System	Structure/Comp	Subcomponent	Materials	Manufacturer	ARD mechanism	ARD effects
9	Control Room Isolation	Motor Starter	Contacts	Not stated	Not stated	WEAR	Increased contact resistance causing arcing

Document: LER 89-019-01-325, Failure of Service Water System to Meet Design Requirements
Reviewed by: L. C. Meyer, INEL

Item	System	Structure/Comp	Subcomponent	Materials	Manufacturer	ARD mechanism	ARD effects
10	Service Water System	Pump	Winding Insulation	Not stated	General Electric	ELETEMP	Degraded insulation on motor winding

Document: LER 89-020-01-528, Apparent Ground Causes Control Element Assembly Slip
Reviewed by: L. C. Meyer, INEL

Item	System	Structure/Comp	Subcomponent	Materials	Manufacturer	ARD mechanism	ARD effects
11	Control Element Assembly	Coil	Coil Lead Wire	Not stated	Combustion Engineering	Not stated	Not aging related

Document: LER 89-031-01-302, Failure of "A" 480V Engineered Safeguards Transformer Causes Temporary Interruption of Decay Heat Cooling and a Plant Opera
Reviewed by: L. C. Meyer, INEL

Item	System	Structure/Comp	Subcomponent	Materials	Manufacturer	ARD mechanism	ARD effects
12	ESFAS	Transformer	Transformer Insulation	Not stated	Not stated	Not stated	Insulation degradation

Document: LER 90-007-01-388, ESF Actuations Due to RPS EPA Breaker Spurious Trip
Reviewed by: L. C. Meyer, INEL

Item	System	Structure/Comp	Subcomponent	Materials	Manufacturer	ARD mechanism	ARD effects
13	Reacotr Protection System	Electrical Protection Assembly	Logic Card	Not stated	General Electric	Not stated	Logic card failed

Document: LER 90-018-244, Dropped Control Rod During Rod Control Exercise Causes Automatic Actuation of RPS
Reviewed by: L. C. Meyer, INEL

Item	System	Structure/Comp	Subcomponent	Materials	Manufacturer	ARD mechanism	ARD effects
14	Control Rod Drive System	Power Bridge	Capacitor	Not stated	Westinghouse	ELETEMP	Degraded capacitor

Document: LER 90-022-01-344, Degraded Fire Penetration Seals as a Result of Inadewuate Construction Technique
Reviewed by: L. C. Meyer, INEL

Item	System	Structure/Comp	Subcomponent	Materials	Manufacturer	ARD mechanism	ARD effects
15	Various	Cable Penetrations	Seal	Silicon foam	Not stated	WEAR	Degradation of foam, splits and gaps.

Table A.2 Gall Report for Licensee Event Reports

Document: LER 89-014-271, Reactor Core Isolation Cooling System Inoperable Due to Motor Burn Out
Reviewed by: L. C. Meyer, INEL

Effect of Aging on Component Function	Contrib to Failure	Reported progs	Rel.progs	Report Recommendations	Page No.	Item
Valve failed to close because of failed motor. An incorrect upper bearing gasket thickness resulted in a motor current 20% above full rated load which is believed to have contributed to premature aging.	Rare	10 CFR 50.73	Vendor specific testing	Not stated	1-4	8

Document: LER 89-015-327, Control Room Isolation Resulting From a Worn Set of Contacts in the 480V Motor Starter for a Main Control Room Ventilation Intake F
Reviewed by: L. C. Meyer, INEL

Effect of Aging on Component Function	Contrib to Failure	Reported progs	Rel.progs	Report Recommendations	Page No.	Item
Contacts not conducting properly and current was arcing over introducing EMI into the circuitry resulting in a spurious high radiation signal that initiated the control room isolation.	Rare	10 CFR 50.73	No specific surveillance for this component	Not stated	1-3	9

Document: LER 89-019-01-325, Failure of Service Water System to Meet Design Requirements
Reviewed by: L. C. Meyer, INEL

Effect of Aging on Component Function	Contrib to Failure	Reported progs	Rel.progs	Report Recommendations	Page No.	Item
Inadequate air flow through the motor winding over a period of time resulted in thermally aged insulation that resulted in a turn to turn failure.	Rare	10 CFR 50.73	IEEE 334-1974 Section 14.2	Not stated	1-4	10

Document: LER 89-020-01-528, Apparent Ground Causes Control Element Assembly Slip
Reviewed by: L. C. Meyer, INEL

Effect of Aging on Component Function	Contrib to Failure	Reported progs	Rel.progs	Report Recommendations	Page No.	Item
Manufacturing defect	Rare	10 CFR 50.73	Vendor specific program	Not stated	4 & 5	11

Document: LER 89-031-01-302, Failure of "A" 480V Engineered Safeguards Transformer Causes Temporary Interruption of Decay Heat Cooling and a Plant Opera
Reviewed by: L. C. Meyer, INEL

Effect of Aging on Component Function	Contrib to Failure	Reported progs	Rel.progs	Report Recommendations	Page No.	Item
Transformer failed causing a cooling pump to de-energize and loss of decay heat cooling. Power was also interrupted to various plant ventilation systems. Event compounded by personnel error.	Rare	10 CFR 50.73	RG 1.118, IEEE 338-1987, IEEE 741-1986	Not stated	1 & 3	12

Document: LER 90-007-01-388, ESF Actuations Due to RPS EPA Breaker Spurious Trip
Reviewed by: L. C. Meyer, INEL

Effect of Aging on Component Function	Contrib to Failure	Reported progs	Rel.progs	Report Recommendations	Page No.	Item
The logic card failure caused the trip breaker to operate and initiated other esf actuations. The card failure was attributed to aging and the aging process was found to be applicable when the epa logic card was both in service and in storage.	Occasional; (12 times/6 Y)	10 CFR 50.73	RG 1.118, IEEE 338-1987	Not stated	1-5	13

Document: LER 90-018-244, Dropped Control Rod During Rod Control Exercise Causes Automatic Actuation of RPS
Reviewed by: L. C. Meyer, INEL

Effect of Aging on Component Function	Contrib to Failure	Reported progs	Rel.progs	Report Recommendations	Page No.	Item
Noisy incoming power to the control rod J-10 (caused the rod to drop) was attributed to the degraded capacitor. Elevated temperature at the power supply location was the cause of the decreased service life of the capacitor.	Rare	10 CFR 50.73	Vendor specific program	Not stated	1-8	14

Document: LER 90-022-01-344, Degraded Fire Penetration Seals as a Result of Inadewuate Construction Technique
Reviewed by: L. C. Meyer, INEL

Effect of Aging on Component Function	Contrib to Failure	Reported progs	Rel.progs	Report Recommendations	Page No.	Item
Degradation of foam is attributed to aging and wear as noted under other defects	Occasional	10 CFR 50.73	Vendor specific program	Not stated	1-6	15

Document: LER 90-023-325, Partial Group 6 Isolation Resulting From Failure of Relay I-CAC-3A
Reviewed by: L. C. Meyer, INEL

Item	System	Structure/Comp	Subcomponent	Materials	Manufacturer	ARD mechanism	ARD effects
16	Containment Isolation Control	Isolation Logic	Coil	Not stated	General Electric	Not stated	Coil burned up

Document: LER 90-023-424, Transformer Failure Results in Loss of Steam Generator Level and Manual Reactor Trip
Reviewed by: L. C. Meyer, INEL

Item	System	Structure/Comp	Subcomponent	Materials	Manufacturer	ARD mechanism	ARD effects
17	Non 1-E Power System	Transformer	Not stated	Not stated	General Electric	Not stated	Internal fault in the "b" phase high side windings

Document: LER 90-029-01-325, CBEAF SYSTEM Actuation Resulting From the Failure of the 1-D22A-K2 Relay Coil.
Reviewed by: L. C. Meyer, INEL

Item	System	Structure/Comp	Subcomponent	Materials	Manufacturer	ARD mechanism	ARD effects
18	Control Building Emergency Air Filtration System	Arm Logic	Relay	Not stated	General Electric	Not stated	Cracks on epoxy coating, relay burned up (probably shorted)

Document: LER 91-001-293, Automatic Closing of the Primary Containment System Group 5 Isolation Valves During Sruveillance Testing
Reviewed by: L. C. Meyer, INEL

Item	System	Structure/Comp	Subcomponent	Materials	Manufacturer	ARD mechanism	ARD effects
19	Primary Isolation Control System	Electric Governor	Transistor	Not stated	Not stated	Not stated	Transistor failed
20	Primary Isolation Control System	Electric Governor	Cable Insulation	Not stated	Woodward Governor Company	ELETEMP, MOIST, & EMBR	Embrittlement due to past exposure to heat and humidity

Document: LER 91-002-01-327, EGTS Inoperable Because of a Train EGTS Being Out of Service for Filter Testing and B Train Diesel Generator Being Declared I
Reviewed by: L. C. Meyer, INEL

Item	System	Structure/Comp	Subcomponent	Materials	Manufacturer	ARD mechanism	ARD effects
21	Emergency Gas Treatment System (EGTS)	Diesel Generator	Fuse	Not stated	Not stated	THERM-CY	Fuse failed

Document: LER 91-006-530, ESF Actuation Due to Loss of Power to 4.16 KV Bus
Reviewed by: L. C. Meyer, INEL

Item	System	Structure/Comp	Subcomponent	Materials	Manufacturer	ARD mechanism	ARD effects
22	1E Power	Circuit Breaker	Trip Circuit	Not stated	Not stated	MOIST	Moisture induced short circuit in trip circuit

Document: LER 91-007-456, Rod Control System Failure Causes Shutdown Bank Control Rods to be in a Condition Prohibited by Technical Specifications
Reviewed by: L. C. Meyer, INEL

Item	System	Structure/Comp	Subcomponent	Materials	Manufacturer	ARD mechanism	ARD effects
23	Rod Control System	Circuit Card	Transistor	Not stated	Not stated	Not stated	Transistor failed

Table A.2 Gall Report for Licensee Event Reports

Document: LER 90-023-325, Partial Group 6 Isolation Resulting From Failure of Relay I-CAC-3A
Reviewed by: L. C. Meyer, INEL

Effect of Aging on Component Function	Contrib to Failure	Reported progs	Rel.progs	Report Recommendations	Page No.	Item
Relay failure resulted in partial loss of cac logic and subsequent partial group 6 isolation. This normally energized coil burned up as a result of normal end of life failure due to aging.	Occasional; (3 in 18 Mo)	10 CFR 50.73	RG 1.118, IEEE 338-1987, Tech Spec. surv.	Not stated	1-3	16

Document: LER 90-023-424, Transformer Failure Results in Loss of Steam Generator Level and Manual Reactor Trip
Reviewed by: L. C. Meyer, INEL

Effect of Aging on Component Function	Contrib to Failure	Reported progs	Rel.progs	Report Recommendations	Page No.	Item
Transformer failed resulted in loss of power to speed control circuitry of the 1B main feedwater pump. Possible premature aging of transformer.	Rare	10 CFR 50.73	No specific surveillance for this component	Not stated	1-4	17

Document: LER 90-029-01-325, CBEAF SYSTEM Actuation Resulting From the Failure of the 1-D22A-K2 Relay Coil.
Reviewed by: L. C. Meyer, INEL

Effect of Aging on Component Function	Contrib to Failure	Reported progs	Rel.progs	Report Recommendations	Page No.	Item
CBEAF system actuation resulted from the failed relay. This normally energized relay failed due to cracks in the epoxy coating on the coil. This was called a normal end of life failure due to aging.	Occasional	10 CFR 50.73	No specific surveillance for this component	Not stated	1-3	18

Document: LER 91-001-293, Automatic Closing of the Primary Containment System Group 5 Isolation Valves During Sruveillance Testing
Reviewed by: L. C. Meyer, INEL

Effect of Aging on Component Function	Contrib to Failure	Reported progs	Rel.progs	Report Recommendations	Page No.	Item
Circuit failed to control governor leading to automatic closure of isolation valves.	Rare	10 CFR 50.73	No specific surveillance for this component	Not stated	1-4	19
Cable embrittlement due to thermal aging was listed as the cause. handling of cable during maintenance and surveillance activities may have contributed to the cable failure.	Rare	10 CFR 50.73	No specific surveillance for this component	Not stated	1-4	20

Document: LER 91-002-01-327, EGTS Inoperable Because of a Train EGTS Being Out of Service for Filter Testing and B Train Diesel Generator Being Declared I
Reviewed by: L. C. Meyer, INEL

Effect of Aging on Component Function	Contrib to Failure	Reported progs	Rel.progs	Report Recommendations	Page No.	Item
Failed fuse resulted in train B EGTS being declared inoperable. Frequent cycling on and off of the air start system due to an air leak is believed to be have degraded the fuse resulting in fuse failure.	Rare	10 CFR 50.73	Tech Spec. required surveillance	Not stated	1-5	21

Document: LER 91-006-530, ESF Actuation Due to Loss of Power to 4.16 KV Bus
Reviewed by: L. C. Meyer, INEL

Effect of Aging on Component Function	Contrib to Failure	Reported progs	Rel.progs	Report Recommendations	Page No.	Item
Breaker opened when it was supposed to be closed. A degraded seal around an air conditioning duct penetration allowed moisture from a rain storm to enter the plant multiplexer cabinets causing the short circuit.	Rare	10 CFR 50.73	RG 1.118, IEEE 338-1987, IEEE 741-1987 SECTIO	Not stated	1-5	22

Document: LER 91-007-456, Rod Control System Failure Causes Shutdown Bank Control Rods to be in a Condition Prohibited by Technical Specifications
Reviewed by: L. C. Meyer, INEL

Effect of Aging on Component Function	Contrib to Failure	Reported progs	Rel.progs	Report Recommendations	Page No.	Item
Transistor failure caused the circuit to fail resulting in no motion control for the group 1 control rods. Aging degradation was given as the cause of the transistor failure.	Rare	10 CFR 50.73	No specific surveillance for this component	Not stated	1-4	23

Document: LER 91-008-260, Unplanned Engineered Safety Features Actuation Due to a Failed PCIS Relay
Reviewed by: L. C. Meyer, INEL

Item	System	Structure/Comp	Subcomponent	Materials	Manufacturer	ARD mechanism	ARD effects
24	Primary Containment Isolation System	Logic Relay	Coil	Not stated	General Electric	Not stated	Burned coil

Document: LER 91-010-01-155, Reactor Protection System Pressure Switches Experiencing Setpoint Drift, Revision 1
Reviewed by: L. C. Meyer, INEL

Item	System	Structure/Comp	Subcomponent	Materials	Manufacturer	ARD mechanism	ARD effects
25	Reactor Protection System	Switches		Not stated	Foxboro	CORR	Corrosion caused switch setpoint drift

Document: LER 91-014-01-498, Erratic Containment Extended Range Pressure Channel Output
Reviewed by: L. C. Meyer, INEL

Item	System	Structure/Comp	Subcomponent	Materials	Manufacturer	ARD mechanism	ARD effects
26	Containment Extended Range Pressure Channel	Pressure Transmitter	Thermisitor	Not stated	Barton	Not stated	Erratic behavior of instrument

Document: LER 91-016-260, Unplanned Engineered Safety Features Actuation Due to a Blown Fuse Caused by a Failed Relay
Reviewed by: L. C. Meyer, INEL

Item	System	Structure/Comp	Subcomponent	Materials	Manufacturer	ARD mechanism	ARD effects
27	ESFAS	Relay	Coil	Not stated	General Electric	ELETEMP	Relay coil failed

Document: LER 91-016-424, Failure to Complete Technical Specification Required Action for Battery Cell Low Voltage
Reviewed by: L. C. Meyer, INEL

Item	System	Structure/Comp	Subcomponent	Materials	Manufacturer	ARD mechanism	ARD effects
28	Various	Battery	NA	Not stated	C & D Batteries	Not stated	Low cell voltage while single cell charging

Document: LER 91-020-237, Reactor Building Ventilation Isolation and Automatic Standby Gas Treatment Initiation Due to Radiation Monitor Power Supply Failure
Reviewed by: L. C. Meyer, INEL

Item	System	Structure/Comp	Subcomponent	Materials	Manufacturer	ARD mechanism	ARD effects
29	Reactor Building Ventilation System	Power Supply	Wire	Not stated	General Electric	WEAR	Insulation worn and spark caused power supply failure

Document: LER 91-021-254, RCIC Declared Inoperable Due to High Pump Flow in ISI Required Action Range
Reviewed by: L. C. Meyer, INEL

Item	System	Structure/Comp	Subcomponent	Materials	Manufacturer	ARD mechanism	ARD effects
30	RCIC System	Tachometer	NA	Not stated	Not stated	Not stated	Instrument drift

Document: LER 91-028-254, Loss of Power to 1A RPS Bus Caused by EPA 1A-1 Tripping on Undervoltage Due to Low M-G Set Output
Reviewed by: L. C. Meyer, INEL

Item	System	Structure/Comp	Subcomponent	Materials	Manufacturer	ARD mechanism	ARD effects
31	M-G Set	Voltage Regulator	Voltage Rheostat	Insulation	General Electric	Not stated	Low voltage from m-g set

Table A.2 Gall Report for Licensee Event Reports

Document: LER 91-008-260, Unplanned Engineered Safety Features Actuation Due to a Failed PCIS Relay
Reviewed by: L. C. Meyer, INEL

Effect of Aging on Component Function	Contrib to Failure	Reported progs	Rel.progs	Report Recommendations	Page No.	Item
The burned coil cause the normally energized relay to fail resulting in loss of logic power and an unplanned actuation of the esfas. This was called a thermally aged relay coil failure.	Occasional	10 CFR 50.73	Tech Spec. required surveillance	Not stated	1-3	24

Document: LER 91-010-01-155, Reactor Protection System Pressure Switches Experiencing Setpoint Drift, Revision 1
Reviewed by: L. C. Meyer, INEL

Effect of Aging on Component Function	Contrib to Failure	Reported progs	Rel.progs	Report Recommendations	Page No.	Item
The drift would adversly effect the RPS operation. Found during refueling outage calibration.	Rare	10 CFR 50.73	Tech Spec. required surveillance	Not stated	1-2	25

Document: LER 91-014-01-498, Erratic Containment Extended Range Pressure Channel Output
Reviewed by: L. C. Meyer, INEL

Effect of Aging on Component Function	Contrib to Failure	Reported progs	Rel.progs	Report Recommendations	Page No.	Item
A cracked thermistor was found on the control card, however the erratic behavior of the pressure transmitter cannot be positively attributed to this thermistor.	Rare	10 CFR 50.73	Tech Spec. surveillance, RG 1.118, IEEE 338	Not stated	1-4	26

Document: LER 91-016-260, Unplanned Engineered Safety Features Actuation Due to a Blown Fuse Caused by a Failed Relay
Reviewed by: L. C. Meyer, INEL

Effect of Aging on Component Function	Contrib to Failure	Reported progs	Rel.progs	Report Recommendations	Page No.	Item
Unplanned ESFAS actuation due to failed relay. The failed relay coil was 15 years old and the service life for a normally-energized coil relay of this type is 15 to 20 years. This was an end of life failure.	Rare	10 CFR 50.73	Tech Spec. surveillance, not specific	Not stated	1-3	27

Document: LER 91-016-424, Failure to Complete Technical Specification Required Action for Battery Cell Low Voltage
Reviewed by: L. C. Meyer, INEL

Effect of Aging on Component Function	Contrib to Failure	Reported progs	Rel.progs	Report Recommendations	Page No.	Item
Battery failed to meet technical specification while charging. This was considered to be related to battery aging phenomena.	Rare	10 CFR 50.73	Tech Spec. surveillance, RG 1.118, IEEE 450	Not stated	1-4	28

Document: LER 91-020-237, Reactor Building Ventilation Isolation and Automatic Standby Gas Treatment Initiation Due to Radiation Monitor Power Supply Failure
Reviewed by: L. C. Meyer, INEL

Effect of Aging on Component Function	Contrib to Failure	Reported progs	Rel.progs	Report Recommendations	Page No.	Item
The ventilation system and gas treatment system actuation resulted from the power supply failure.	Occasional	10 CFR 50.73	No specific surveillance for this component	Not stated	1-4	29

Document: LER 91-021-254, RCIC Declared Inoperable Due to High Pump Flow in ISI Required Action Range
Reviewed by: L. C. Meyer, INEL

Effect of Aging on Component Function	Contrib to Failure	Reported progs	Rel.progs	Report Recommendations	Page No.	Item
Failure due to instrument drift caused by aging	Rare	10 CFR 50.73	No specific surveillance for this component	Not stated	1-4	30

Document: LER 91-028-254, Loss of Power to 1A RPS Bus Caused by EPA 1A-1 Tripping on Undervoltage Due to Low M-G Set Output
Reviewed by: L. C. Meyer, INEL

Effect of Aging on Component Function	Contrib to Failure	Reported progs	Rel.progs	Report Recommendations	Page No.	Item
Cause of dip is unknown, but normal wear of the voltage adjustment rheostat was supected. It was believed to have developed a flat spot or corrosion at the point of the previous adjustment due to normal wear at that point over a long period of time.	Occasional	10 CFR 50.73	Vendor specific program	Not stated	1-6	31

Table A.2 Gall Report for Licensee Event Reports

Document: LER 91-028-325, Component Failure of a Reactor Water Cleanup System Isolation Logic Relay Resulted in an Unplanned Engineered Safety Feature A
Reviewed by: L. C. Meyer, INEL

Item	System	Structure/Comp	Subcomponent	Materials	Manufacturer	ARD mechanism	ARD effects
32	RWCU	Relay	Coil	Insulation	General Electric	Not stated	Relay coil failed after insulation breakdown

Document: LER 91-030-423, Motor Control Center Auxiliary Control Relay Failure Due to Thermal Aging
Reviewed by: L. C. Meyer, INEL

Item	System	Structure/Comp	Subcomponent	Materials	Manufacturer	ARD mechanism	ARD effects
33	Motor Control Center	Relay	Coil	Insulation	ITE Gould	ELETEMP & EMBR	Relay coil insulaton embrittlement and failure

Document: LER 92-001-155, Brittle Motor Lead Wires Discovered in VOP-7050 (Main Steam Isolation Valve-MSIV)
Reviewed by: L. C. Meyer, INEL

Item	System	Structure/Comp	Subcomponent	Materials	Manufacturer	ARD mechanism	ARD effects
34	Main Steam	Isolation Valve Motor	Lead Wire Insulation	Butyl rubber	Limitorque	ELETEMP & EMBR	Brittle and cracked insulation

Document: LER 92-001-263, Shutdown Required by Technical Specification Due to Inoperable Bellows Leak Detection System for Safety Relief Valves
Reviewed by: L. C. Meyer, INEL

Item	System	Structure/Comp	Subcomponent	Materials	Manufacturer	ARD mechanism	ARD effects
35	Bellows Leak Detection System	Valve	Seating Material	Cast urethane	Automatic Switch Company	ELETEMP	Urethane seat material degraded due to high temperature

Document: LER 92-001-296, Engineered Safety Feature Actuation Caused by a Failed Relay Coil
Reviewed by: L. C. Meyer, INEL

Item	System	Structure/Comp	Subcomponent	Materials	Manufacturer	ARD mechanism	ARD effects
36	Engineered Safety Feature Actuating System (ESFAS)	Relay	Coil	Not stated	General Electric	ELETEMP	Degraded insulation causing coil failure

Document: LER 92-001-339, Reactor Trip Caused by MFRV Closure Upon Failure of Driver Card
Reviewed by: L. C. Meyer, INEL

Item	System	Structure/Comp	Subcomponent	Materials	Manufacturer	ARD mechanism	ARD effects
37	Feedwater system	Main Feed Regulating Valve	Power Supply	Not stated	Not stated	Not stated	Power supply failed on driver card

Document: LER 92-002-247, Reactor Trip Due to Main Feedwater Regulating Valve Going Closed
Reviewed by: L. C. Meyer, INEL

Item	System	Structure/Comp	Subcomponent	Materials	Manufacturer	ARD mechanism	ARD effects
38	Feedwater system	Feedwater Regulating Valve	Solenoid Valve	Not stated	Not stated	Not stated	Solenoid valve failed

Document: LER 92-004-389, Manual Reactor Trip Due to Low Steam Generator Water Level Caused by a Failed Circuit in the 2A Feedwater Regulating Control Sy
Reviewed by: L. C. Meyer, INEL

Item	System	Structure/Comp	Subcomponent	Materials	Manufacturer	ARD mechanism	ARD effects
39	Feedwater Regulatiog Valve Control System	Power Supply	Capacitor	Not stated	Not stated	Not stated	Capacitor failed

Document: LER 91-028-325, Component Failure of a Reactor Water Cleanup System Isolation Logic Relay Resulted in an Unplanned Engineered Safety Feature A
Reviewed by: L. C. Meyer, INEL

Effect of Aging on Component Function	Contrib to Failure	Reported progs	Rel.progs	Report Recommendations	Page No.	Item
ESFAS actuation resulted from the relay failure. Component failure determined to be a normal end of life failure due to aging. This was a normally energized relay.	Occasional	10 CFR 50.73	Tech Spec. not specific for this component	Not stated	1-4	32

Document: LER 91-030-423, Motor Control Center Auxiliary Control Relay Failure Due to Thermal Aging
Reviewed by: L. C. Meyer, INEL

Effect of Aging on Component Function	Contrib to Failure	Reported progs	Rel.progs	Report Recommendations	Page No.	Item
Elevated temperature from continuous operation of relays caused embrittlement and failure. Heat also discolored other plastic parts near the coil.	Occasional	10 CFR 50.73	Vendor specific program	Not stated	1-5	33

Document: LER 92-001-155, Brittle Motor Lead Wires Discovered in VOP-7050 (Main Steam Isolation Valve-MSIV)
Reviewed by: L. C. Meyer, INEL

Effect of Aging on Component Function	Contrib to Failure	Reported progs	Rel.progs	Report Recommendations	Page No.	Item
Loss of isolation capability, the degraded wire insulation was found in the limit switch housing as a result of planned maintenance during a scheduled refueling outage.	Rare	10 CFR 50.73	Vendor specific progarm, GL 89-10, NUREG-1352	Not stated	1-4	34

Document: LER 92-001-263, Shutdown Required by Technical Specification Due to Inoperable Bellows Leak Detection System for Safety Relief Valves
Reviewed by: L. C. Meyer, INEL

Effect of Aging on Component Function	Contrib to Failure	Reported progs	Rel.progs	Report Recommendations	Page No.	Item
Valve failed to seat due to degradation of the seating material from exposure to temperatures near manufacturers rated temperature.	Rare	10 CFR 50.73	Vendor specific program	Not stated	1-6	35

Document: LER 92-001-296, Engineered Safety Feature Actuation Caused by a Failed Relay Coil
Reviewed by: L. C. Meyer, INEL

Effect of Aging on Component Function	Contrib to Failure	Reported progs	Rel.progs	Report Recommendations	Page No.	Item
The coil failure iniated partial actuation of the ESFAS system.	OCCAIONAL	10 CFR 50.73	Vendor specific program, Tech. Spec. Surveil.	Not stated	1-5	36

Document: LER 92-001-339, Reactor Trip Caused by MFRV Closure Upon Failure of Driver Card
Reviewed by: L. C. Meyer, INEL

Effect of Aging on Component Function	Contrib to Failure	Reported progs	Rel.progs	Report Recommendations	Page No.	Item
Power supply failure caused the MFRV valve to fail closed isolating normal feedwater and causing a reactor trip.	Occasional	10 CFR 50.73	No specific program	Not stated	1-3	37

Document: LER 92-002-247, Reactor Trip Due to Main Feedwater Regulating Valve Going Closed
Reviewed by: L. C. Meyer, INEL

Effect of Aging on Component Function	Contrib to Failure	Reported progs	Rel.progs	Report Recommendations	Page No.	Item
Solenoid valve failued relieving air pressure to the diaphragm of the regulating valve which caused it to go to the closed position.	Rare	10 CFR 50.73	No specific program	Not stated	1-3	38

Document: LER 92-004-389, Manual Reactor Trip Due to Low Steam Generator Water Level Caused by a Failed Circuit in the 2A Feedwater Regulating Control Sy
Reviewed by: L. C. Meyer, INEL

Effect of Aging on Component Function	Contrib to Failure	Reported progs	Rel.progs	Report Recommendations	Page No.	Item
Because of the capacitor failure the lead lag circuit output current was low and the steam regulating valve closed. The reactor was manually tripped.	Rare	10 CFR 50.73	Vendor specific program	Not stated	1-3	39

Document: LER 92-006-331, Emergency Safety Feature Actuation During Modification Acceptance Testing Due to Damaged Switchyard Cable
Reviewed by: L. C. Meyer, INEL

Item	System	Structure/Comp	Subcomponent	Materials	Manufacturer	ARD mechanism	ARD effects
40	1E Power	Cable	Insulation	Ethylene propylene rubber	Not stated	WEATH, CORR, & MOIST	Insulation degraded, galvanic corrosion rusted wire cores

Document: LER 92-006-354, Reactor Shutdown to Comply With Technical Specification 3.6.1.1, Due to Failure of Suppression Chamber to Drywell Vacuum Break
Reviewed by: L. C. Meyer, INEL

Item	System	Structure/Comp	Subcomponent	Materials	Manufacturer	ARD mechanism	ARD effects
41	Various	Drywell Vacuum Breakers	Seal	Not stated	Not stated	Not stated	Seal degraded due to aging

Document: LER 92-007-01-33, Failure of Analog Transmitter Trip System (ATTS) Trip Relays Due to Thermal Aging
Reviewed by: L. C. Meyer, INEL

Item	System	Structure/Comp	Subcomponent	Materials	Manufacturer	ARD mechanism	ARD effects
42	Analog Transmitter Trip System	Relay	Coil	Not stated	Amerace	ELETEMP	Relay coil wire insulation embrittlement

Document: LER 92-009-01-499, Missed Technical Specification Required Surveillance Due to a Faulty Toxic Gas Monitoring System Modem
Reviewed by: L. C. Meyer, INEL

Item	System	Structure/Comp	Subcomponent	Materials	Manufacturer	ARD mechanism	ARD effects
43	Emergency Response — Display System (ERFDADS)	Modem	NA	Not stated	Black Box Corporation	Not stated	Modem failed

Document: LER 92-011-325, Primary Containment Monitoring System Inoperability Due to Relay Failure
Reviewed by: L. C. Meyer, INEL

Item	System	Structure/Comp	Subcomponent	Materials	Manufacturer	ARD mechanism	ARD effects
44	Containment Atmospheric Control (CAC) System	Containment Control – Logic	Relay	Not stated	General Electric	Not stated	Relay failed (end of life)

Document: LER 92-021-237, Automatic Isolation of Reactor Building Ventilation Due to Radiation Monitor Trip Relay Failure
Reviewed by: L. C. Meyer, INEL

Item	System	Structure/Comp	Subcomponent	Materials	Manufacturer	ARD mechanism	ARD effects
45	Reactor Building Ventilation System	RBV Radiation Monitor	Relay	Not stated	General Electric	Not stated	Burned out coil

Document: LER 92-034-01-333, Engineered Safety Feature Actuations Due to Transformer Failure
Reviewed by: L. C. Meyer, INEL

Item	System	Structure/Comp	Subcomponent	Materials	Manufacturer	ARD mechanism	ARD effects
46	ESFAS	Transformer	NA	Not stated	General Electric	ELETEMP	Insulation degradation in transfomer

Document: LER 92-006-331, Emergency Safety Feature Actuation During Modification Acceptance Testing Due to Damaged Switchyard Cable
Reviewed by: L. C. Meyer, INEL

Effect of Aging on Component Function	Contrib to Failure	Reported progs	Rel.progs	Report Recommendations	Page No.	Item
A tear or crack in the insulation exposed wires to ambient conditions and moisture intrusion with continuous dc potential on wires may have contributed to galvanic corrosion leading to an open circuit. The failed circuit caused sf actuation during test.	Rare	10 CFR 50.73	No specific program	Not stated	1-8	40

Document: LER 92-006-354, Reactor Shutdown to Comply With Technical Specification 3.6.1.1, Due to Failure of Suppression Chamber to Drywell Vacuum Break
Reviewed by: L. C. Meyer, INEL

Effect of Aging on Component Function	Contrib to Failure	Reported progs	Rel.progs	Report Recommendations	Page No.	Item
Leak in vacuum breakers was too large and violated the technical specifications resulting in reactor shut down. Two of the three leaking breakers also had seal and pallet alignment problems.	Rare	10 CFR 50.73	No specific program	Not stated	1-5	41

Document: LER 92-007-01-33, Failure of Analog Transmitter Trip System (ATTS) Trip Relays Due to Thermal Aging
Reviewed by: L. C. Meyer, INEL

Effect of Aging on Component Function	Contrib to Failure	Reported progs	Rel.progs	Report Recommendations	Page No.	Item
Debris from the embrittled coil spool was inhibiting movement of the relay plunger resulting in sticking relay and excessive delay time. The relay had been in service 4 years which exceeded the recommended service life of 3 years	Occasional	10 CFR 50.73	Tech Spec. required surveillance	Not stated	1-5	42

Document: LER 92-009-01-499, Missed Technical Specification Required Surveillance Due to a Faulty Toxic Gas Monitoring System Modem
Reviewed by: L. C. Meyer, INEL

Effect of Aging on Component Function	Contrib to Failure	Reported progs	Rel.progs	Report Recommendations	Page No.	Item
Garbled data sent to erfdads computer. Failure of modem attributed to aging. Operators were unable to meet technical specifications requiring the each chemical detection system be demonstrated operable every 12 hours.	Rare	10 CFR 50.73	No specific program	Not stated	1-5	43

Document: LER 92-011-325, Primary Containment Monitoring System Inoperability Due to Relay Failure
Reviewed by: L. C. Meyer, INEL

Effect of Aging on Component Function	Contrib to Failure	Reported progs	Rel.progs	Report Recommendations	Page No.	Item
Failure of this relay resulted in loss of power to various containment isolation valves and inoperability of the cac system.	Occasional	10 CFR 50.73	Tech Spec. required surveillance	Not stated	1-3	44

Document: LER 92-021-237, Automatic Isolation of Reactor Building Ventilation Due to Radiation Monitor Trip Relay Failure
Reviewed by: L. C. Meyer, INEL

Effect of Aging on Component Function	Contrib to Failure	Reported progs	Rel.progs	Report Recommendations	Page No.	Item
Failure of relay coil caused the RBV system to actuate.	Rare	10 CFR 50.73	No specific program	Not stated	1-4	45

Document: LER 92-034-01-333, Engineered Safety Feature Actuations Due to Transformer Failure
Reviewed by: L. C. Meyer, INEL

Effect of Aging on Component Function	Contrib to Failure	Reported progs	Rel.progs	Report Recommendations	Page No.	Item
Fault in middle phase b winding due to dielectric breakdown of insulation caused transformer failure resulting in ESFAS actuations. The dielectric breakdown due to aging resulted in multiple faults.	Rare	10 CFR 50.73	RG 1.118, IEEE 338-1987	Not stated	1-16	46

Table A.2 Gall Report for Licensee Event Reports

Document: LER 92-038-255, Reactor Trip Caused by a Loss of the Preferred AC BUS Y-20 Coincident With a Blown Fuse in a Second Channel of the Reactor Pro
Reviewed by: L. C. Meyer, INEL

Item	System	Structure/Comp	Subcomponent	Materials	Manufacturer	ARD mechanism	ARD effects
47	Reactor Protection System	Inverter	Transformer	Not stated	Sola	ELETEMP	Transformer coils failed

Document: LER 93-002-249, Control Valve Fast Closure Half-Scram Pressure Switches Out-of Calibration Due to Setpoint Drift
Reviewed by: L. C. Meyer, INEL

Item	System	Structure/Comp	Subcomponent	Materials	Manufacturer	ARD mechanism	ARD effects
48	Reactor Protection System	Pressure Switch	NA	Not stated	Barksdale	VIB	Wear of face of the plunger

Document: LER 93-003-530, Emergency Diesel Generator Unable to Start and Run in Manual Test Mode
Reviewed by: L. C. Meyer, INEL

Item	System	Structure/Comp	Subcomponent	Materials	Manufacturer	ARD mechanism	ARD effects
49	Emergency Diesel Generator	Starting System	Relay	Not stated	Agastat	Not stated	Relay failed by fault of a suppression varistor across coil

Document: LER 93-005-01-275, Medium Voltage Cable Failures Due to Chemical Degradation and Undkown Causes
Reviewed by: L. C. Meyer, INEL

Item	System	Structure/Comp	Subcomponent	Materials	Manufacturer	ARD mechanism	ARD effects
50	Various	Cable	12KV Underground Cable	Ethylene-propylene=rubber (EPR) and neoprene jacket	Okonite	CHEM, CONTAM, & CORR	Chemical degradation of jacket and corrosion of shield
51	Various	Cable	12KV Underground Cable	Ethylene-propylene=rubber (EPR) and neoprene jacket	Okonite	Not stated	Anomalies occurred over time

Document: LER 93-005-01-305, Annual Transmitter Calibration Finds a Shift in the Pressurizer High Pressure Reactor Trip Signal Initiation Due to Instrument Drift
Reviewed by: L. C. Meyer, INEL

Item	System	Structure/Comp	Subcomponent	Materials	Manufacturer	ARD mechanism	ARD effects
52	Reactor Protection System	Pressure Transmitter	NA	Not stated	Foxboro	Not stated	Transmitter drift

Document: LER 93-007-249, Yarway Reactor Water Level Switch Failure
Reviewed by: L. C. Meyer, INEL

Item	System	Structure/Comp	Subcomponent	Materials	Manufacturer	ARD mechanism	ARD effects
53	High PRessure Coolant Injection System (HPCI)	Level Switch	NA	Not stated	Yarway	MECHSTR	Spring force degradation

Document: LER 93-008-237, Yarway Reactor Water Level Switch Failure
Reviewed by: , L. C. Meyer, INEL

Item	System	Structure/Comp	Subcomponent	Materials	Manufacturer	ARD mechanism	ARD effects
54	High PRessure Coolant Injection System (HPCI)	Level Switch	NA	Not stated	Yarway	MECHSTR	Spring force degradation

Document: LER 92-038-255, Reactor Trip Caused by a Loss of the Preferred AC BUS Y-20 Coincident With a Blown Fuse in a Second Channel of the Reactor Prc
Reviewed by: L. C. Meyer, INEL

Effect of Aging on Component Function	Contrib to Failure	Reported progs	Rel.progs	Report Recommendations	Page No.	Item
The transformer failure resulted from accelerated aging due to improper inernal wiring in the inverter. Only one primary winding was connected resulting in operation at a higher temperature. the Y-20 bus power failure tripped the reactor.	Rare	10 CFR 50.73	Tech. Spec. required surveillance, RG 1.118	Not stated	1-8	47

Document: LER 93-002-249, Control Valve Fast Closure Half-Scram Pressure Switches Out-of Calibration Due to Setpoint Drift
Reviewed by: L. C. Meyer, INEL

Effect of Aging on Component Function	Contrib to Failure	Reported progs	Rel.progs	Report Recommendations	Page No.	Item
Vibration contributed to the drift of the set point because of wear on the plunger face.	Rare	10 CFR 50.73	Tech Spec. required surveillance	Not stated	1-6	48

Document: LER 93-003-530, Emergency Diesel Generator Unable to Start and Run in Manual Test Mode
Reviewed by: L. C. Meyer, INEL

Effect of Aging on Component Function	Contrib to Failure	Reported progs	Rel.progs	Report Recommendations	Page No.	Item
The starting system check circuitry relay shorted and the resulting current surge damaged other electrical components on the fiber optics card in the EDG starting circuit. The EDG would not start in the manual test mode. Component aging was the cause	Rare	10 CFR 50.73	RG 1.108, IEEE 387-1984 Section 7.5, IEEE 749	Not stated	1-9	49

Document: LER 93-005-01-275, Medium Voltage Cable Failures Due to Chemical Degradation and Undkown Causes
Reviewed by: L. C. Meyer, INEL

Effect of Aging on Component Function	Contrib to Failure	Reported progs	Rel.progs	Report Recommendations	Page No.	Item
A ground fault developed at the cable jacket degradation location (insulation breakdown). Excess chlorides and a fatty acid, ethyl ester compound, were identified as the chemical that attacked the cable jacket. Water carried chemical into conduit.	Rare	10 CFR 50.73	No specific program	Not stated	1-16	50
Ground fault occurred on cable. water was in conduit (cable was designed for wet conditions) cable removed from conduit and no root cause identified from inspections or tests conducted by utility and manufacturer.	Rare	10 CFR 50.73	No specific program	Not stated	1-16	51

Document: LER 93-005-01-305, Annual Transmitter Calibration Finds a Shift in the Pressurizer High Pressure Reactor Trip Signal Initiation Due to Instrument Drif
Reviewed by: L. C. Meyer, INEL

Effect of Aging on Component Function	Contrib to Failure	Reported progs	Rel.progs	Report Recommendations	Page No.	Item
The transmitter would not initiate a trip signal at the required point. The method of calibration was most probable cause and aging was the next most likely cause.	Occasional	10 CFR 50.73	RG 1.118, IEEE 338-1987	Not stated	1-5	52

Document: LER 93-007-249, Yarway Reactor Water Level Switch Failure
Reviewed by: L. C. Meyer, INEL

Effect of Aging on Component Function	Contrib to Failure	Reported progs	Rel.progs	Report Recommendations	Page No.	Item
Switch tripped outside of technical specification limits. Excessive set point drifts were also found.	Frequently	10 CFR 50.73	RG 1.118, IEEE 338-1987	Not stated	1-5	53

Document: LER 93-008-237, Yarway Reactor Water Level Switch Failure
Reviewed by: L. C. Meyer, INEL

Effect of Aging on Component Function	Contrib to Failure	Reported progs	Rel.progs	Report Recommendations	Page No.	Item
Out of tolerance	Frequently	10 CFR 50.73	RG 1.118, IEEE 338-1987	Not stated	1-6	54

Table A.2 Gall Report for Licensee Event Reports

Document: LER 93-009-498, Technical Specification 3.0.3 Entry Due to Potentially Undersized Fuses in the Solid State Protection System
Reviewed by: L. C. Meyer, INEL

Item	System	Structure/Comp	Subcomponent	Materials	Manufacturer	ARD mechanism	ARD effects
55	Solid State Protection System	Fuse	NA	Not stated	Not stated	Not stated	Fuse failed

Table A.2 Gall Report for Licensee Event Reports

Document: LER 93-009-498, Technical Specification 3.0.3 Entry Due to Potentially Undersized Fuses in the Solid State Protection System
Reviewed by: L. C. Meyer, INEL

Effect of Aging on Component Function	Contrib to Failure	Reported progs	Rel.progs	Report Recommendations	Page No.	Item
An independent laboratory determined that the fuse did not open as the result of a high current fault. It was not possible to determine whether the fuse had a defect. LER states that the event was caused by the random age related failure of a ssps fuse.	Rare	10 CFR 50.73	No specific program	Not stated	1-5	55

Table A.2 Gall Report for NRC Bulletins

Document: BL 90-01, Loss of Fill-Oil in Transmitters Manufactured by Rosemount
Reviewed by: E. W. Roberts, INEL

Item	System	Structure/Comp	Subcomponent	Materials	Manufacturer	ARD mechanism	ARD effects
1		Pressure Transmitters Model 1153 & 1154	O-Ring	Metal	Rosemount	Not stated	Loss of transmitter oil

Table A.2 Gall Report for NRC Bulletins

Document: BL 90-01, Loss of Fill-Oil in Transmitters Manufactured by Rosemount
Reviewed by: E. W. Roberts, INEL

Effect of Aging on Component Function	Contrib to Failure	Reported progs	Rel.progs	Report Recommendations	Page No.	Item
Transmitter drift, slow response, inability to respond over full range, sustained zero/span drift, or total failure	Frequent	Not discussed in report	Bul 90-01 Suppl 1, RG 1.118, IEEE 338-1987	identify transmitters and take appropriate corrective action [4]		1

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10. SUPPLEMENTARY NOTES

11. ABSTRACT *(200 words or less)*

Argonne National Laboratory and Idaho National Engineering Laboratory in support of the License Renewal Project Directorate of the U.S. Nuclear Regulatory Commission (NRC) performed a comprehensive review of literature pertaining to nuclear power plant aging effects. This generic aging lessons learned (GALL) effort was a systematic review of plant aging information in order to assess materials and component aging issues related to continued operation and license renewal of operating reactors. Literature on mechanical, structural, thermal-hydraulic, and electrical components and systems reviewed consisted of 163 Nuclear Plant Aging Research Reports, 31 NRC Generic Letters, 265 Information Notices, 82 Licensee Event reports, 5 Bulletins, and 10 Nuclear Management and Resources Council Industry Reports. The results of these reviews were systematized using a standardized GALL tabular format and standardized definitions of aging related degradation mechanisms and effects. A computerized data base has also been developed for all review tables and can be used to search for information on structures, components, and relevant aging effects. A survey of the GALL tables reveals that all significant component and structure aging issues are currently being addressed by the regulatory process. However, aging of what are termed passive components and structures has been highlighted for continued scrutiny.

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Nuclear Power Plant Generic Aging Lessons Learned (GALL)

Appendix B

Prepared by
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Nuclear Power Plant Generic Aging Lessons Learned (GALL)

Appendix B

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Prepared by
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Nuclear Power Plant Generic Aging Lessons Learned:
- Mechanical, Structural, and Thermal-Hydraulic Components and Systems
- Electrical Components and Systems

by

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W. J. Shack, O. K. Chopra, D. C. Ma, A. Erdemir,
J. L. Edson, L. C. Meyer, and E. W. Roberts

Abstract

The purpose of this generic aging lessons learned (GALL) review is to provide a systematic review of plant aging information in order to assess materials and component aging issues related to continued operation and license renewal of operating reactors. Literature on mechanical, structural, and thermal-hydraulic components and systems reviewed consisted of 97 Nuclear Plant Aging Research (NPAR) reports, 23 NRC Generic Letters, 154 Information Notices, 29 Licensee Event Reports (LERs), 4 Bulletins, and 9 Nuclear Management and Resources Council Industry Reports (NUMARC IRs) and literature on electrical components and systems reviewed consisted of 66 NPAR reports, 8 NRC Generic Letters, 111 Information Notices, 53 LERs, 1 Bulletin, and 1 NUMARC IR. More than 550 documents were reviewed. The results of these reviews were systematized using a standardized GALL tabular format and standardized definitions of aging-related degradation mechanisms and effects. The tables are included in volumes 1 and 2 of this report. A computerized data base has also been developed for all review tables and can be used to expedite the search for desired information on structures, components, and relevant aging effects. A survey of the GALL tables reveals that all ongoing significant component aging issues are currently being addressed by the regulatory process. However, the aging of what are termed passive components has been highlighted for continued scrutiny.

Contents

Appendix B: GALL Literature Review Tables - NUMARC Industry Reports

B.1 Mechanical, Structural, and Thermal-Hydraulic Components and Systems

Document: IR 90-01, PWR Reactor Containment Structures Industry Report
Reviewed by: David C. Ma, ANL

Item	System	Structure/Comp	Subcomponent	Materials	Manufacturer	ARD mechanism	ARD effects
1	Reinforced or Prestress Concrete Containments	All	Not stated	Concrete	Not stated	All	Not stated
2	Reinforced or Prestress Concrete Containments	Concrete Dome & Concrete Containment Wall Above Grade	Not stated	Concrete	Not stated	FRZ-THAW	Scaling, cracking, & spalling
3	Reinforced or Prestress Concrete Containments	Concrete Dome & Concrete Containment Wall Above Grade	Not stated	Concrete	Not stated	LEACH	Increase of porosity & permeability
4	Reinforced or Prestress Concrete Containments	Concrete Dome &Concrete Containment Wall Above Grade	Not stated	Concrete	Not stated	AGR-CHEM	Increase of porosity & permeability, cracking, & spalling
5	Reinforced or Prestress Concrete Containments	Concrete Dome &Concrete Containment Wall Above Grade	Not stated	Concrete	Not stated	AGREAC Unresolved	Expansion & cracking
6	Reinforced or Prestress Concrete Containments	Concrete Dome &Concrete Containment Wall Above Grade	Not stated	Concrete	Not stated	ELE-TEMP	Loss of strength & modulus
7	Reinforced or Prestress Concrete Containments	Concrete Dome &Concrete Containment Wall Above Grade	Not stated	Concrete	Not stated	EMBR/IR	Loss of strength & modulus
8	Reinforced or Prestress Concrete Containments	Concrete Dome & Concrete Containment Wall Above Grade	Not stated	Concrete	Not stated	CORR/RE	Cracking, spalling, loss of bond, & loss of material
9	Reinforced or Prestress Concrete Containments	Concrete Dome & Concrete Containment Wall Above Grade	Not stated	Concrete	Not stated	FAT	Cumulative fatigue damage
10	Reinforced or Prestress Concrete Containments	Concrete Dome & Concrete Containment Wall Above Grade	Not stated	Concrete	Not stated	CONCAL	Reduction of concrete strength
11	Reinforced or Prestress Concrete Containments	Concrete Containment Wall Below Grade	Not stated	Concrete	Not stated	FRZ-THAW	Scaling, cracking, & spalling
12	Reinforced or Prestress Concrete Containments	Concrete Containment Wall Below Grade	Not stated	Concrete	Not stated	LEACH	Increase of porosity & permeability

Table B.1 Gall Report for NUMARC Industry Reports

Document: IR 90-01, PWR Reactor Containment Structures Industry Report
Reviewed by: David C. Ma, ANL

Effect of Aging on Component Function	Contrib to Failure	Reported progs	Rel.progs	Report Recommendations	Page No.	Item
Loss of pressure boundary.	Not stated	If resolution based upon evaluation of plant-specific features, then baseline inspection not needed.		NRC recommendation: A one time focused inspection of containment is proposed to provide assurance for continued satisfactory performance and to identify existing degradation mechanisms and to take necessary corrective actions.		1
Loss of pressure boundary.	Not stated	Non-significant if located in region of weathering index<100 day-in/yr or concrete meets CC-2231.7.1		NRC Recommendation: Potential freeze thaw damage of the dome of concrete containments should be addressed.	4-3 to 4-7	2
Loss of pressure boundary.	Not stated	Not stated		Non-significant for components not exposed to flowing water or constructed using ACI 201.2R-77 to ensure dense, well-cured concrete with low permeability.	4-8 to 4-11	3
Loss of pressure boundary.	Not stated	Not stated		Non-significant for components not exposed to aggressive environment (pH <5.5, chloride >500 ppm, & sulfate >1500 ppm); or exposed to aggressive groundwater for intermittent periods only.	4-12 to 4-14	4
Loss of pressure boundary.	Not stated	Non-significant for aggregate taken from regions other than those known to (More)		NRC recommendation: AGREAC can not be ruled out. Tests alone are not satisfactory in predicting performance. AGREAC may occur >25 years. Use of pozzolans & low alkali content cement may not control reactions for concretes.(See IR90-06 & 90-10)	4-14 to 4-17	5
Loss of pressure boundary.	Not stated	Not stated		Non-significant for concrete maintained at <66_C (150_F) & local area temperatures <93_C (200_F), or plant-specific justification is provided in accordance with ACI 349-85.	4-20 to 4-25, 4-34	6
Loss of pressure boundary.	Not stated	Not stated		Non-significant because the total neutron fluence & integrated gamma doses are low compared to the levels causing degradation, i.e., 10^19 n/cm^2 & 10^10 rads, respectively.	4-25 to 4-31, 4-35, 4-36	7
Loss of pressure boundary.	Not stated	Not stated		Non-significant for concrete not exposed to aggressive environment, pH <11.5 or chlorides >500 ppm; or concrete has low water-to-cement ratio (0.35-0.45) & adequate air entrainment (3-6%).	4-17 to 4-19, 4-31 to 4-33	8
Loss of pressure boundary.	Not stated	Not stated		Non-significant because designed to have good fatigue strength in accordance with ASME Sect. III, Div. 2 & ACI 215R-74	4-52 to 4-54	9
Loss of pressure boundary.	Not stated	Not stated		Non-significant if no degradation of concrete strength was noted during initial structural testing, or if aluminum piping were not used for concrete placement.	4-54, 4-55	10
Loss of pressure boundary.	Not stated	Not stated		Non-significant for component located in a geographic region of weathering index <100 day-in./yr or concrete mix design meets air content & water-to-cement ratio requirements of ASME Sect. III, Div. 2, CC-2231.7.1.	4-3 to 4-7	11
Loss of pressure boundary.	Not stated	Not stated		Non-significant for components not exposed to flowing water or constructed using ACI 201.2R-77 to ensure dense, well-cured concrete with low permeability.	4-8 to 4-11	12

Document: IR 90-01, PWR Reactor Containment Structures Industry Report
Reviewed by: David C. Ma, ANL

Item	System	Structure/Comp	Subcomponent	Materials	Manufacturer	ARD mechanism	ARD effects
13	Reinforced or Prestress Concrete Containments	Concrete Containment Wall Below Grade	Not stated	Concrete	Not stated	AGR-CHEM	Increase of porosity & permeability, cracking, & spalling
14	Reinforced or Prestress Concrete Containments	Concrete Containment Wall Below Grade	Not stated	Concrete	Not stated	AGREAC Unresolved	Expansion & cracking
15	Reinforced or Prestress Concrete Containments	Concrete Containment Wall Below Grade	Not stated	Concrete	Not stated	ELE-TEMP	Loss of strength & modulus
16	Reinforced or Prestress Concrete Containments	Concrete Containment Wall Below Grade	Not stated	Concrete	Not stated	EMBR/IR	Loss of strength & modulus
17	Reinforced or Prestress Concrete Containments	Concrete Containment Wall Below Grade	Not stated	Concrete	Not stated	CORR/RE	Cracking, spalling, loss of bond, & loss of material
18	Reinforced or Prestress Concrete Containments	Concrete Containment Wall Below Grade	Not stated	Concrete	Not stated	FAT	Cumulative fatigue damage
19	Reinforced or Prestress Concrete Containments	Concrete Containment Wall Below Grade	Not stated	Concrete	Not stated	CONCAL	Reduction of concrete strength
20	Reinforced or Prestress Concrete Containments	Concrete Basemat	Not stated	Concrete	Not stated	FRZ-THAW	Scaling, cracking, & spalling
21	Reinforced or Prestress Concrete Containments	Concrete Basemat	Not stated	Concrete	Not stated	LEACH	Increase of porosity & permeability
22	Reinforced or Prestress Concrete Containments	Concrete Basemat	Not stated	Concrete	Not stated	AGR-CHEM	Increase of porosity & permeability, cracking, & spalling
23	Reinforced or Prestress Concrete Containments	Concrete Basemat	Not stated	Concrete	Not stated	AGREAC Unresolved	Expansion & cracking

Document: IR 90-01, PWR Reactor Containment Structures Industry Report
Reviewed by: David C. Ma, ANL

Effect of Aging on Component Function	Contrib to Failure	Reported progs	Rel.progs	Report Recommendations	Page No.	Item
Loss of pressure boundary.	Not stated	Accessible concrete surfaces are periodically examined in accordance with Type A integrated (More)		Management for the effects of aggressive chemical of concrete surfaces that are not periodically examined due to inaccessibility requires plant-specific program.	5-4 to 5-6	13
Loss of pressure boundary.	Not stated	Non-significant for aggregate taken from regions other than those known to (More)		NRC recommendation: AGREAC can not be ruled out. Tests alone are not satisfactory in predicting performance. AGREAC may occur >25 years. Use of pozzolans & low alkali content cement may not control reactions for concretes.(See IR90-06 & 90-10)	4-14 to 4-17	14
Loss of pressure boundary.	Not stated	Not stated		Non-significant for concrete maintained at <66_C (150_F) & local area temperatures <93_C (200_F), or plant-specific justification is provided in accordance with ACI 349-85.	4-20 to 4-25, 4-34	15
Loss of pressure boundary.	Not stated	Not stated		Non-significant because the total neutron fluence & integrated gamma doses are low compared to the levels causing degradation, i.e., 1019 n/cm2 & 1010 rads, respectively.	4-25 to 4-31, 4-35, 4-36	16
Loss of pressure boundary.	Not stated	Accessible surfaces examined with ASME Sect. XI; inaccessible surfaces require further evaluation		NRC recommendation: Potential degradation due to chlorine corrosion of the PWR containments has to be addressed in the plant specific baseline inspection. (See IR90-06 & 90-10)	5-4 to 5-6	17
Loss of pressure boundary.	Not stated	Not stated		Non-significant because designed to have good fatigue strength in accordance with ASME Sect. III, Div. 2 & ACI 215R-74	4-52 to 4-54	18
Loss of pressure boundary.	Not stated	Not stated		Non-significant if no degradation of concrete strength was noted during initial structural testing, or if aluminum piping were not used for concrete placement.	4-54, 4-55	19
Loss of pressure boundary.	Not stated	Not stated		Non-significant for component located in a geographic region of weathering index <100 day-in./ yr or concrete mix design meets air content & water-to-cement ratio requirements of ASME Sect. III, Div. 2, CC-2231.7.1.	4-3 to 4-7	20
Loss of pressure boundary.	Not stated	Not stated		Non-significant for components not exposed to flowing water or constructed using ACI 201.2R-77 to ensure dense, well-cured concrete with low permeability.	4-8 to 4-11	21
Loss of pressure boundary.	Not stated	Accessible concrete surfaces are periodically examined in accordance with Type A integrated (More)		Management for the effects of aggressive chemical of concrete surfaces that are not periodically examined due to inaccessibility requires plant-specific program.	5-4 to 5-6	22
Loss of pressure boundary.	Not stated	Non-significant for aggregate taken from regions other than those known to (More)		NRC recommendation: AGREAC can not be ruled out. Tests alone are not satisfactory in predicting performance. AGREAC may occur >25 years. Use of pozzolans & low alkali content cement may not control reactions for concretes.(See IR90-06 & 90-10)	4-14 to 4-17	23

Table B.1 Gall Report for NUMARC Industry Reports

Document: IR 90-01, PWR Reactor Containment Structures Industry Report
Reviewed by: David C. Ma, ANL

Item	System	Structure/Comp	Subcomponent	Materials	Manufacturer	ARD mechanism	ARD effects
24	Reinforced or Prestress Concrete Containments	Concrete Basemat	Not stated	Concrete	Not stated	ELE-TEMP	Loss of strength & modulus
25	Reinforced or Prestress Concrete Containments	Concrete Basemat	Not stated	Concrete	Not stated	EMBR/IR	Loss of strength & modulus
26	Reinforced or Prestress Concrete Containments	Concrete Basemat	Not stated	Concrete	Not stated	CORR/RE	Cracking, spalling, loss of bond, & loss of material
27	Reinforced or Prestress Concrete Containments	Concrete Basemat	Not stated	Concrete	Not stated	FAT	Cumulative fatigue damage
28	Reinforced or Prestress Concrete Containments	Concrete Basemat	Not stated	Concrete	Not stated	SETTLE Unresolved	Cracking, in-crease in component stress level, distortion
29	Reinforced or Prestress Concrete Containments	Containment Liner Interior Surface & Containment Liner Above Grade Exterior Surface	Not stated	CS	Not stated	ELE-TEMP	Loss of strength & modulus
30	Reinforced or Prestress Concrete Containments	Containment Liner Interior Surface & Containment Liner Above Grade Exterior Surface	Not stated	CS	Not stated	EMBR/IR	Loss of fracture toughness
31	Reinforced or Prestress Concrete Containments	Containment Liner Interior Surface & Containment Liner Above Grade Exterior Surface	Not stated	CS	Not stated	CORR	Loss of material
32	Reinforced or Prestress Concrete Containments	Containment Liner Interior Surface & Containment Liner Above Grade Exterior Surface	Not stated	CS	Not stated	FAT	Cumulative fatigue damage
33	Reinforced or Prestress Concrete Containments	Containment Liner Below Grade Exterior Surface	Not stated	CS	Not stated	ELE-TEMP	Loss of strength & modulus
34	Reinforced or Prestress Concrete Containments	Containment Liner Below Grade Exterior Surface	Not stated	CS	Not stated	EMBR/IR	Loss of fracture toughness
35	Reinforced or Prestress Concrete Containments	Containment Liner Below Grade Exterior Surface	Not stated	CS	Not stated	CORR	Loss of material
36	Reinforced or Prestress Concrete Containments	Containment Liner Below Grade Exterior Surface	Not stated	CS	Not stated	FAT	Cumulative fatigue damage

Table B.1 Gall Report for NUMARC Industry Reports

Document: IR 90-01, PWR Reactor Containment Structures Industry Report
Reviewed by: David C. Ma, ANL

Effect of Aging on Component Function	Contrib to Failure	Reported progs	Rel.progs	Report Recommendations	Page No.	Item
Loss of pressure boundary.	Not stated	Not stated		Non-significant for concrete maintained at <66_C (150_F) & local area temperatures <93_C (200_F), or plant-specific justification is provided in accordance with ACI 349-85.	4-20 to 4-25, 4-34	24
Loss of pressure boundary.	Not stated	Not Stated		Non-significant because the total neutron fluence & integrated gamma doses are low compared to the levels causing degradation, i.e., 10^19 n/cm^2 & 10^10 rads, respectively.	4-25 to 4-31, 4-35, 4-36	25
Loss of pressure boundary.	Not stated	Accessible surfaces examined with ASME Sect. XI; inaccessible surfaces require further evaluation		NRC recommendation: Potential degradation due to chlorine corrosion of the PWR containments has to be addressed in the plant specific baseline inspection.(See IR90-06 & 90-10)	5-4 to 5-6	26
Loss of pressure boundary.	Not stated	Not stated		Non-significant because designed to have good fatigue strength in accordance with ASME Sect. III, Div. 2 & ACI 215R-74	4-52 to 4-54	27
Loss of pressure boundary.	Not stated	Plant settlement monitoring during construction & continued during (More)		NRC recommendation: Effect of settlement of the PWR containments need to be evaluated.(See IR90-06 & 90-10)	4-56, 5-13	28
Loss of pressure boundary.	Not stated	Not stated		Non-significant because operating temperatures within PWR containment structures are well below 371 C (700_F) level at which the structural integrity of rebar/structural steel begins to be significantly affected.	4-34, 4-47 to 4-49	29
Loss of pressure boundary.	Not stated	Not stated		Non-significant because the total radiation exposure is far below the 10^19 n/cm^2 level that could cause change in mechanical or physical properties.	4-49 to 4-51	30
Loss of pressure boundary.	Not stated	Not stated		Galvanic corrosion & corrosion due to aggressive aqueous solutions will not occur if dissimilar metals are not used & if aggressive ground water (chlorides >500 ppm) is not present.	4-42 to 4-47	31
Loss of pressure boundary.	Not stated	Not stated		Non-significant because designed to have good fatigue strength in accordance with ASME Sect. III, Div. 2 & ACI 215R-74	4-52 to 4-54	32
Loss of pressure boundary.	Not stated	Not stated		Non-significant because operating temperatures within PWR containment structures are well below 371 C (700_F) level at which the structural integrity of rebar/structural steel begins to be significantly affected.	4-34, 4-47 to 4-49	33
Loss of pressure boundary.	Not stated	Not stated		Non-significant because the total radiation exposure is far below the 10^19 n/cm^2 level that could cause change in mechanical or physical properties.	4-49 to 4-51	34
Loss of pressure boundary.	Not stated	Periodic examination and monitoring of accessible areas in accordance with ASME Sect. XI, (More)		For inaccessible areas, plant-specific program is required.	5-9 to 5-12	35
Loss of pressure boundary.	Not stated	Not stated		Non-significant because designed to have good fatigue strength in accordance with ASME Sect. III, Div. 2 & ACI 215R-74	4-52 to 4-54	36

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Item	System	Structure/Comp	Subcomponent	Materials	Manufacturer	ARD mechanism	ARD effects
37	Reinforced or Prestress Concrete Containments	Basemat Liner Interior Surface	Not stated	CS	Not stated	ELE-TEMP	Loss of strength & modulus
38	Reinforced or Prestress Concrete Containments	Basemat Liner Interior Surface	Not stated	CS	Not stated	EMBR/IR	Loss of fracture toughness
39	Reinforced or Prestress Concrete Containments	Basemat Liner Interior Surface	Not stated	CS	Not stated	CORR	Loss of material
40	Reinforced or Prestress Concrete Containments	Basemat Liner Interior Surface	Not stated	CS	Not stated	FAT	Cumulative fatigue damage
41	Reinforced or Prestress Concrete Containments	Basemat Liner Exterior Surface	Not stated	CS	Not stated	ELE-TEMP	Loss of strength & modulus
42	Reinforced or Prestress Concrete Containments	Basemat Liner Exterior Surface	Not stated	CS	Not stated	EMBR/IR	Loss of fracture toughness
43	Reinforced or Prestress Concrete Containments	Basemat Liner Exterior Surface	Not stated	CS	Not stated	CORR	Loss of material
44	Reinforced or Prestress Concrete Containments	Basemat Liner Exterior Surface	Not stated	CS	Not stated	FAT	Cumulative fatigue damage
45	Reinforced or Prestress Concrete Containments	Liner Anchors Above Grade	Not stated	CS	Not stated	ELE-TEMP	Loss of strength & modulus
46	Reinforced or Prestress Concrete Containments	Liner Anchors Above Grade	Not stated	CS	Not stated	EMBR/IR	Loss of fracture toughness
47	Reinforced or Prestress Concrete Containments	Liner Anchors Above Grade	Not stated	CS	Not stated	CORR	Loss of material
48	Reinforced or Prestress Concrete Containments	Liner Anchors Above Grade	Not stated	CS	Not stated	FAT	Cumulative fatigue damage

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Effect of Aging on Component Function	Contrib to Failure	Reported progs	Rel.progs	Report Recommendations	Page No.	Item
Loss of pressure boundary.	Not stated	Not stated		Non-significant because operating temperatures within PWR containment structures are well below 371 C (700_F) level at which the structural integrity of rebar/structural steel begins to be significantly affected.	4-34, 4-47 to 4-49	37
Loss of pressure boundary.	Not stated	Not stated		Non-significant because the total radiation exposure is far below the 10^19 n/cm^2 level that could cause change in mechanical or physical properties.	4-49 to 4-51	38
Loss of pressure boundary.	Not stated	Not stated		Galvanic corrosion & corrosion due to aggressive aqueous solutions will not occur if dissimilar metals are not used & if aggressive ground water (chlorides >500 ppm) is not present.	4-42 to 4-47	39
Loss of pressure boundary.	Not stated	Not stated		Non-significant because designed to have good fatigue strength in accordance with ASME Sect. III, Div. 2 & ACI 215R-74	4-52 to 4-54	40
Loss of pressure boundary.	Not stated	Not stated		Non-significant because operating temperatures within PWR containment structures are well below 371 C (700_F) level at which the structural integrity of rebar/structural steel begins to be significantly affected.	4-34, 4-47 to 4-49	41
Loss of pressure boundary.	Not stated	Not stated		Non-significant because the total radiation exposure is far below the 10^19 n/cm^2 level that could cause change in mechanical or physical properties.	4-49 to 4-51	42
Loss of pressure boundary.	Not stated	Periodic examination and monitoring of accessible areas in accordance with ASME Sect. XI, (More)		For inaccessible areas, plant-specific program is required.	5-9 to 5-12	43
Loss of pressure boundary.	Not stated	Not stated		Non-significant because designed to have good fatigue strength in accordance with ASME Sect. III, Div. 2 & ACI 215R-74	4-52 to 4-54	44
Loss of pressure boundary.	Not stated	Not stated		Non-significant because operating temperatures within PWR containment structures are well below 371 C (700_F) level at which the structural integrity of rebar/structural steel begins to be significantly affected.	4-34, 4-47 to 4-49	45
Loss of pressure boundary.	Not stated	Not stated		Non-significant because the total radiation exposure is far below the 10^19 n/cm^2 level that could cause change in mechanical or physical properties.	4-49 to 4-51	46
Loss of pressure boundary.	Not stated	Not stated		Galvanic corrosion & corrosion due to aggressive aqueous solutions will not occur if dissimilar metals are not used & if aggressive ground water (chlorides >500 ppm) is not present.	4-42 to 4-47	47
Loss of pressure boundary.	Not stated	Not stated		Non-significant because designed to have good fatigue strength in accordance with ASME Sect. III, Div. 2 & ACI 215R-74	4-52 to 4-54	48

Table B.1 Gall Report for NUMARC Industry Reports

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Item	System	Structure/Comp	Subcomponent	Materials	Manufacturer	ARD mechanism	ARD effects
49	Reinforced or Prestress Concrete Containments	Liner Anchors Below Grade	Not stated	CS	Not stated	ELE-TEMP	Loss of strength & modulus
50	Reinforced or Prestress Concrete Containments	Liner Anchors Below Grade	Not stated	CS	Not stated	EMBR/IR	Loss of fracture toughness
51	Reinforced or Prestress Concrete Containments	Liner Anchors Below Grade	Not stated	CS	Not stated	CORR	Loss of material
52	Reinforced or Prestress Concrete Containments	Liner Anchors Below Grade	Not stated	CS	Not stated	FAT	Cumulative fatigue damage
53	Reinforced or Prestress Concrete Containments	Dome Reinforcing Steel & Containment Wall Reinforcing Steel Above Grade	Not stated	CS	Not stated	ELE-TEMP	Loss of strength & modulus
54	Reinforced or Prestress Concrete Containments	Dome Reinforcing Steel & Containment Wall Reinforcing Steel Above Grade	Not stated	CS	Not stated	EMBR/IR	Loss of fracture toughness
55	Reinforced or Prestress Concrete Containments	Dome Reinforcing Steel & Containment Wall Reinforcing Steel Above Grade	Not stated	CS	Not stated	CORR/RE	Loss of strength, loss of material
56	Reinforced or Prestress Concrete Containments	Dome Reinforcing Steel & Containment Wall Reinforcing Steel Above Grade	Not stated	CS	Not stated	FAT	Cumulative fatigue damage
57	Reinforced or Prestress Concrete Containments	Containment Wall Reinforcing Steel Below Grade & Basemat Reinforcing Steel	Not stated	CS	Not stated	ELE-TEMP	Loss of strength & modulus
58	Reinforced or Prestress Concrete Containments	Containment Wall Reinforcing Steel Below Grade & Basemat Reinforcing Steel	Not stated	CS	Not stated	EMBR/IR	Loss of fracture toughness
59	Reinforced or Prestress Concrete Containments	Containment Wall Reinforcing Steel Below Grade & Basemat Reinforcing Steel	Not stated	CS	Not stated	CORR/RE	Loss of strength, loss of material
60	Reinforced or Prestress Concrete Containments	Containment Wall Reinforcing Steel Below Grade & Basemat Reinforcing Steel	Not stated	CS	Not stated	FAT	Cumulative fatigue damage
61	Reinforced or Prestress Concrete Containments	Prestressing Tendons & Ducts	Not stated	CS	Not stated	ELE-TEMP	Loss of strength & modulus

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Effect of Aging on Component Function	Contrib to Failure	Reported progs	Rel.progs	Report Recommendations	Page No.	Item
Loss of pressure boundary.	Not stated	Not stated		Non-significant because operating temperatures within PWR containment structures are well below 371 C (700_F) level at which the structural integrity of rebar/structural steel begins to be significantly affected.	4-34, 4-47 to 4-49	49
Loss of pressure boundary.	Not stated	Not stated		Non-significant because the total radiation exposure is far below the 10^19 n/cm^2 level that could cause change in mechanical or physical properties.	4-49 to 4-51	50
Loss of pressure boundary.	Not stated	Periodic examination and monitoring of accessible areas in accordance with ASME Sect. XI, (More)		For inaccessible areas, plant-specific program is required.	5-9 to 5-12	51
Loss of pressure boundary.	Not stated	Not stated		Non-significant because designed to have good fatigue strength in accordance with ASME Sect. III, Div. 2 & ACI 215R-74	4-52 to 4-54	52
Loss of pressure boundary.	Not stated	Not stated		Non-significant because operating temperatures within PWR containment structures are well below 371 C (700_F) level at which the structural integrity of rebar/structural steel begins to be significantly affected.	4-34, 4-47 to 4-49	53
Loss of pressure boundary.	Not stated	Not stated		Non-significant because the total neutron fluence is far below the 10^19 n/sq.cm level for degradation of reinforcing steel.	4-35, 4-36	54
Loss of pressure boundary.	Not stated	Not stated		Non-significant for concrete not exposed to aggressive environment, pH <11.5 or chlorides >500 ppm; or concrete has low water-to-cement ratio (0.35-0.45) & adequate air entrainment (3-6%).	4-17 to 4-19, 4-31 to 4-33	55
Loss of pressure boundary.	Not stated	Not stated		Non-significant because designed to have good fatigue strength in accordance with ASME Sect. III, Div. 2 & ACI 215R-74	4-52 to 4-54	56
Loss of pressure boundary.	Not stated	Not stated		Non-significant because operating temperatures within PWR containment structures are well below 371Deg-C (700Deg-F) level at which the structural integrity of rebar/structural steel begins to be significantly affected.	4-34, 4-47 to 4-49	57
Loss of pressure boundary.	Not stated	Not stated		Non-significant because the total neutron fluence is far below the 10^19 n/sq.cm level for degradation of reinforcing steel.	4-35, 4-36	58
Loss of pressure boundary.	Not stated	Accessible surfaces examined with ASME Sect. XI; inaccessible surfaces require further evaluation		NRC recommendation: Potential degradation due to chlorine corrosion of the PWR containments has to be addressed in the plant specific baseline inspection. (See IR90-06 & 90-10)	5-4 to 5-6	59
Loss of pressure boundary.	Not stated	Not stated		Non-significant because designed to have good fatigue strength in accordance with ASME Sect. III, Div. 2 & ACI 215R-74	4-52 to 4-54	60
Loss of pressure boundary.	Not stated	Not stated		Non-significant because prestressing tendons are subjected to temperatures <60 C (<140_F).	4-38 to 4-40	61

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Item	System	Structure/Comp	Subcomponent	Materials	Manufacturer	ARD mechanism	ARD effects
62	Reinforced or Prestress Concrete Containments	Prestressing Tendons & Ducts	Not stated	CS	Not stated	EMBR/IR	Loss of fracture toughness
63	Reinforced or Prestress Concrete Containments	Prestressing Tendons & Ducts	Not stated	CS	Not stated	CORR Unresolved	Loss of material
64	Prestressed Concrete Containments	Prestressing Tendons & Ducts	Not stated	CS	Not stated	RELAX	Reduction of design margin
65	Prestressed Concrete Containments	Prestressing Tendons & Ducts	Not stated	CS	Not stated	FAT	Cumulative fatigue damage
66	Free-standing cylindrical and spherical sleel containments with eliptical bottoms	All	Not stated	Concrete	Not stated	All	Not stated
67	Free-standing Cylindrical & Spherical Steel Containments with Elliptical Bottom	Containment Shell Interior Surface & Containment Shell Exterior	Not stated	CS	Not stated	ELE-TEMP	Loss of strength & modulus
68	Free-standing Cylindrical & Spherical Steel Containments with Elliptical Bottom	Containment Shell Interior Surface & Containment Shell Exterior	Not stated	CS	Not stated	EMBR/IR	Loss of fracture toughness
69	Free-standing Cylindrical & Spherical Steel Containments with Elliptical Bottom	Containment Shell Interior Surface & Containment Shell Exterior	Not stated	CS	Not stated	CORR	Loss of material
70	Free-standing Cylindrical & Spherical Steel Containments with Eliptical Bottom	Containment Shell Interior Surface & Containment Shell Exterior	Not stated	CS	Not stated	FAT	Cumulative fatigue damage
71	Free-standing Cylindrical & Spherical Steel Containments with Eliptical Bottom	Containment Shell Interior Surface & Containment Shell Exterior	Not stated	CS	Not stated	EMBR/SA	Loss of fracture toughness
72	Free-standing Cylindrical & Spherical Steel Containments with Eliptical Bottom	Embedded Shell Region & Sand Pocket Region	Not stated	CS	Not stated	ELE-TEMP	Loss of strength & modulus
73	Free-standing Cylindrical & Spherical Steel Containments with Eliptical Bottom	Embedded Shell Region & Sand Pocket Region	Not stated	CS	Not stated	EMBR/IR	Loss of fracture toughness
74	Free-standing Cylindrical & Spherical Steel Containments with Eliptical Bottom	Embedded Shell Region & Sand Pocket Region	Not stated	CS	Not stated	CORR	Loss of material

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Effect of Aging on Component Function	Contrib to Failure	Reported progs	Rel.progs	Report Recommendations	Page No.	Item
Loss of pressure boundary.	Not stated	Not stated		Non-significant because tendons will not receive enough radiation to incurage related degradation, i.e., <=10^19 n/cm^2.	4-40, 4-41	62
Loss of pressure boundary.	Not stated	Examination & testing of tendons & leakage of corrosion protection medium in (More)		NRC recommendation: Large amount of grease leakage can degrade concrete strength. IWL lacks certain criteria in RG 1.35. Also, anchor heads have failed in prestressed concrete containments.	4-37, 4-38, 5-7	63
Loss of pressure boundary.	Not stated	Reg. Guide RG 1.35.		Inspection & load monitoring to detect progressive reductions of prestress for the license renewal term using RG 1.35.	4-41, 4-42, 5-8	64
Loss of pressure boundary.	Not stated	Not stated		Non-significant because designed to have good fatigue strength in accordance with ASME Sect. III, Div. 2 & ACI 215R-74	4-52 to 4-54	65
Loss of pressure boundary.	Not stated	If resolution based upon evaluation of plant-specific features, then baseline inspection not needed.		NRC recommendation: A one time focused inspection of containment is proposed to provide assurance for continued satisfactory performance and to identify existing degradation mechanisms and to take necessary corrective actions.		66
Loss of pressure boundary.	Not stated	Not stated		Non-significant because operating temperatures within PWR containment structures are well below 371 C (700_F) level at which the structural integrity of rebar/structural steel begins to be significantly affected.	4-34, 4-47 to 4-49	67
Loss of pressure boundary.	Not stated	Not stated		Non-significant because the total radiation exposure is far below the 10^19 n/cm^2 level that could cause change in mechanical or physical properties.	4-49 to 4-51	68
Loss of pressure boundary.	Not stated	Not stated		Galvanic corrosion and SCC are not significant if dissimilar metals are not used.	4-60 to 4-66	69
Loss of pressure boundary.	Not stated	Not stated		Non-significant because designed to have good fatigue strength in accordance with ASME Sect. III, Div. 2 & ACI 215R-74	4-52 to 4-54	70
Loss of pressure boundary.	Not stated	Not stated		Dynamic strain aging is non-significant for component stress under elastic limit. Static strain aging is non-significant for components that were not cold worked; or the plates were normalized or stress relieved.	4-57 to 4-59	71
Loss of pressure boundary.	Not stated	Not stated		Same as for containment shell interior or exterior surfaces.	4-34, 4-47 to 4-49	72
Loss of pressure boundary.	Not stated	Not stated		Non-significant because the total radiation exposure is far below the 1019 n/cm2 level that could cause change in mechanical or physical properties.	4-49 to 4-51	73
Loss of pressure boundary.	Not stated	Periodic examination and monitoring of accessible areas in accordance with ASME Sect. XI, (More)		For inaccessible areas, plant-specific program is required.	5-9 to 5-12	74

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Item	System	Structure/Comp	Subcomponent	Materials	Manufacturer	ARD mechanism	ARD effects
75	Free-standing Cylindrical & Spherical Steel Containments with Eliptical Bottom	Embedded Shell Region & Sand Pocket Region	Not stated	CS	Not stated	FAT	Cumulative fatigue damage
76	Free-standing Cylindrical & Spherical Steel Containments with Eliptical Bottom	Embedded Shell Region & Sand Pocket Region	Not stated	CS	Not stated	EMBR/SA	Loss of fracture toughness
77	Free-standing Steel Containments with Flat Bottom & Ice-condenser	All	Not stated	Concrete	Not stated	All	Not stated
78	Free-standing Steel Containments with Flat Bottom & Ice-condenser	Dome Shell Interior Surface, Dome Shell Exterior Surface, Cylindrical shell Interior Surface, & Cylindrical Shell Exterior Surface	Not stated	CS	Not stated	ELE-TEMP	Loss of strength & modulus
79	Free-standing Steel Containments with Flat Bottom & Ice-condenser	Dome Shell Interior Surface, Dome Shell Exterior Surface, Cylindrical shell Interior Surface, & Cylindrical Shell Exterior Surface	Not stated	CS	Not stated	EMBR/IR	Loss of fracture toughness
80	Free-standing Steel Containments with Flat Bottom & Ice-condenser	Dome Shell Interior Surface, Dome Shell Exterior Surface, Cylindrical shell Interior Surface, & Cylindrical Shell Exterior Surface	Not stated	CS	Not stated	CORR	Loss of material
81	Free-standing Steel Containments with Flat Bottom & Ice-condenser	Dome Shell Interior Surface, Dome Shell Exterior Surface, Cylindrical shell Interior Surface, & Cylindrical Shell Exterior Surface	Not stated	CS	Not stated	FAT	Cumulative fatigue damage
82	Free-standing Steel Containments with Flat Bottom & Ice-condenser	Dome Shell Interior Surface, Dome Shell Exterior Surface, Cylindrical shell Interior Surface, & Cylindrical Shell Exterior Surface	Not stated	CS	Not stated	EMBR/SA	Loss of fracture toughness
83	Free-standing Steel Containments with Flat Bottom & Ice-condenser	Embedded Shell Region, Basemat Liner, & Liner Anchors	Not stated	CS	Not stated	ELE-TEMP	Loss of strength & modulus
84	Free-standing Steel Containments with Flat Bottom & Ice-condenser	Embedded Shell Region, Basemat Liner, & Liner Anchors	Not stated	CS	Not stated	EMBR/IR	Loss of fracture toughness
85	Free-standing Steel Containments with Flat Bottom & Ice-Condenser	Embedded Shell Region, Basemat Liner, & Liner Anchors	Not stated	CS	Not stated	CORR	Loss of strength, loss of material

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Effect of Aging on Component Function	Contrib to Failure	Reported progs	Rel.progs	Report Recommendations	Page No.	Item
Loss of pressure boundary.	Not stated	Not stated		Non-significant because designed to have good fatigue strength in accordance with ASME Sect. III, Div. 2 & ACI 215R-74	4-52 to 4-54	75
Loss of pressure boundary.	Not stated	Not stated		Same as for containment shell interior or exterior surfaces.	4-57 to 4-59	76
Loss of pressure boundary.	Not stated	If resolution based upon evaluation of plant-specific features, then baseline inspection not needed.		NRC recommendation: A one time focused inspection of containment is proposed to provide assurance for continued satisfactory performance and to identify existing degradation mechanisms and to take necessary corrective actions.		77
Loss of pressure boundary.	Not stated	Not stated		Non-significant because operating temperatures within PWR containment structures are well below 371 C (700_F) level at which the structural integrity of rebar/structural steel begins to be significantly affected.	4-34, 4-47 to 4-49	78
Loss of pressure boundary.	Not stated	Not stated		Non-significant because the total radiation exposure is far below the 10^19 n/cm^2 level that could cause change in mechanical or physical properties.	4-49 to 4-51	79
Loss of pressure boundary.	Not stated	Not stated		Galvanic corrosion and SCC are not significant if dissimilar metals are not used.	4-60 to 4-66	80
Loss of pressure boundary.	Not stated	Not stated		Non-significant because designed to have good fatigue strength in accordance with ASME Sect. III, Div. 2 & ACI 215R-74	4-52 to 4-54	81
Loss of pressure boundary.	Not stated	Not stated		Dynamic strain aging is non-significant for component stress under elastic limit. Static strain aging is non-significant for components that were not cold worked; or the plates were normalized or stress relieved.	4-57 to 4-59	82
Loss of pressure boundary.	Not stated	Not stated		Non-significant because operating temperatures within PWR containment structures are well below 371 C (700_F) level at which the structural integrity of rebar/structural steel begins to be significantly affected.	4-34, 4-47 to 4-49	83
Loss of pressure boundary.	Not stated	Not stated		Non-significant because the total radiation exposure is far below the 10^19 n/cm^2 level that could cause change in mechanical or physical properties.	4-49 to 4-51	84
Loss of pressure boundary.	Not stated	Periodic examination and monitoring of accessible areas in accordance with ASME Sect. XI, (More)		For inaccessible areas, plant-specific program is required.	5-9 to 5-12	85

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Item	System	Structure/Comp	Subcomponent	Materials	Manufacturer	ARD mechanism	ARD effects
86	Free-standing Steel Containments with Flat Bottom & Ice-Condenser	Embedded Shell Region, Basemat Liner, & Liner Anchors	Not stated	CS	Not stated	FAT	Cumulative fatigue damage
87	Free-standing Steel Containments with Flat Bottom & Ice-Condenser	Concrete Basemat	Not stated	Concrete	Not stated	FRZ-THAW	Scaling, cracking, & spalling
88	Free-standing Steel Containments with Flat Bottom & Ice-Condenser	Concrete Basemat	Not stated	Concrete	Not stated	LEACH	Increase of porosity & permeability
89	Free-standing Steel Containments with Flat Bottom & Ice-Condenser	Concrete Basemat	Not stated	Concrete	Not stated	AGR-CHEM	Increase of porosity & permeability, cracking, & spalling
90	Free-standing Steel Containments with Flat Bottom & Ice-Condenser	Concrete Basemat	Not stated	Concrete	Not stated	AGREAC Unresolved	Expansion & cracking
91	Free-standing Steel Containments with Flat Bottom & Ice-Condenser	Concrete Basemat	Not stated	Concrete	Not stated	ELE-TEMP	Loss of strength & modulus
92	Free-standing Steel Containments with Flat Bottom & Ice-Condenser	Concrete Basemat	Not stated	Concrete	Not stated	EMBR/IR	Loss of fracture toughness
93	Free-standing Steel Containments with Flat Bottom & Ice-Condenser	Concrete Basemat	Not stated	Concrete	Not stated	CORR/RE	Loss of strength, loss of material
94	Free-standing Steel Containments with Flat Bottom & Ice-Condenser	Concrete Basemat	Not stated	Concrete	Not stated	FAT	Cumulative fatigue damage
95	Free-standing Steel Containments with Flat Bottom & Ice-Condenser	Concrete Basemat	Not stated	Concrete	Not stated	CONCAL	Reduction of concrete strength
96	Free-standing Steel Containments with Flat Bottom & Ice-Condenser	Concrete Basemat	Not stated	Concrete	Not stated	SETTLE Unresolved	Cracking, in-crease in component stress level, distortion
97	Free-standing Steel Containments with Flat Bottom & Ice-Condenser	Basemat Reinforcing Steel	Not stated	CS	Not stated	ELE-TEMP	Loss of strength & modulus

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Effect of Aging on Component Function	Contrib to Failure	Reported progs	Rel.progs	Report Recommendations	Page No.	Item
Loss of pressure boundary.	Not stated	Not stated		Non-significant because designed to have good fatigue strength in accordance with ASME Sect. III, Div. 2 & ACI 215R-74	4-52 to 4-54	86
Loss of pressure boundary.	Not stated	Not stated		Non-significant for component located in a geographic region of weathering index <100 day-in./ yr or concrete mix design meets air content & water-to-cement ratio requirements of ASME Sect. III, Div. 2, CC-2231.7.1.	4-3 to 4-7	87
Loss of pressure boundary.	Not stated	Not stated		Non-significant for components not exposed to flowing water or constructed using ACI 201.2R-77 to ensure dense, well-cured concrete with low permeability.	4-8 to 4-11	88
Loss of pressure boundary.	Not stated	Accessible concrete surfaces are periodically examined in accordance with Type A integrated (More)		Management for the effects of aggressive chemical of concrete surfaces that are not periodically examined due to inaccessibility requires plant-specific program.	5-4 to 5-6	89
Loss of pressure boundary.	Not stated	Non-significant for aggregate taken from regions other than those known to (More)		NRC recommendation: AGREAC can not be ruled out. Tests alone are not satisfactory in predicting performance. AGREAC may occur >25 years. Use of pozzolans & low alkali content cement may not control reactions for concretes.(See IR90-06 & 90-10)	4-14 to 4-17	90
Loss of pressure boundary.	Not stated	Not stated		Non-significant for concrete maintained at <66_C (150_F) & local area temperatures <93_C (200_F), or plant-specific justification is provided in accordance with ACI 349-85.	4-20 to 4-25, 4-34	91
Loss of pressure boundary.	Not stated	Not stated		Non-significant because the total neutron fluence & integrated gamma doses are low compared to the levels causing degradation, i.e., 1019 n/cm2 & 1010 rads, respectively.	4-25 to 4-31, 4-35, 4-36	92
Loss of pressure boundary.	Not stated	Accessible surfaces examined with ASME Sect. XI; inaccessible surfaces require further evaluation		NRC recommendation: Potential degradation due to chlorine corrosion of the PWR containments has to be addressed in the plant specific baseline inspection. (See IR90-06 & 90-10)	5-4 to 5-6	93
Loss of pressure boundary.	Not stated	Not stated		Non-significant because designed to have good fatigue strength in accordance with ASME Sect. III, Div. 2 & ACI 215R-74	4-52 to 4-54	94
Loss of pressure boundary.	Not stated	Not stated		Non-significant if no degradation of concrete strength was noted during initial structural testing, or if aluminum piping were not used for concrete placement.	4-54, 4-55	95
Loss of pressure boundary.	Not stated	Plant settlement monitoring during construction & continued during (More)		NRC recommendation: Effect of settlement of the PWR containments need to be evaluated.(See IR90-06 & 90-10)	4-56, 5-13	96
Loss of pressure boundary.	Not stated	Not stated		Non-significant because operating temperatures within PWR containment structures are well below 371 C (700_F) level at which rebar/concrete/pre-stressed tendons begin to be significantly affected.	4-20 to 4-25, 4-34	97

Table B.1 Gall Report for NUMARC Industry Reports

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Item	System	Structure/Comp	Subcomponent	Materials	Manufacturer	ARD mechanism	ARD effects
98	Free-standing Steel Containments with Flat Bottom & Ice-Condenser	Basemat Reinforcing Steel	Not stated	CS	Not stated	EMBR/IR	Loss of fracture toughness
99	Free-standing Steel Containments with Flat Bottom & Ice-Condenser	Basemat Reinforcing Steel	Not stated	CS	Not stated	CORR/RE	Loss of strength, loss of material
100	Free-standing Steel Containments with Flat Bottom & Ice-Condenser	Basemat Reinforcing Steel	Not stated	CS	Not stated	FAT	Cumulative fatigue damage
101	All Type PWR Containments	Penetration Sleeves	Not stated	CS	Not stated	ELE-TEMP	Loss of strength & modulus
102	All Type PWR Containments	Penetration Sleeves	Not stated	CS	Not stated	EMBR/IR	Loss of fracture toughness
103	All Type PWR Containments	Penetration Sleeves	Not stated	CS	Not stated	CORR	Loss of strength, loss of material
104	All Type PWR Containments	Penetration Sleeves	Not stated	CS	Not stated	FAT Unresolved	Cumulative fatigue damage
105	All Type PWR Containments	Penetration Sleeves	Not stated	CS	Not stated	EMBR/SA	Loss of fracture toughness
106	All Type PWR Containments	Penetration Bellows	Not stated	SS	Not stated	ELE-TEMP	Loss of strength & modulus
107	All Type PWR Containments	Penetration Bellows	Not stated	SS	Not stated	EMBR/IR	Loss of fracture toughness
108	All Type PWR Containments	Penetration Bellows	Not stated	SS	Not stated	CORR	Loss of strength, loss of material
109	All Type PWR Containments	Penetration Bellows	Not stated	SS	Not stated	FAT Unresolved	Cumulative fatigue damage
110	All Type PWR Containments	Penetration Bellows	Not stated	SS	Not stated	EMBR/SA	Loss of fracture toughness
111	All Type PWR Containments	Dissimilar Metal Welds	Not stated	CS	Not stated	ELE-TEMP	Loss of strength & modulus
112	All Type PWR Containments	Dissimilar Metal Welds	Not stated	CS	Not stated	EMBR/IR	Loss of fracture toughness

Table B.1 Gall Report for NUMARC Industry Reports

Document: IR 90-01, PWR Reactor Containment Structures Industry Report
Reviewed by: David C. Ma, ANL

Effect of Aging on Component Function	Contrib to Failure	Reported progs	Rel.progs	Report Recommendations	Page No.	Item
Loss of pressure boundary.	Not stated	Not stated		Non-significant because the total neutron fluence is far below the 10^19 n/cm^2 level for degradation of reinforcing steel.	4-35, 4-36	98
Loss of pressure boundary.	Not stated	Accessible surfaces examined with ASME Sect. XI; inaccessible surfaces require further evaluation		NRC recommendation: Potential degradation due to chlorine corrosion of the PWR containments has to be addressed in the plant specific baseline inspection. (See IR90-06 & 90-10)	5-4 to 5-6	99
Loss of pressure boundary.	Not stated	Not stated		Non-significant because designed to have good fatigue strength in accordance with ASME Sect. III, Div. 2 & ACI 215R-74	4-52 to 4-54	100
Loss of pressure boundary.	Not stated	Not stated		Non-significant because operating temperatures within PWR containment structures are well below 371 C (700_F) level at which the structural integrity of rebar/structural steel begins to be significantly affected.	4-34, 4-47 to 4-49	101
Loss of pressure boundary.	Not stated	Not stated		Non-significant because the total radiation exposure is far below the 10^19 n/cm^2 level that could cause change in mechanical or physical properties.	4-49 to 4-51	102
Loss of pressure boundary.	Not stated	Not stated		Galvanic corrosion & corrosion due to aggressive aqueous solutions will not occur if dissimilar metals are not used & if aggressive ground water (chlorides >500 ppm) is not present.	4-42 to 4-47	103
Loss of pressure boundary.	Not stated	ASME Sect. III, Subsect. NB fatigue reanalysis, monitoring of penetration (More)		NRC recommendation: Fatigue of penetration sleeve anchors can be induced by thermal cyclic loading & may not be detectable by leak rate tests.	5-14, 5-15	104
Loss of pressure boundary.	Not stated	Not stated		Dynamic strain aging is non-significant for component stress under elastic limit. Static strain aging is non-significant for components that were not cold worked; or the plates were normalized or stress relieved.	4-57 to 4-59	105
Loss of pressure boundary.	Not stated	Not stated		Same as for penetration sleeves.	4-34, 4-47 to 4-49	106
Loss of pressure boundary.	Not stated	Not stated		Same as for penetration sleeves.	4-49 to 4-51	107
Loss of pressure boundary.	Not stated	Not stated		Galvanic corrosion and SCC are not significant if dissimilar metals are not used or the SS bellows are protected by shields from corrosive environment.	4-60 to 4-66	108
Loss of pressure boundary.	Not stated	Same as for penetration sleeves.		Same as for penetration sleeves.	5-14, 5-15	109
Loss of pressure boundary.	Not stated	Not stated		Same as for penetration sleeves.	4-57 to 4-59	110
Loss of pressure boundary.	Not stated	Not stated		Non-significant because operating temperatures within PWR containment structures are well below 371 C (700_F) level at which the structural integrity of rebar/structural steel begins to be significantly affected.	4-34, 4-47 to 4-49	111
Loss of pressure boundary.	Not stated	Not stated		Non-significant because the total radiation exposure is far below the 10^19 n/cm^2 level that could cause change in mechanical or physical properties.	4-49 to 4-51	112

Table B.1 Gall Report for NUMARC Industry Reports

Document: IR 90-01, PWR Reactor Containment Structures Industry Report
Reviewed by: David C. Ma, ANL

Item	System	Structure/Comp	Subcomponent	Materials	Manufacturer	ARD mechanism	ARD effects
113	All Type PWR Containments	Dissimilar Metal Welds	Not stated	CS	Not stated	CORR	Loss of strength, loss of material
114	All Type PWR Containments	Dissimilar Metal Welds	Not stated	CS	Not stated	FAT	Cumulative fatigue damage
115	All Type PWR Containments	Personnel Airlock & Equipment Hatches	Not stated	CS	Not stated	ELE-TEMP	Loss of strength & modulus
116	All Type PWR Containments	Personnel Airlock & Equipment Hatches	Not stated	CS	Not stated	EMBR/IR	Loss of fracture toughness
117	All Type PWR Containments	Personnel Airlock & Equipment Hatches	Not stated	CS	Not stated	CORR	Loss of strength loss of material
118	All Type PWR Containments	Personnel Airlock & Equipment Hatches	Not stated	CS	Not stated	FAT	Cumulative fatigue damage
119	All Type PWR Containments	Personnel Airlock & Equipment Hatches	Not stated	CS	Not stated	EMBR/SA	Loss of fracture toughness

Document: IR 90-02, BWR Pressure Vessel Industry Report
Reviewed by: O. Chopra/D. Gavenda, ANL

Item	System	Structure/Comp	Subcomponent	Materials	Manufacturer	ARD mechanism	ARD effects
1	BWR Pressure Vessel Industry Report	Top Head	Not stated	SA302-Gr B, SA533-Gr B	Not stated	EMBR/IR	Loss of fracture toughness
2	BWR Pressure Vessel	Top Head	Not stated	SA302-Gr B, SA533-Gr B	Not stated	CORR/IGSCC	Crack initiation & growth
3	BWR Pressure Vessel	Top Head	Not stated	SA302-Gr B, SA533-Gr B	Not stated	CORR/IASCC	Crack initiation & growth
4	BWR Pressure Vessel	Top Head	Not stated	SA302-Gr B, SA533-Gr B	Not stated	CORR	Loss of material, corrosion product buildup
5	BWR Pressure Vessel	Top Head	Not stated	SA302-Gr B, SA533-Gr B	Not stated	ERO/CORR	Wall thinning, loss of material
6	BWR Pressure Vessel	Top Head	Not stated	SA302-Gr B, SA533-Gr B	Not stated	FAT	Cumulative fatigue damage
7	BWR Pressure Vessel	Vessel Shell	Beltline Shell	SA302-Gr B, SA533-Gr B	Not stated	EMBR/IR	Loss of fracture toughness

Document: IR 90-01, PWR Reactor Containment Structures Industry Report
Reviewed by: David C. Ma, ANL

Effect of Aging on Component Function	Contrib to Failure	Reported progs	Rel.progs	Report Recommendations	Page No.	Item
Loss of pressure boundary.	Not stated	Not stated		Galvanic corrosion & corrosion due to aggressive aqueous solutions will not occur if dissimilar metals are not used & if aggressive ground water (chlorides >500 ppm) is not present.	4-42 to 4-47	113
Loss of pressure boundary.	Not stated	Not stated		Non-significant because designed to have good fatigue strength in accordance with ASME Sect. III, Div. 2 & ACI 215R-74	4-52 to 4-54	114
Loss of pressure boundary.	Not stated	Not stated		Non-significant because operating temperatures within PWR containment structures are well below 371 C (700_F) level at which the structural integrity of rebar/structural steel begins to be significantly affected.	4-34, 4-47 to 4-49	115
Loss of pressure boundary.	Not stated	Not stated		Non-significant because the total radiation exposure is far below the 10^19 n/cm^2 level that could cause change in mechanical or physical properties.	4-49 to 4-51	116
Loss of pressure boundary.	Not stated	Not stated		Galvanic corrosion & corrosion due to aggressive aqueous solutions will not occur if dissimilar metals are not used & if aggressive ground water (chlorides >500 ppm) is not present.	4-42 to 4-47	117
Loss of pressure boundary.	Not stated	Not stated		Non-significant because designed to have good fatigue strength in accordance with ASME Sect. III, Div. 2 & ACI 215R-74	4-52 to 4-54	118
Loss of pressure boundary.	Not stated	Not stated		Same as for penetration sleeves.	4-57 to 4-59	119

Document: IR 90-02, BWR Pressure Vessel Industry Report
Reviewed by: O. Chopra/D. Gavenda, ANL

Effect of Aging on Component Function	Contrib to Failure	Reported progs	Rel.progs	Report Recommendations	Page No.	Item
Loss of pressure boundary.	Not stated	Not stated		Non-significant because neutron fluence is <10^17 n/cm^2 the level identified in 10CFR 50 Appendix H requiring surveillance program	4-2 to 4-4	1
Loss of pressure boundary.	Not stated	Not stated		Non-significant because low-alloy steel & SS clad with >5% ferrite are not susceptible to CORR/IGSCC and/or applied stresses are low	4-14 to 4-24	2
Loss of pressure boundary.	Not stated	Not stated		CORR/IASCC is non-significant for low-alloy steel components subjected to neutron fluences typical of BWR vessel service	4-24, 4-25	3
Loss of pressure boundary.	Not stated	Not stated		Non-significant because cladding is resistant to CORR, removal of cladding results in very low corrosion rates	4-25 to 4-27	4
Loss of pressure boundary.	Not stated	Not stated		Non-significant because SS or Ni alloy cladding are resistant to ERO/CORR and/or relatively low flow	4-27, 4-28	5
Loss of pressure boundary.	Not stated	Design basis or plant-specific fatigue usage factor is <0.25 for CS in high (More)		NRC recommendation: Licensee must verify that plant-specific analyses based on conservative extrapolation of an enveloping set of transients & including effects of environment, demonstrate that fatigue usage factor is <1	4-5 to 4-13	6
Loss of pressure boundary.	Not stated	Verification of integrity by requirements of Appendices G & H of 10CFR50 & (More)		NRC recommendation: A 100% volumetric inspection of all beltline & all other accessible welds required by ASME Sect. XI. Exceptions for license renewal will be reviewed on a case by case basis.	5-3 to 5-9, 5-26 to 5-28	7

Table B.1 Gall Report for NUMARC Industry Reports

Document: IR 90-02, BWR Pressure Vessel Industry Report
Reviewed by: O. Chopra/D. Gavenda, ANL

Item	System	Structure/Comp	Subcomponent	Materials	Manufacturer	ARD mechanism	ARD effects
8	BWR Pressure Vessel	Vessel Shell	Beltline Shell	SA302-Gr B, SA533-Gr B	Not stated	CORR/IGSCC	Crack initiation & growth
9	BWR Pressure Vessel	Vessel Shell	Beltline Shell	SA302-Gr B, SA533-Gr B	Not stated	CORR/IASCC	Crack initiation & growth
10	BWR Pressure Vessel	Vessel Shell	Beltline Shell	SA302-Gr B, SA533-Gr B	Not stated	CORR	Loss of material, corrosion product buildup
11	BWR Pressure Vessel	Vessel Shell	Beltline Shell	SA302-Gr B, SA533-Gr B	Not stated	ERO/CORR	Wall thinning, loss of material
12	BWR Pressure Vessel	Vessel Shell	Beltline Shell	SA302-Gr B,SA533-Gr B	Not stated	FAT	Cumulative fatigue damage
13	BWR Pressure Vessel	Vessel Shell	Beltline Welds	Low-alloy steel weld	Not stated	EMBR/IR	Loss of fracture toughness
14	BWR Pressure Vessel	Vessel Shell	Beltline Welds	Low-alloy steel weld	Not stated	CORR/IGSCC	Crack initiation & growth
15	BWR Pressure Vessel	Vessel Shell	Beltline Welds	Low-alloy steel weld	Not stated	CORR/IASCC	Crack initiation & growth
16	BWR Pressure Vessel	Vessel Shell	Beltline Welds	Low-alloy steel weld	Not stated	CORR	Loss of material, corrosion product buildup
17	BWR Pressure Vessel	Vessel Shell	Beltline Welds	Low-alloy steel weld	Not stated	ERO/CORR	Wall thinning, loss of material
18	BWR Pressure Vessel	Vessel Shell	Beltline Welds	Low-alloy steel weld	Not stated	FAT	Cumulative fatigue damage
19	BWR Pressure Vessel	Vessel Shell	Other than beltline shell & welds	SA302-Gr B, SA533-Gr B	Not stated	EMBR/IR	Loss of fracture toughness
20	BWR Pressure Vessel	Vessel Shell	Other than beltline shell & welds	SA302-Gr B, SA533-Gr B	Not stated	CORR/IGSCC	Crack initiation & growth
21	BWR Pressure Vessel	Vessel Shell	Other than beltline shell & welds	SA302-Gr B, SA533-Gr B	Not stated	CORR/IASCC	Crack initiation & growth
22	BWR Pressure Vessel	Vessel Shell	Other than beltline shell & welds	SA302-Gr B, SA533-Gr B	Not stated	CORR	Loss of material, corrosion product buildup

Document: IR 90-02, BWR Pressure Vessel Industry Report
Reviewed by: O. Chopra/D. Gavenda, ANL

Effect of Aging on Component Function	Contrib to Failure	Reported progs	Rel.progs	Report Recommendations	Page No.	Item
Loss of pressure boundary.	Not stated	Not stated		Non-significant because low-alloy steel & SS clad with >5% ferrite are not susceptible to CORR/IGSCC and/or applied stresses are low	4-14 to 4-24	8
Loss of pressure boundary.	Not stated	Not stated		CORR/IASCC is non-significant for low-alloy steel components subjected to neutron fluences typical of BWR vessel service	4-24, 4-25	9
Loss of pressure boundary.	Not stated	Not stated		Non-significant because cladding is resistant to CORR, removal of cladding results in very low corrosion rates	4-25 to 4-27	10
Loss of pressure boundary.	Not stated	Not stated		Non-significant because SS or Ni alloy cladding are resistant to ERO/CORR and/or relatively low flow	4-27, 4-28	11
Loss of pressure boundary.	Not stated	Design basis or plant-specific fatigue usage factor is <0.25 for CS in high (More)		NRC recommendation: Licensee must verify that plant-specific analyses based on conservative extrapolation of an enveloping set of transients & including effects of environment, demonstrate that fatigue usage factor is <1	4-5 to 4-13	12
Loss of pressure boundary.	Not stated	Verification of integrity by requirements of Appendices G & H of 10CFR50 & (More)		NRC recommendation: A 100% volumetric inspection of all beltline & all other accessible welds required by ASME Sect. XI. Exceptions for license renewal will be reviewed on a case by case basis.	5-3 to 5-9, 5-26 to 5-28	13
Loss of pressure boundary.	Not stated	Non-significant because weld metal with >5% ferrite is not susceptible to (More)		NRC recommendation: Same as for EMBR/IR	4-14 to 4-24	14
Loss of pressure boundary.	Not stated	Not stated		CORR/IASCC is non-significant for low-alloy steel components subjected to neutron fluences typical of BWR vessel service	4-24, 4-25	15
Loss of pressure boundary.	Not stated	Not stated		Non-significant because cladding is resistant to CORR, removal of cladding results in very low corrosion rates	4-25 to 4-27	16
Loss of pressure boundary.	Not stated	Not stated		Non-significant because SS or Ni alloy cladding are resistant to ERO/CORR and/or relatively low flow	4-27, 4-28	17
Loss of pressure boundary.	Not stated	Design basis or plant-specific fatigue usage factor is <0.25 for CS in high (More)		NRC recommendation: Licensee must verify that plant-specific analyses based on conservative extrapolation of an enveloping set of transients & including effects of environment, demonstrate that fatigue usage factor is <1	4-5 to 4-13	18
Loss of pressure boundary.	Not stated	Not stated		Non-significant because neutron fluence is <10^17 n/ cm^2 the level identified in 10CFR 50 Appendix H requiring surveillance program	4-2 to 4-4	19
Loss of pressure boundary.	Not stated	Not stated		Non-significant because low-alloy steel & SS clad with >5% ferrite are not susceptible to CORR/IGSCC and/or applied stresses are low	4-14 to 4-24	20
Loss of pressure boundary.	Not stated	Not stated		CORR/IASCC is non-significant for low-alloy steel components subjected to neutron fluences typical of BWR vessel service	4-24, 4-25	21
Loss of pressure boundary.	Not stated	Not stated		Non-significant because cladding is resistant to CORR, removal of cladding results in very low corrosion rates	4-25 to 4-27	22

Document: IR 90-02, BWR Pressure Vessel Industry Report
Reviewed by: O. Chopra/D. Gavenda, ANL

Item	System	Structure/Comp	Subcomponent	Materials	Manufacturer	ARD mechanism	ARD effects
23	BWR Pressure Vessel	Vessel Shell	Other than beltline shell & welds	SA302-Gr B, SA533-Gr B	Not stated	ERO/CORR	Wall thinning, loss of material
24	BWR Pressure Vessel	Vessel Shell	Other than beltline shell & welds	SA302-Gr B, SA533-Gr B	Not stated	FAT	Cumulative fatigue damage
25	BWR Pressure Vessel	Vessel Flange	Not stated	SA336, SA508-Cl 2	Not stated	EMBR/IR	Loss of fracture toughness
26	BWR Pressure Vessel	Vessel Flange	Not stated	SA336, SA508-Cl 2	Not stated	CORR/IGSCC	Crack initiation & growth
27	BWR Pressure Vessel	Vessel Flange	Not stated	SA336, SA508-Cl 2	Not stated	CORR/IASCC	Crack initiation & growth
28	BWR Pressure Vessel	Vessel Flange	Not stated	SA336, SA508-Cl 2	Not stated	CORR	Loss of material, corrosion product buildup
29	BWR Pressure Vessel	Vessel Flange	Not stated	SA336, SA508-Cl 2	Not stated	ERO/CORR	Wall thinning, loss of material
30	BWR Pressure Vessel	Vessel Flange	Not stated	SA336, SA508-Cl 2	Not stated	FAT	Cumulative fatigue damage
31	BWR Pressure Vessel	Bottom Head	Not stated	SA302-Gr B, SA533-Gr B	Not stated	EMBR/IR	Loss of fracture toughness
32	BWR Pressure Vessel	Bottom Head	Not stated	SA302-Gr B, SA533-Gr B	Not stated	CORR/IGSCC	Crack initiation & growth
33	BWR Pressure Vessel	Bottom Head	Not stated	SA302-Gr B, SA533-Gr B	Not stated	CORR/IASCC	Crack initiation & growth
34	BWR Pressure Vessel	Bottom Head	Not stated	SA302-Gr B, SA533-Gr B	Not stated	CORR	Loss of material, corrosion product buildup
35	BWR Pressure Vessel	Bottom Head	Not stated	SA302-Gr B, SA533-Gr B	Not stated	ERO/CORR	Wall thinning, loss of material
36	BWR Pressure Vessel	Bottom Head	Not stated	SA302-Gr B, SA533-Gr B	Not stated	FAT	Cumulative fatigue damage
37	BWR Pressure Vessel	Closure Studs	Not stated	SA193, SA540	Not stated	EMBR/IR	Loss of fracture toughness

Document: IR 90-02, BWR Pressure Vessel Industry Report
Reviewed by: O. Chopra/D. Gavenda, ANL

Effect of Aging on Component Function	Contrib to Failure	Reported progs	Rel.progs	Report Recommendations	Page No.	Item
Loss of pressure boundary.	Not stated	Not stated		Non-significant because SS or Ni alloy cladding are resistant to ERO/ CORR and/or relatively low flow	4-27, 4-28	23
Loss of pressure boundary.	Not stated	Design basis or plant-specific fatigue usage factor is <0.25 for CS in high (More)		NRC recommendation: Licensee must verify that plant-specific analyses based on conservative extrapolation of an enveloping set of transients & including effects of environment, demonstrate that fatigue usage factor is <1	4-5 to 4-13	24
Loss of pressure boundary.	Not stated	Not stated		Non-significant because neutron fluence is <10^17 n/ cm^2 the level identified in 10CFR 50 Appendix H requiring surveillance program	4-2 to 4-4	25
Loss of pressure boundary.	Not stated	Not stated		Non-significant because low-alloy steel & SS clad with >5% ferrite are not susceptible to CORR/IGSCC and/or applied stresses are low	4-14 to 4-24	26
Loss of pressure boundary.	Not stated	Not stated		CORR/IASCC is non-significant for low-alloy steel components subjected to neutron fluences typical of BWR vessel service	4-24, 4-25	27
Loss of pressure boundary.	Not stated	Not stated		Non-significant because cladding is resistant to CORR, removal of cladding results in very low corrosion rates	4-25 to 4-27	28
Loss of pressure boundary.	Not stated	Not stated		Non-significant because SS or Ni alloy cladding are resistant to ERO/ CORR and/or relatively low flow	4-27, 4-28	29
Loss of pressure boundary.	Not stated	Design basis or plant-specific fatigue usage factor is <0.25 for CS in high (More)		NRC recommendation: Verify that plant-specific analyses based on conservative extrapolation of enveloping set of transients including environmental effects, yield usage factor <1; identified by ASME Sect. XI Task group as significant for vessel flange.	4-5 to 4-13	30
Loss of pressure boundary.	Not stated	Not stated		Non-significant because neutron fluence is <10^17 n/ cm^2 the level identified in 10CFR 50 Appendix H requiring surveillance program.	4-2 to 4-4	31
Loss of pressure boundary.	Not stated	Not stated		Non-significant because low-alloy steel & SS clad with >5% ferrite are not susceptible to CORR/IGSCC and/or applied stresses are low	4-14 to 4-24	32
Loss of pressure boundary.	Not stated	Not stated		CORR/IASCC is non-significant for low-alloy steel components subjected to neutron fluences typical of BWR vessel service	4-24, 4-25	33
Loss of pressure boundary.	Not stated	Not stated		Non-significant because cladding is resistant to CORR, removal of cladding results in very low corrosion rates	4-25 to 4-27	34
Loss of pressure boundary.	Not stated	Not stated		Non-significant because SS or Ni alloy cladding are resistant to ERO/ CORR and/or relatively low flow	4-27, 4-28	35
Loss of pressure boundary.	Not stated	Design basis or plant-specific fatigue usage factor is <0.25 for CS in high (More)		NUMARC recomm: Non-significant for all BWRs & for BWR-2 if dT between top and bottom head has not exceeded 63 deg C (145 deg F). NRC recomm: Verify that fatigue usage based on enveloping setup conditions including environmental effects is < 1.	4-5 to 4-13	36
Loss of pressure boundary.	Not stated	Not stated		Non-significant because neutron fluence is <10^17 n/ cm^2 the level identified in 10CFR 50 Appendix H requiring surveillance program	4-2 to 4-4	37

Table B.1 Gall Report for NUMARC Industry Reports

Document: IR 90-02, BWR Pressure Vessel Industry Report
Reviewed by: O. Chopra/D. Gavenda, ANL

Item	System	Structure/Comp	Subcomponent	Materials	Manufacturer	ARD mechanism	ARD effects
38	BWR Pressure Vessel	Closure Studs	Not stated	SA193, SA540	Not stated	CORR/IGSCC	Crack initiation & growth
39	BWR Pressure Vessel	Closure Studs	Not stated	SA193, SA540	Not stated	CORR/IASCC	Crack initiation & growth
40	BWR Pressure Vessel	Closure Studs	Not stated	SA193, SA540	Not stated	CORR	Loss of material, corrosion product buildup
41	BWR Pressure Vessel	Closure Studs	Not stated	SA193, SA540	Not stated	ERO/CORR	Wall thinning loss of material
42	BWR Pressure Vessel	Closure Studs.	Not stated	SA193, SA540	Not stated	FAT	Cumulative fatigue damage
43	BWR Pressure Vessel	Support Skirt	Not stated	SA533-Gr B	Not stated	EMBR/IR	Loss of fracture toughness
44	BWR Pressure Vessel	Support Skirt	Not stated	SA533-Gr B	Not stated	CORR/IGSCC	Crack initiation & growth
45	BWR Pressure Vessel	Support Skirt	Not stated	SA533-Gr B	Not stated	CORR/IASCC	Crack initiation & growth
46	BWR Pressure Vessel	Support Skirt	Not stated	SA533-Gr B	Not stated	CORR	Loss of material corrosion product buildup
47	BWR Pressure Vessel	Support Skirt	Not stated	SA533-GR B	Not stated	ERO/CORR	Wall thinning loss of material
48	BWR Pressure Vessel	Support Skirt	Not stated	SA533-GR B	Not stated	FAT	Cumulative fatigue damage
49	BWR Pressure Vessel	Attachment Welds	Not stated	SS, Alloy 182	Not stated	EMBR/IR	Loss of fracture toughness
50	BWR Pressure Vessel	Attachment Welds	Not stated	SS, Alloy 182	Not stated	CORR/IGSCC	Crack initiation & growth
51	BWR Pressure Vessel	Attachment Welds	Not stated	SS,Alloy 182	Not stated	CORR/IASCC	Crack initiation & growth
52	BWR Pressure Vessel	Attachment Welds	Not stated	SS,Alloy 182	Not stated	CORR	Loss of material, corrosion product buildup
53	BWR Pressure Vessel	Attachment Welds	Not stated	SS,Alloy 182	Not stated	ERO/CORR	Wall thinning, loss of material

Document: IR 90-02, BWR Pressure Vessel Industry Report
Reviewed by: O. Chopra/D. Gavenda, ANL

Effect of Aging on Component Function	Contrib to Failure	Reported progs	Rel.progs	Report Recommendations	Page No.	Item
Loss of pressure boundary.	Not stated	ASME Sect. XI, Subsect. IWB augmented by RICSIL 055 & RG 1.65		ASME Sect. XI, Subsect. IWB, inspection and testing programs, exam category B-G-1, recommendations of RICSIL 055, & replacement in accordance with RG 1.65	5-18, 5-20	38
Loss of pressure boundary.	Not stated	Not stated		CORR/IASCC is non-significant for low-alloy steel components subjected to neutron fluences typical of BWR vessel service	4-24, 4-25	39
Loss of pressure boundary.	Not stated	Not stated		Non-significant because not exposed to corrosive environment	4-25 to 4-27	40
Loss of pressure boundary.	Not stated	Not stated		Non-significant because not exposed to flowing liquid	4-27, 4-28	41
Loss of pressure boundary.	Not stated	ASME Sect. III, Subsect. NB reanalysis of usage factor & ASME Sect. XI, (More)		NRC recommendation: Licensee must verify that plant-specific analyses based on conservative extrapolation of an enveloping set of transients & including effects of environment, demonstrate that fatigue usage factor is <1	5-9 to 5-17, 5-20	42
Loss of core support.	Not stated	Not stated		Non-significant because shift in reference temperature due to neutron exposure is <11 deg C	4-2 to 4-4	43
Loss of core support.	Not stated	Not stated		Non-significant because not subjected to corrosive environment	4-14 to 4-24	44
Loss of core support.	Not stated	Not stated		CORR/IASCC is non-significant for low-alloy steel components subjected to neutron fluences typical of BWR vessel service	4-24, 4-25	45
Loss of core support.	Not stated	Not stated		Non-significant because not subjected to coolant environment	4-25 to 4-27	46
Loss of core support.	Not stated	Not stated		Non-significant because not exposed to flowing liquid	4-27, 4-28	47
Loss of core support.	Not stated	ASME Sect. III, Subsect. NB reanalysis of usage factor.		NRC recommendation: Licensee must verify that plant-specific analyses based on conservative extrapolation of an enveloping set of operating conditions, demonstrate that fatigue usage factor is <1	5-9 to 5-17, 5-28, 5-29	48
Loss of pressure boundary.	Not stated	Not stated		Non-significant because neutron fluence is <10^17 n/ cm^2 the level identified in 10CFR 50 Appendix H requiring surveillance program	4-2 to4-4	49
Loss of pressure boundary.	Not stated	Select plant-specific aging management plan comprising of qualified inspec. (More)		This item was not the subject of the NRC review.	5-18, 5-19	50
Loss of pressure boundary.	Not stated	Not stated		CORR/IASCC is non-significant for SS and Ni-Cr-Fe alloy components because total fast neutron fluence within the license renewal term is <10^20 n/cm^2 for highly stressed components & <5 x10^20 n/cm^2 for components subjected to stresses <68 MPa.	4-24, 4-25	51
Loss of pressure boundary.	Not stated	Not stated		Non-significant because SS or Ni alloy is resistant to CORR	4-25 to 4-27	52
Loss of pressure boundary.	Not stated	Not stated		Non-significant because SS or Ni alloy is resistant to ERO/CORR and/or relatively low flow	4-27, 4-28	53

Table B.1 Gall Report for NUMARC Industry Reports

Document: IR 90-02, BWR Pressure Vessel Industry Report
Reviewed by: O. Chopra/D. Gavenda, ANL

Item	System	Structure/Comp	Subcomponent	Materials	Manufacturer	ARD mechanism	ARD effects
54	BWR Pressure Vessel	Attachment Welds	Not stated	SS,Alloy 182	Not stated	FAT	Cumulative fatigue damage
5	BWR Pressure Vessel	Nozzles	Feedwater	SA508-Cl2	Not stated	EMBR/IR	Loss of fracture toughness
56	BWR Pressure Vessel	Nozzles	Feedwater	SA508-Cl2	Not stated	CORR/IGSCC	Crack initiation & growth
57	BWR Pressure Vessel	Nozzles	Feedwater	SA508-Cl2	Not stated	CORR/IASCC	Crack initiation & growth
58	BWR Pressure Vessel	Nozzles	Feedwater	SA508-Cl2	Not stated	CORR	Loss of material, corrosion product buildup
59	BWR Pressure Vessel	Nozzles	Feedwater	SA508-Cl2	Not stated	ERO/CORR	Wall thinning, loss of material
60	BWR Pressure Vessel	Nozzles	Feedwater	SA508-Cl2	Not stated	FAT	Cumulative fatigue damage
61	BWR Pressure Vessel	Nozzles	BWR/2CRDRL uncapped	SA508-Cl2	Not stated	EMBR/IR	Loss of fracture toughness
62	BWR Pressure Vessel	Nozzles	BWR/2CRDRL uncapped	SA508-Cl2	Not stated	CORR/IGSCC	Crack initiation & growth
63	BWR Pressure Vessel	Nozzles	BWR/2CRDRL uncapped	SA508-Cl2	Not stated	CORR/IASCC	Crack initiation & growth
64	BWR Pressure Vessel	Nozzles	BWR/2CRDRL uncapped	SA508-Cl2	Not stated	CORR	Loss of material, corrosion product buildup
65	BWR Pressure Vessel	Nozzles	BWR/2CRDRL uncapped	SA508-Cl2	Not stated	ERO/CORR	Wall thinning, loss of material
66	BWR Pressure Vessel	Nozzles	BWR/2CRDRL uncapped	SA508-Cl2	Not stated	FAT	Cumulative fatigue damage
67	BWR Pressure Vessel	Nozzles	BWR/5 LPCI	SA508-Cl2	Not stated	EMBR/IR	Loss of fracture toughness

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Effect of Aging on Component Function	Contrib to Failure	Reported progs	Rel.progs	Report Recommendations	Page No.	Item
Loss of pressure boundary.	Not stated	Non-significant because no fatigue cracking expected under operating conditions		NRC recomm.: Licensee must verify that plant-specific analyses based on conservative extrapolation of an enveloping set of transients & including effects of environment, demonstrate that usage factor is <1.	4-5 to 4-13	54
Loss of pressure boundary.	Not stated	Not stated		Non-significant because neutron fluence is <10^17 n/cm^2 the level identified in 10CFR 50 Appendix H requiring surveillance program	4-2 to 4-4	55
Loss of pressure boundary.	Not stated	ASME Sect. XI, Subsect. IWB augmented by NUREG 0313 & Generic letter 88-01		ASME Sect. XI, Subsect. IWB inspection and testing programs; exam. categories B-D & B-F, additional requirements of NUREG 0313 implemented by Generic letter 88-01	5-18, 5-21	56
Loss of pressure boundary.	Not stated	Not stated		CORR/IASCC is non-significant for low-alloy steel components subjected to neutron fluences typical of BWR vessel service	4-24, 4-25	57
Loss of pressure boundary.	Not stated	Not stated		Non-significant because the components are internally clad with SS which is resistant to corrosion	4-25 to 4-27	58
Loss of pressure boundary.	Not stated	Not stated		Non-significant because SS or Ni alloy cladding are resistant to ERO/ CORR and/or relatively low flow	4-27, 4-28	59
Loss of pressure boundary.	Not stated	ASME Sect. III, Subsect. NB reanalysis of usage factor & ASME Sect. XI, (More)		NRC recommendation: Licensee must verify that plant-specific analyses based on conservative extrapolation of an enveloping set of transients & including effects of environment, demonstrate that fatigue usage factor is <1	5-9 to 5-17, 5-21	60
Loss of pressure boundary.	Not stated	Not stated		Non-significant because neutron fluence is <10^17 n/ cm^2 the level identified in 10CFR 50 Appendix H requiring surveillance program	4-2 to 4-4	61
Loss of pressure boundary.	Not stated	ASME Sect. XI, Subsect. IWB augmented by NUREG 0313 & Generic letter 88-01		ASME Sect. XI, Subsect. IWB inspection and testing programs; exam. categories B-D & B-F, additional requirements of NUREG 0313 implemented by Generic letter 88-01	5-18, 5-21	62
Loss of pressure boundary.	Not stated	Not stated		CORR/IASCC is non-significant for low-alloy steel components subjected to neutron fluences typical of BWR vessel service	4-24, 4-25	63
Loss of pressure boundary.	Not stated	Not stated		Non-significant because the components are internally clad with SS which is resistant to corrosion	4-25 to 4-27	64
Loss of pressure boundary.	Not stated	Not stated		Non-significant because SS or Ni alloy cladding are resistant to ERO/CORR and/or relatively low flow	4-27, 4-28	65
Loss of pressure boundary.	Not stated	Current practices to be enhanced, select plant-specific aging management program		This item was not the subject of the NRC review.	5-9 to 5-17, 5-23	66
Loss of pressure boundary.	Not stated	Verification of integrity by requirements of Appendices G & H of 10CFR50 & (More)		NRC recommendation: A 100% volumetric inspection of all beltline & all other accessible welds required by ASME Sect. XI. Exceptions for license renewal will be reviewed on a case by case basis.	5-3 to 5-9, 5-24	67

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Item	System	Structure/Comp	Subcomponent	Materials	Manufacturer	ARD mechanism	ARD effects
68	BWR Pressure Vessel	Nozzles	BWR/5 LPCI	SA508-Cl2	Not stated	CORR/IGSCC	Crack initiation & growth
69	BWR Pressure Vessel	Nozzles	BWR/5 LPCI	SA508-Cl2	Not stated	CORR/IASCC	Crack initiation & growth
70	BWR Pressure Vessel	Nozzles	BWR/5 LPCI	SA508-Cl2	Not stated	CORR	Loss of material, corrosion product buildup
71	BWR Pressure Vessel	Nozzles	BWR/5 LPCI	SA508-Cl2	Not stated	ERO/CORR	Wall thinning, loss of material
72	BWR Pressure Vessel	Nozzles	BWR/5 LPCI	SA508-Cl2	Not stated	FAT	Cumulative fatigue damage
73	BWR Pressure Vessel	Nozzles	All Other	SA508-Cl2	Not stated	EMBR/IR	Loss of fracture toughness
74	BWR Pressure Vessel	Nozzles	All Other	SA508-Cl2	Not stated	CORR/IGSCC	Crack initiation & growth
75	BWR Pressure Vessel	Nozzles	All Other	SA508-Cl2	Not stated	CORR/IASCC	Crack initiation & growth
76	BWR Pressure Vessel	Nozzles	All Other	SA508-Cl2	Not stated	CORR	Loss of material, corrosion product buildup
77	BWR Pressure Vessel	Nozzles	All Other	SA508-Cl2	Not stated	ERO/CORR	Wall thinning, loss of material
78	BWR Pressure Vessel	Nozzles	All Other	SA508-Cl2	Not stated	FAT	Cumulative fatigue damage
79	BWR Pressure Vessel	Safe Ends	BWR/2CRDRL	CS, SB-166	Not stated	EMBR/IR	Loss of fracture toughness
80	BWR Pressure Vessel	Safe Ends	BWR/2CRDRL	CS, SB-166	Not stated	CORR/IGSCC	Crack initiation & growth
81	BWR Pressure Vessel	Safe Ends	BWR/2CRDRL	CS, SB-166	Not stated	CORR/IASCC	Crack initiation & growth

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Effect of Aging on Component Function	Contrib to Failure	Reported progs	Rel.progs	Report Recommendations	Page No.	Item
Loss of pressure boundary.	Not stated	ASME Sect. XI, Subsect. IWB augmented by NUREG 0313 & Generic letter 88-01		ASME Sect. XI, Subsect. IWB inspection and testing programs; exam. categories B-D & B-F, additional requirements of NUREG 0313 implemented by Generic letter 88-01	5-18, 5-21	68
Loss of pressure boundary.	Not stated	Not stated		CORR/IASCC is non-significant for low-alloy steel components subjected to neutron fluences typical of BWR vessel service	4-24, 4-25	69
Loss of pressure boundary.	Not stated	Not stated		Non-significant because the components are internally clad with SS which is resistant to corrosion	4-25 to 4-27	70
Loss of pressure boundary.	Not stated	Not stated		Non-significant because SS or Ni alloy cladding are resistant to ERO/ CORR and/or relatively low flow	4-27, 4-28	71
Loss of pressure boundary.	Not stated	Design basis or plant specific fatigue usage factor is <0.25 for CS in high stress		NRC recommendation: Licensee must verify that plant-specific analyses based on conservative extrapolation of an enveloping set of transients & including effects of environment, demonstrate that fatigue usage factor is <1	5-9 to 5-17, 5-21	72
Loss of pressure boundary.	Not stated	Not stated		Non-significant because neutron fluence is <10^17 n/ cm^2 the level identified in 10CFR 50 Appendix H requiring surveillance program	4-2 to 4-4	73
Loss of pressure boundary.	Not stated	ASME Sect. XI, Subsect. IWB augmented by NUREG 0313 & Generic letter 88-01		ASME Sect. XI, Subsect. IWB inspection and testing programs; exam. categories B-D & B-F, additional requirements of NUREG 0313 implemented by Generic letter 88-01	5-18, 5-21	74
Loss of pressure boundary.	Not stated	Not stated		CORR/IASCC is non-significant for low-alloy steel components subjected to neutron fluences typical of BWR vessel service	4-24, 4-25	75
Loss of pressure boundary.	Not stated	Not stated		Non-significant because the components are internally clad with SS which is resistant to corrosion	4-25 to 4-27	76
Loss of pressure boundary.	Not stated	Not stated		Non-significant because SS or Ni alloy cladding are resistant to ERO/ CORR and/or relatively low flow	4-27, 4-28	77
Loss of pressure boundary.	Not stated	Design basis or plant specific fatigue usage factor is <0.25 for CS in high (More)		NRC recommendation: Licensee must verify that plant-specific analyses based on conservative extrapolation of an enveloping set of transients & including effects of environment, demonstrate that fatigue usage factor is <1	4-5 to 4-13	78
Loss of pressure boundary.	Not stated	Not stated		Non-significant because neutron fluence is <10^17 n/cm^2 the level identified in 10CFR 50 Appendix H requiring surveillance program, & Ni-Cr-Fe alloys are not susceptible to neutron embrittlement at fluence less than 10^20 n/cm^2	4-2 to 4-4	79
Loss of pressure boundary.	Not stated	ASME Sect. XI, Subsect. IWB augmented by NUREG 0313 & Generic letter 88-01		ASME Sect. XI, Subsect. IWB inspection and testing programs; exam. categories B-D & B-F, additional requirements of NUREG 0313 implemented by Generic letter 88-01	5-18, 5-26	80
Loss of pressure boundary.	Not stated	Not stated		CORR/IASCC is non-significant for low-alloy steel components subjected to neutron fluences typical of BWR vessel service & for Ni alloy components because the total fast neutron fluence within the license renewal term is <10^20 n/cm^2.	4-24, 4-25	81

Table B.1 Gall Report for NUMARC Industry Reports

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Item	System	Structure/Comp	Subcomponent	Materials	Manufacturer	ARD mechanism	ARD effects
32	BWR Pressure Vessel	Safe Ends	BWR/2CRDRL	CS, SB-166	Not stated	CORR	Loss of material, corrosion product buildup
83	BWR Pressure Vessel	Safe Ends	BWR/2CRDRL	CS, SB-166	Not stated	ERO/CORR	Wall thinning, loss of material
84	BWR Pressure Vessel	Safe Ends	BWR/2CRDRL	CS, SB-166	Not stated	FAT	Cumulative fatigue damage
85	BWR Pressure Vessel	Safe Ends	BWR/5LPCI	SS, SB-166	Not stated	EMBR/IR	Loss of fracture toughness
86	BWR Pressure Vessel	Safe Ends	BWR/5LPCI	SS, SB-166	Not stated	CORR/IGSCC	Crack initiation & growth
87	BWR Pressure Vessel	Safe Ends	BWR/5LPCI	SS, SB-166	Not stated	CORR/IASCC	Crack initiation & growth
88	BWR Pressure Vessel	Safe Ends	BWR/5LPCI	SS, SB-166	Not stated	CORR	Loss of material, corrosion product buildup
89	BWR Pressure Vessel	Safe Ends	BWR/5LPCI	SS, SB-166	Not stated	ERO/CORR	Wall thinning, loss of material
90	BWR Pressure Vessel	Safe Ends	BWR/5LPCI	SS, SB-166	Not stated	FAT	Cumulative fatigue damage
91	BWR Pressure Vessel	Safe Ends	Feed Water	CS, SB-166	Not stated	EMBR/IR	Loss of fracture toughness
92	BWR Pressure Vessel	Safe Ends	Feed Water	CS, SB-166	Not stated	CORR/IGSCC	Crack initiation & growth

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Effect of Aging on Component Function	Contrib to Failure	Reported progs	Rel.progs	Report Recommendations	Page No.	Item
Loss of pressure boundary.	Not stated	Not stated		Non-significant because components are internally clad with SS or fabricated of Ni-Cr-Fe alloy which are resistant to corrosion	4-25 to 4-27	82
Loss of pressure boundary.	Not stated	Not stated		Non-significant because SS or Ni alloy cladding and Ni-Cr-Fe alloys are resistant to E/C and/or relatively low flow	4-27, 4-28	83
Loss of pressure boundary.	Not stated	ASME Sect. III, Subsect. NB reanalysis of usage factor; Sect. XI, Subsect. (More)		NRC recommendation: Licensee must verify that plant-specific analyses based on conservative extrapolation of an enveloping set of transients & including effects of environment, demonstrate that fatigue usage factor is <1	5-9 to 5-17, 5-26	84
Loss of pressure boundary.	Not stated	Not stated		Non-significant because neutron fluence is <10^17 n/ cm^2 the level identified in 10CFR 50 Appendix H requiring surveillance program, and SS and Ni alloys are not susceptible to neutron embrittlement at fluence less than 10^20 n/cm^2	4-2 to 4-4	85
Loss of pressure boundary.	Not stated	ASME Sect. XI, Subsect. IWB augmented by NUREG 0313 & Generic letter 88-01		ASME Sect. XI, Subsect. IWB inspection and testing programs; exam. categories B-D & B-F, additional requirements of NUREG 0313 implemented by Generic letter 88-01	5-18, 5-26	86
Loss of pressure boundary.	Not stated	Not stated		CORR/IASCC is non-significant for SS and Ni-Cr-Fe alloy components because total fast neutron fluence within the license renewal term is <10^20 n/cm^2 for highly stressed components & <5 x10^20 n/cm^2 for components subjected to stresses <68 MPa.	4-24, 4-25	87
Loss of pressure boundary.	Not stated	Not stated		Non-significant because the components are fabricated of SS or Ni-Cr-Fe alloy which are resistant to corrosion	4-25 to 4-27	88
Loss of pressure boundary.	Not stated	Not stated		Non-significant because austenitic SSs and Ni-Cr-Fe alloys are resistant to E/C and/or relatively low flow	4-27, 4-28	89
Loss of pressure boundary.	Not stated	Design basis or plant specific fatigue usage factor is <0.25 for CS in high (More)		NRC recommendation: Licensee must verify that plant-specific analyses based on conservative extrapolation of an enveloping set of transients & including effects of environment, demonstrate that fatigue usage factor is <1	4-5 to 4-13	90
Loss of pressure boundary.	Not stated	Not stated		Non-significant because neutron fluence is <10^17 n/ cm^2 the level identified in 10CFR 50 Appendix H requiring surveillance program, & Ni-Cr-Fe alloys are not susceptible to neutron embrittlement at fluence less than 10^20 n/cm^2	4-2 to 4-4	91
Loss of pressure boundary.	Not stated	ASME Sect. XI, Subsect. IWB augmented by NUREG 0313 & Generic letter 88-01		ASME Sect. XI, Subsect. IWB inspection and testing programs; exam. categories B-D & B-F, additional requirements of NUREG 0313 implemented by Generic letter 88-01	5-18, 5-26	92

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Item	System	Structure/Comp	Subcomponent	Materials	Manufacturer	ARD mechanism	ARD effects
93	BWR Pressure Vessel	Safe Ends	Feed Water	CS, SB-166	Not stated	CORR/IASCC	Crack initiation & growth
94	BWR Pressure Vessel	Safe Ends	Feed Water	CS, SB-166	Not stated	CORR	Loss of material, corrosion product buildup
95	BWR Pressure Vessel	Safe Ends	Feed Water	CS, SB-166	Not stated	ERO/CORR	Wall thinning, loss of material
96	BWR Pressure Vessel	Safe Ends	Feed Water	CS, SB-166	Not stated	FAT	Cumulative fatigue damage
97	BWR Pressure Vessel	Safe Ends	All Other	CS, SB-166	Not stated	EMBR/IR	Loss of fracture toughness
98	BWR Pressure Vessel	Safe Ends	All Other	CS, SB-166	Not stated	CORR/IGSCC	Crack initiation & growth
99	BWR Pressure Vessel	Safe Ends	All Other	CS, SB-166	Not stated	CORR/IASCC	Crack initiation & growth
100	BWR Pressure Vessel	Safe Ends	All Other	CS, SB-166	Not stated	CORR	Loss of material, corrosion product buildup
101	BWR Pressure Vessel	Safe Ends	All Other	CS, SB-166	Not stated	ERO/CORR	Wall thinning, loss of material
102	BWR Pressure Vessel	Safe Ends	All Other	CS, SB-166	Not stated	FAT	Cumulative fatigue damage
103	BWR Pressure Vessel	Penetrations	CRD StubTubes	SS, SB-167	Not stated	EMBR/IR	Loss of fracture toughness
104	BWR Pressure Vessel	Penetrations	CRD StubTubes	SS, SB-167	Not stated	CORR/IGSCC	Crack initiation & growth

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Effect of Aging on Component Function	Contrib to Failure	Reported progs	Rel.progs	Report Recommendations	Page No.	Item
Loss of pressure boundary.	Not stated	Not stated		Non-significant for low-alloy steels subjected to neutron fluences typical of BWR vessel; & for Ni alloys because total fluence is <10^20 or <5*10^20 n/cm^2, for components subjected to high or <68MPa stresses.	4-24, 4-25	93
Loss of pressure boundary.	Not stated	Not stated		Non-significant because the components are internally clad with SS or fabricated of Ni alloy which are resistant to corrosion	4-25 to 4-27	94
Loss of pressure boundary.	Not stated	Not stated		Non-significant because SS or Ni alloy cladding & Ni-Cr-Fe alloys are resistant to E/C; and/or relatively low flow	4-27, 4-28	95
Loss of pressure boundary.	Not stated	ASME Sect. III, Subsect. NB reanalysis of usage factor; Sect. XI, Subsect. (More)		NRC recommendation: Licensee must verify that plant-specific analyses based on conservative extrapolation of an enveloping set of transients & including effects of environment, demonstrate that fatigue usage factor is <1	5-9 to 5-17, 5-26	96
Loss of pressure boundary.	Not stated	Not stated		Non-significant because neutron fluence is <10^17 n/ cm^2 the level identified in 10CFR 50 Appendix H requiring surveillance program, & Ni-Cr-Fe alloys are not susceptible to neutron embrittlement at fluence less than 10^20 n/cm^2	4-2 to 4-4	97
Loss of pressure boundary.	Not stated	ASME Sect. XI, Subsect. IWB augmented by NUREG 0313 & Generic letter 88-01		ASME Sect. XI, Subsect. IWB inspection and testing programs; exam. categories B-D & B-F, additional requirements of NUREG 0313 implemented by Generic letter 88-01	5-18, 5-26	98
Loss of pressure boundary.	Not stated	Not stated		Non-significant for low-alloy steels subjected to neutron fluences typical of BWR vessel; & for Ni alloys because total fluence is <10^20 or <5*10^20 n/cm^2, for components subjected to high or <68MPa stresses.	4-24, 4-25	99
Loss of pressure boundary.	Not stated	Not stated		Non-significant because the components are internally clad with SS or fabricated of Ni alloy which are resistant to corrosion	4-25 to 4-27	100
Loss of pressure boundary.	Not stated	Not stated		Non-significant because SS or Ni alloy cladding & Ni-Cr-Fe alloys are resistant to E/C; and/or relatively low flow	4-27, 4-28	101
Loss of pressure boundary.	Not stated	Design basis or plant specific fatigue usage factor is <0.25 for CS in high (More)		NRC recommendation: Licensee must verify that plant-specific analyses based on conservative extrapolation of an enveloping set of transients & including effects of environment, demonstrate that fatigue usage factor is <1	4-5 to 4-13	102
Loss of pressure boundary.	Not stated	Not stated		Non-significant because neutron fluence is <10^17 n/cm^2 the level identified in 10CFR 50 Appendix H requiring surveillance program;& SS and Ni-Cr-Fe alloys are not susceptible to neutron embrittlement at fluence less than 10^20 n/ cm^2	4-2 to 4-4	103
Loss of pressure boundary.	Not stated	ASME Sect. XI, Subsect. IWB; exam. category B-E		ASME Sect. XI, Subsect. IWB inspection and testing programs; exam. category B-E	5-18, 5-26	104

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Item	System	Structure/Comp	Subcomponent	Materials	Manufacturer	ARD mechanism	ARD effects
105	BWR Pressure Vessel	Penetrations	CRD StubTubes	SS, SB-167	Not stated	CORR/IASCC	Crack initiation & growth
106	BWR Pressure Vessel	Penetrations	CRD StubTubes	SS, SB-167	Not stated	CORR	Loss of material, corrosion product buildup
107	BWR Pressure Vessel	Penetrations	CRD StubTubes	SS, SB-167	Not stated	ERO/CORR	Wall thinning, loss of material
108	BWR Pressure Vessel	Penetrations	CRD StubTubes	SS, SB-167	Not stated	FAT	Cumulative fatigue damage
109	BWR Pressure Vessel	Penetrations	All Other	SB-167	Not stated	EMBR/IR	Loss of fracture toughness
110	BWR Pressure Vessel	Penetrations	All Other	SB-167	Not stated	CORR/IGSCC	Crack initiation & growth
111	BWR Pressure Vessel	Penetrations	All Other	SB-167	Not stated	CORR/IASCC	Crack initiation & growth
112	BWR Pressure Vessel	Penetrations	All Other	SB-167	Not stated	CORR	Loss of material, corrosion product buildup
113	BWR Pressure Vessel	Penetrations	All Other	SB-167	Not stated	ERO/CORR	Wall thinning, loss of material
114	BWR Pressure Vessel	Penetrations	All Other	SB-167	Not stated	FAT	Cumulative fatigue damage

Document: IR 90-03, BWR Vessel Internals Industry Report
Reviewed by: O. Chopra/D. Gavenda, ANL

Item	System	Structure/Comp	Subcomponent	Materials	Manufacturer	ARD mechanism	ARD effects
1	BWR Vessel Internals	Access Hole Cover	Not stated	Alloy 600	Not stated	EMBR/IR	Loss of fracture toughness
2	BWR Vessel Internals	Access Hole Cover	Not stated	Alloy 600	Not stated	EMBR/TE	Loss of fracture toughness

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Effect of Aging on Component Function	Contrib to Failure	Reported progs	Rel.progs	Report Recommendations	Page No.	Item
Loss of pressure boundary.	Not stated	Not stated		CORR/IASCC is non-significant for SS and Ni-Cr-Fe alloy components because total fast neutron fluence within the license renewal term is <10^20 n/cm^2 for highly stressed components & <5 x10^20 n/cm^2 for components subjected to stresses <68 MPa.	4-24, 4-25	105
Loss of pressure boundary.	Not stated	Not stated		Non-significant because the components are fabricated of SS or Ni-Cr-Fe alloy which are very resistant to corrosion	4-25 to 4-27	106
Loss of pressure boundary.	Not stated	Not stated		Non-significant because austenitic SSs and Ni-Cr-Fe alloys are resistant to E/C and/or relatively low flow	4-27, 4-28	107
Loss of pressure boundary.	Not stated	ASME Sect. III, Subsect. NB reanalysis; ASME Sect. XI, Subsect. IWB, inspection		NRC recommendation: Fatigue usage factor of stub tubes could be as high 0.67 during 40-yr life. More frequent inspections may be needed	5-9 to5-17, 5-26	108
Loss of pressure boundary.	Not stated	Not stated		Non-significant because neutron fluence is <10^17 n/ cm^2 the level identified in 10CFR 50 Appendix H requiring surveillance program; & Ni-Cr-Fe alloys are not susceptible to neutron embrittlement at fluence less than 10^20 n/ cm^2	4-2 to 4-4	109
Loss of pressure boundary.	Not stated	ASME Sect. XI, Subsect. IWB; exam. category B-E		ASME Sect. XI, Subsect. IWB inspection and testing programs; exam. category B-E	5-18, 5-26	110
Loss of pressure boundary.	Not stated	Not stated		CORR/IASCC is non-significant for Ni alloy components because the total fast neutron fluence within the license renewal term is <10^20 n/ cm^2 for highly stressed components & <5 x 10^20 n/cm^2 for components that are subjected to stresses <68 MPa	4-24, 4-25	111
Loss of pressure boundary.	Not stated	Not stated		Non-significant because the components are fabricated of Ni-Cr-Fe alloy which is resistant to corrosion	4-25 to4-27	112
Loss of pressure boundary.	Not stated	Not stated		Non-significant because Ni-Cr-Fe alloys are resistant to E/C and/or relatively low flow	4-27, 4-28	113
Loss of pressure boundary.	Not stated	Design basis or plant specific fatigue usage factor is <0.25 for CS in high (More)		NRC recommendation: Licensee must verify that plant-specific analyses based on conservative extrapolation of an enveloping set of transients & including effects of environment, demonstrate that fatigue usage factor is <1	4-5 to 4-13	114

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Effect of Aging on Component Function	Contrib to Failure	Reported progs	Rel.progs	Report Recommendations	Page No.	Item
Flow blockage, loose part damage.	Not stated	Not stated		Non-significant because even though neutron irradiation decreases fracture toughness in Ni-alloy components, the fracture toughness levels remain adequate even at end of life fluence levels because the applied stresses are low	4-3 to 4-7	1
Flow blockage, loose part damage.	Not stated	Not stated		Non-significant because Ni-alloys are not susceptible to thermal aging embrittlement	4-3 to 4-7	2

Table B.1 Gall Report for NUMARC Industry Reports

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Item	System	Structure/Comp	Subcomponent	Materials	Manufacturer	ARD mechanism	ARD effects
3	BWR Vessel Internals	Access Hole Cover	Not stated	Alloy 600	Not stated	CORR/IGSCC	Crack initiation & growth
4	BWR Vessel Internals	Access Hole Cover	Not stated	Alloy 600	Not stated	CORR/IASCC	Crack initiation & growth
5	BWR Vessel Internals	Access Hole Cover	Not stated	Alloy 600	Not stated	CORR	Loss of material
6	BWR Vessel Internals	Access Hole Cover	Not stated	Alloy 600	Not stated	ERO/CORR	Wall thinning, loss of material
7	BWR Vessel Internals	Access Hole Cover	Not stated	Alloy 600	Not stated	FAT	Cumulative fatigue damage
8	BWR Vessel Internals	Control Blade	Not stated	SS	Not stated	EMBR/IR	Loss of fracture toughness
9	BWR Vessel Internals	Control Blade	Not stated	SS	Not stated	EMBR/TE	Loss of fracture toughness
10	BWR Vessel Internals	Control Blade	Not stated	SS	Not stated	CORR/IGSCC	Crack initiation & growth
11	BWR Vessel Internals	Control Blade	Not stated	SS	Not stated	CORR/IASCC	Crack initiation & growth
12	BWR Vessel Internals	Control Blade	Not stated	SS	Not stated	CORR	Loss of material
13	BWR Vessel Internals	Control Blade	Not stated	SS	Not stated	ERO/CORR	Wall thinning, loss of material
14	BWR Vessel Internals	Control Blade	Not stated	SS	Not stated	FAT	Cumulative fatigue damage
15	BWR Vessel Internals	Core Plate	Not stated	SS	Not stated	EMBR/IR	Loss of fracture toughness
16	BWR Vessel Internals	Core Plate	Not stated	SS	Not stated	EMBR/TE	Loss of fracture toughness

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Effect of Aging on Component Function	Contrib to Failure	Reported progs	Rel.progs	Report Recommendations	Page No.	Item
Flow blockage, loose part damage.	Not stated	Recommendations of GESIL 462S1		GESIL 462S1 recommends volumetric inspections, implementation is plant-specific, & recommended repair is to attach reinforcement hardware	5-10, 5-12	3
Flow blockage, loose part damage.	Not stated	Not stated		Total fast neutron fluence within the license renewal term is non-significant because it is <5 x 10^20 n/ cm^2 for low stressed components & <10^20 n/ cm^2 for high-stressed components	4-14 to 4-20	4
Flow blockage, loose part damage.	Not stated	Not stated		Non-significant because corrosion rates are very low	4-21, 4-22	5
Flow blockage, loose part damage.	Not stated	Not stated		Non-significant because Ni-alloy are resistant to E/C, and/or low flow rate, and implementation of HWC which requires oxygen addition in the feedwater line to limit E/C	4-23, 4-24	6
Flow blockage, loose part damage.	Not stated	Nonsignificant because cyclic stresses are minimal or absent such that (More)		NRC recommendation: Not acceptable without detailed information. Evaluations based on ASME Sect. III, of all safety-related internal components should show a usage of <0.7 for the 60-yr lifetime of the plant	4-8 to 4-10	7
Impair reactor shutdown, loose part damage.	Not stated	Not stated		Non-significant because even though neutron irradiation decreases fracture toughness in SS components, the fracture toughness levels remain adequate even at end of life fluence levels because the applied stresses are low	4-3 to 4-7	8
Impair reactor shutdown, loose part damage.	Not stated	Not stated		Non-significant because wrought SS is not susceptible to thermal aging embrittlement	4-3 to 4-7	9
Impair reactor shutdown, loose part damage.	Not stated	Guidelines of GESIL 157 and operational parameters monitoring		GESIL 157 routine replacement, operational parameter monitoring are current & effective programs for detection & evaluation-replacement	5-10, 5-12	10
Impair reactor shutdown, loose part damage.	Not stated	Guidelines of GESIL 157 and operational parameters monitoring		GESIL 157 routine replacement, operational parameter monitoring are current & effective programs for detection & evaluation-replacement	5-10, 5-13	11
Impair reactor shutdown, loose part damage.	Not stated	Not stated		Non-significant because corrosion rates are very low	4-21, 4-22	12
Impair reactor shutdown, loose part damage.	Not stated	Not stated		Non-significant because SS is resistant to E/C, and/or low flow rate, and implementation of HWC which requires oxygen addition in the feedwater line to limit E/C	4-23, 4-24	13
Impair reactor shutdown, loose part damage.	Not stated	Non-significant because cyclic stresses are minimal or absent such that ASME (More)		NRC recommendation: Not acceptable without detailed information. Evaluations based on ASME Sect. III, of all safety-related internal components should show a usage of <0.7 for the 60-yr lifetime of the plant	4-8 to 4-10	14
Prevent CR insertion.	Not stated	Not stated		Non-significant because even though neutron irradiation decreases fracture toughness in SS components, the fracture toughness levels remain adequate even at end of life fluence levels because the applied stresses are low	4-3 to 4-7	15
Prevent CR insertion.	Not stated	Not stated		Non-significant because wrought SS is not susceptible to thermal aging embrittlement	4-3 to 4-7	16

Document: IR 90-03, BWR Vessel Internals Industry Report
Reviewed by: O. Chopra/D. Gavenda, ANL

Item	System	Structure/Comp	Subcomponent	Materials	Manufacturer	ARD mechanism	ARD effects
17	BWR Vessel Internals	Core Plate	Not stated	SS	Not stated	CORR/IGSCC	Crack initiation & growth
18	BWR Vessel Internals	Core Plate	Not stated	SS	Not stated	CORR/IASCC	Crack initiation & growth
19	BWR Vessel Internals	Core Plate	Not stated	SS	Not stated	CORR	Loss of material
20	BWR Vessel Internals	Core Plate	Not stated	SS	Not stated	ERO/CORR	Wall thinning, loss of material
21	BWR Vessel Internals	Core Plate	Not stated	SS	Not stated	FAT	Cumulative fatigue damage
22	BWR Vessel Internals	Core Shroud & Top Guide	Not stated	SS	Not stated	EMBR/IR	Loss of fracture toughness
23	BWR Vessel Internals	Core Shroud & Top Guide	Not stated	SS	Not stated	EMBR/TE	Loss of fracture toughness
24	BWR Vessel Internals	Core Shroud & Top Guide	Not stated	SS	Not stated	CORR/IGSCC	Crack initiation & growth
25	BWR Vessel Internals	Core Shroud & Top Guide	Not stated	SS	Not stated	CORR/IASCC	Crack initiation & growth
26	BWR Vessel Internals	Core Shroud & Top Guide	Not stated	SS	Not stated	CORR	Loss of material
27	BWR Vessel Internals	Core Shroud & Top Guide	Not stated	SS	Not stated	ERO/CORR	Wall thinning, loss of material
28	BWR Vessel Internals	Core Shroud & Top Guide	Not stated	SS	Not stated	FAT	Cumulative fatigue damage
29	BWR Vessel Internals	Core Shroud Head Bolts	Not stated	SS, Alloy 600	Not stated	EMBR/IR	Loss of fracture toughness

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Effect of Aging on Component Function	Contrib to Failure	Reported progs	Rel.progs	Report Recommendations	Page No.	Item
Prevent CR insertion.	Not stated	Enhance current practices by selecting plant-specific management comprising (More)		This item was not the subject of the NRC review.	5-10, 5-14	17
Prevent CR insertion.	Not stated	Not stated		Non-significant for low-alloy steels subjected to neutron fluences typical of BWR vessel; & for Ni alloys because total fluence is <10^20 or <5*10^20 n/cm^2, for components subjected to high or low stresses.	4-14 to 4-20	18
Prevent CR insertion.	Not stated	Not stated		Non-significant because corrosion rates are very low	4-21, 4-22	19
Prevent CR insertion.	Not stated	Not stated		Non-significant because SS is resistant to E/C, and/or low flow rate, and implementation of HWC which requires oxygen addition in the feedwater line to limit E/C	4-23, 4-24	20
Prevent CR insertion.	Not stated	Non-significant because cyclic stresses are minimal or absent such that ASME (More)		NRC recommendation: Not acceptable without detailed information. Evaluations based on ASME Sect. III, of all safety-related internal components should show a usage of <0.7 for the 60-yr lifetime of the plant	4-8 to 4-10	21
Core support loss, prevent CR insertion.	Not stated	Not stated		Non-significant because even though neutron irradiation decreases fracture toughness in SS components, the fracture toughness levels remain adequate even at end of life fluence levels because the applied stresses are low	4-3 to 4-7	22
Core support loss, prevent CR insertion.	Not stated	Not stated		Non-significant because wrought SS is not susceptible to thermal aging embrittlement	4-3 to 4-7	23
Core support loss, prevent CR insertion.	Not stated	Enhance current practices by selecting plant-specific management comprising (More)		This item was not the subject of the NRC review.	5-10, 5-14, 5-21	24
Core support loss, prevent CR insertion.	Not stated	Enhance current practices by selecting plant-specific aging management plan; (More)		This item was not the subject of the NRC review.	5-10, 5-14, 5-21	25
Core support loss, prevent CR insertion.	Not stated	Not stated		Non-significant because corrosion rates are very low	4-21, 4-22	26
Core support loss, prevent CR insertion.	Not stated	Not stated		Non-significant because SS is resistant to E/C, and/or low flow rate, and implementation of HWC which requires oxygen addition in the feedwater line to limit E/C	4-23, 4-24	27
Core support loss, prevent CR insertion.	Not stated	Non-significant because cyclic stresses are minimal or absent such that ASME (More)		NRC recommendation: Not acceptable without detailed information. Evaluations based on ASME Sect. III, of all safety-related internal components should show a usage of <0.7 for the 60-yr lifetime of the plant	4-8 to 4-10	28
Damage by shroud head, loss of ECC.	Not stated	Not stated		Non-significant because even though neutron irradiation decreases fracture toughness in SS and Ni-alloy components, the fracture toughness levels remain adequate even at end of life fluence levels because the applied stresses are low	4-3 to 4-7	29

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Item	System	Structure/Comp	Subcomponent	Materials	Manufacturer	ARD mechanism	ARD effects
30	BWR Vessel Internals	Core Shroud Head Bolts	Not stated	SS, Alloy 600	Not stated	EMBR/TE	Loss of fracture toughness
31	BWR Vessel Internals	Core Shroud Head Bolts	Not stated	SS, Alloy 600	Not stated	CORR/IGSCC	Crack initiation & growth
32	BWR Vessel Internals	Core Shroud Head Bolts	Not stated	SS, Alloy 600	Not stated	CORR/IASCC	Crack initiation & growth
33	BWR Vessel Internals	Core Shroud Head Bolts	Not stated	SS, Alloy 600	Not stated	CORR	Loss of material
34	BWR Vessel Internals	Core Shroud Head Bolts	Not stated	SS, Alloy 600	Not stated	ERO/CORR	Wall thinning, loss of material
35	BWR Vessel Internals	Core Shroud Head Bolts	Not stated	SS, Alloy 600	Not stated	FAT	Cumulative fatigue damage
36	BWR Vessel Internals	Core Spray Interanl Piping	Not stated	SS	Not stated	EMBR/IR	Loss of fracture toughness
37	BWR Vessel Internals	Core Spray Internal Piping	Not stated	SS	Not stated	EMBR/TE	Loss of fracture toughness
38	BWR Vessel Internals	Core Spray Internal Piping	Not stated	SS	Not stated	CORR/IGSCC	Crack initiation & growth
39	BWR Vessel Internals	Core Spray Internal Piping	Not stated	SS	Not stated	CORR/IASCC	Crack initiation & growth
40	BWR Vessel Internals	Core Spray Internal Piping	Not stated	SS	Not stated	CORR	Loss of material
41	BWR Vessel Internals	Core Spray Internal Piping	Not stated	SS	Not stated	ERO/CORR	Wall thinning, loss of material
42	BWR Vessel Internals	Core Spray Internal Piping	Not stated	SS	Not stated	FAT	Cumulative fatigue damage

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Effect of Aging on Component Function	Contrib to Failure	Reported progs	Rel.progs	Report Recommendations	Page No.	Item
Damage by shroud head, loss of ECC.	Not stated	Not stated		Non-significant because wrought SS & Ni-alloys are not susceptible to thermal aging embrittlement	4-3 to 4-7	30
Damage by shroud head, loss of ECC.	Not stated	Implementation of GESIL 433		GESIL 433 recommends UT examination during outages, implementation is plant-specific, & replacement is with crevice-free design	5-10, 5-15	31
Damage by shroud head, loss of ECC.	Not stated	Not stated		Total fast neutron fluence within the license renewal term is non-significant because it is <5 x 10^20 n/ cm^2 for low stressed components & <10^20 n/cm^2 for high-stressed components	4-14 to 4-20	32
Damage by shroud head, loss of ECC.	Not stated	Not stated		Non-significant because corrosion rates are very low	4-21, 4-22	33
Damage by shroud head, loss of ECC.	Not stated	Not stated		Non-significant because SS and Ni-alloys are resistant to E/C, and/or low flow rate, and implementation of HWC which requires oxygen addition in the feedwater line to limit E/C	4-23, 4-24	34
Damage by shroud head, loss of ECC.	Not stated	Non-significant because cyclic stresses are minimal or absent such that ASME (More)		NRC recommendation: Not acceptable without detailed information. Evaluations based on ASME Sect. III, of all safety-related internal components should show a usage of <0.7 for the 60-yr lifetime of the plant	4-8 to 4-10	35
Loss of ECC.	Not stated	Not stated		Non-significant because even though neutron irradiation decreases fracture toughness in SS components, the fracture toughness levels remain adequate even at end of life fluence levels because the applied stresses are low	4-3 to 4-7	36
Loss of ECC.	Not stated	Not stated		Non-significant because wrought SS is not susceptible to thermal aging embrittlement	4-3 to 4-7	37
Loss of ECC.	Not stated	Enhance current practices by selecting plant-specific management comprising (More)		This item was not the subject of the NRC review.	5-10, 5-16, 5-17	38
Loss of ECC.	Not stated	Not stated		Total fast neutron fluence within the license renewal term is non-significant because it is <5 x 10^20 n/ cm^2 for low stressed components & <10^20 n/cm^2 for high-stressed components	4-14 to 4-20	39
Loss of ECC.	Not stated	Not stated		Non-significant because corrosion rates are very low	4-21, 4-22	40
Loss of ECC.	Not stated	Not stated		Non-significant because SS is resistant to E/C, and/or low flow rate, and implementation of HWC which requires oxygen addition in the feedwater line to limit E/C	4-23, 4-24	41
Loss of ECC.	Not stated	Non-significant because cyclic stresses are minimal or absent such that ASME (More)		NRC recommendation: Not acceptable without detailed information. Evaluations based on ASME Sect. III, of all safety-related internal components should show a usage of <0.7 for the 60-yr lifetime of the plant	4-8 to 4-10	42

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Item	System	Structure/Comp	Subcomponent	Materials	Manufacturer	ARD mechanism	ARD effects
43	BWR Vessel Internals	Core Spray Sparger	Not stated	SS	Not stated	EMBR/IR	Loss of fracture toughness
44	BWR Vessel Internals	Core Spray Sparger	Not stated	SS	Not stated	EMBR/TE	Loss of fracture toughness
45	BWR Vessel Internals	Core Spray Sparger	Not stated	SS	Not stated	CORR/IGSCC	Crack initiation & growth
46	BWR Vessel Internals	Core Spray Sparger	Not stated	SS	Not stated	CORR/IASCC	Crack initiation & growth
47	BWR Vessel Internals	Core Spray Sparger	Not stated	SS	Not stated	CORR	Loss of material
48	BWR Vessel Internals	Core Spray Sparger	Not stated	SS	Not stated	ERO/CORR	Wall thinning, loss of material
49	BWR Vessel Internals	Core Spray Sparger	Not stated	SS	Not stated	FAT	Cumulative fatigue damage
50	BWR Vessel Internals	Control Rod Drive (CRD) Housing	Not stated	SS	Not stated	EMBR/IR	Loss of fracture toughness
51	BWR Vessel Internals	Control Rod Drive (CRD) Housing	Not stated	SS	Not stated	EMBR/TE	Loss of fracture toughness
52	BWR Vessel Internals	Control Rod Drive (CRD) Housing	Not stated	SS	Not stated	CORR/IGSCC	Crack initiation & growth
53	BWR Vessel Internals	Control Rod Drive (CRD) Housing	Not stated	SS	Not stated	CORR/IASCC	Crack initiation & growth
54	BWR Vessel Internals	Control Rod Drive (CRD) Housing	Not stated	SS	Not stated	CORR	Loss of material
55	BWR Vessel Internals	Control Rod Drive (CRD) Housing	Not stated	SS	Not stated	ERO/CORR	Wall thinning, loss of material
56	BWR Vessel Internals	Control Rod Drive (CRD) Housing	Not stated	SS	Not stated	FAT	Cumulative fatigue damage

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Effect of Aging on Component Function	Contrib to Failure	Reported progs	Rel.progs	Report Recommendations	Page No.	Item
Loss of ECC.	Not stated	Not stated		Non-significant because even though neutron irradiation decreases fracture toughness in SS components, the fracture toughness levels remain adequate even at end of life fluence levels because the applied stresses are low	4-3 to 4-7	43
Loss of ECC.	Not stated	Not stated		Non-significant because wrought SS is not susceptible to thermal aging embrittlement	4-3 to 4-7	44
Loss of ECC.	Not stated	Recommendations of NRC Bulletin 80-13		NRC Bulletin 80-13 recommends visual inspection during refueling outages; analytical evaluation; & repair	5-10, 5-17	45
Loss of ECC.	Not stated	Not stated		Total fast neutron fluence within the license renewal term is non-significant because it is <5 x 10^20 n/cm^2 for low stressed components & <10^20 n/ cm^2 for high-stressed components	4-14 to 4-20	46
Loss of ECC.	Not stated	Not stated		Non-significant because corrosion rates are very low	4-21, 4-22	47
Loss of ECC.	Not stated	Not stated		Non-significant because SS is resistant to E/C, and/or low flow rate, and implementation of HWC which requires oxygen addition in the feedwater line to limit E/C	4-23, 4-24	48
Loss of ECC.	Not stated	Non-significant because cyclic stresses are minimal or absent such that ASME (More)		NRC recommendation: Not acceptable without detailed information. Evaluations based on ASME Sect. III, of all safety-related internal components should show a usage of <0.7 for the 60-yr lifetime of the plant	4-8 to 4-10	49
Loss of pressure boundary, prevent CR insertion.	Not stated	Not stated		Non-significant because even though neutron irradiation decreases fracture toughness in SS components, the fracture toughness levels remain adequate even at end of life fluence levels because the applied stresses are low	4-3 to 4-7	50
Loss of pressure boundary, prevent CR insertion.	Not stated	Not stated		Non-significant because wrought SS is not susceptible to thermal aging embrittlement	4-3 to 4-7	51
Loss of pressure boundary, prevent CR insertion.	Not stated	ASME Sect. XI, Subsect. IWB		ASME Sect. XI, Subsect. IWB, exam. categories B-O & B-P requires volumetric exam. of welds & VT-2 of pressure retaining boundary & system leakage & hydrostatic tests	5-10, 5-18	52
Loss of pressure boundary, prevent CR insertion.	Not stated	Not stated		Total fast neutron fluence within the license renewal term is non-significant because it is <5 x 10^20 n/ cm^2 for low stressed components & <10^20 n/ cm^2 for high-stressed components	4-14 to 4-20	53
Loss of pressure boundary, prevent CR insertion.	Not stated	Not stated		Non-significant because corrosion rates are very low	4-21, 4-22	54
Loss of pressure boundary, prevent CR insertion.	Not stated	Not stated		Non-significant because SS is resistant to E/C, and/or low flow rate, and implementation of HWC which requires oxygen addition in the feedwater line to limit E/C	4-23, 4-24	55
Loss of pressure boundary, prevent CR insertion.	Not stated	ASME Sect. XI, Subsect. IWB & recommendations of NP-5181M & NP-5836M		NRC recommendation: Not acceptable without detailed information. Evaluations based on ASME Sect. III, of all safety-related internal components should show a usage of <0.7 for the 60-yr lifetime of the plant	5-4 to 5-10	56

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Item	System	Structure/Comp	Subcomponent	Materials	Manufacturer	ARD mechanism	ARD effects
57	BWR Vessel Internals	Intermediate Range Monitor/ Source Range Monitor(IRM/SRM) Dry Tubes	Not stated	SS	Not stated	EMBR/IR	Loss of fracture toughness
58	BWR Vessel Internals	Intermediate Range Monitor/ Source Range Monitor(IRM/SRM) Dry Tubes	Not stated	SS	Not stated	EMBR/TE	Loss of fracture toughness
59	BWR Vessel Internals	Intermediate Range Monitor/ Source Range Monitor(IRM/SRM) Dry Tubes	Not stated	SS	Not stated	CORR/IGSCC	Crack initiation & growth
60	BWR Vessel Internals	Intermediate Range Monitor/ Source Range Monitor(IRM/SRM) Dry Tubes	Not stated	SS	Not stated	CORR/IASCC	Crack initiation & growth
61	BWR Vessel Internals	Intermediate Range Monitor/ Source Range Monitor(IRM/SRM) Dry Tubes	Not stated	SS	Not stated	CORR	Loss of material
62	BWR Vessel Internals	Intermediate Range Monitor/ Source Range Monitor(IRM/SRM) Dry Tubes	Not stated	SS	Not stated	ERO/CORR	Wall thinning, loss of material
63	BWR Vessel Internals	Intermediate Range Monitor/ Source Range Monitor(IRM/SRM) Dry Tubes	Not stated	SS	Not stated	FAT	Cumulative fatigue damage
64	BWR Vessel Internals	Jet Pump	Not stated	SS, (CASS), Alloy 600, X750	Not stated	EMBR/IR	Loss of fracture toughness
65	BWR Vessel Internals	Jet Pump	Not stated	SS, (CASS), Alloy 600, X750	Not stated	EMBR/TE	Loss of fracture toughness
66	BWR Vessel Internals	Jet Pump	Not stated	SS, (CASS), Alloy 600, X750	Not stated	CORR/IGSCC	Crack initiation & growth
67	BWR Vessel Internals	Jet Pump	Not stated	SS, (CASS), Alloy 600, X750	Not stated	CORR/IASCC	Crack initiation & growth
68	BWR Vessel Internals	Jet Pump	Not stated	SS, (CASS), Alloy 600, X750	Not stated	CORR	Loss of material

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Effect of Aging on Component Function	Contrib to Failure	Reported progs	Rel.progs	Report Recommendations	Page No.	Item
Loss of pressure boundary.	Not stated	Not stated		Non-significant because even though neutron irradiation decreases fracture toughness in SS components, the fracture toughness levels remain adequate even at end of life fluence levels because the applied stresses are low	4-3 to 4-7	57
Loss of pressure boundary.	Not stated	Not stated		Non-significant because wrought SS is not susceptible to thermal aging embrittlement	4-3 to 4-7	58
Loss of pressure boundary.	Not stated	Recommendations of GESIL 409		Recommendations of GESIL 409, leakage monitoring, & replacement with crevice-free design and resistant material	5-10, 5-19	59
Loss of pressure boundary.	Not stated	Recommendations of GESIL 409		Recommendations of GESIL 409, leakage monitoring, & replacement with crevice-free design and resistant material	5-10, 5-19	60
Loss of pressure boundary.	Not stated	Not stated		Non-significant because corrosion rates are very low	4-21, 4-22	61
Loss of pressure boundary.	Not stated	Not stated		Non-significant because SS is resistant to E/C, and/or low flow rate, and implementation of HWC which requires oxygen addition in the feedwater line to limit E/C	4-23, 4-24	62
Loss of pressure boundary.	Not stated	Non-significant because cyclic stresses are minimal or absent such that ASME (More)		NRC recommendation: Not acceptable without detailed information. Evaluations based on ASME Sect. III, of all safety-related internal components should show a usage of <0.7 for the 60-yr lifetime of the plant	4-8 to 4-10	63
Loose part damage.	Not stated	Not stated		Non-significant because even though neutron irradiation decreases fracture toughness in SS and Ni-alloy components, the fracture toughness levels remain adequate even at end of life fluence levels because the applied stresses are low	4-3 to 4-7	64
Loose part damage.	Not stated	Not stated		Non-significant because wrought SS & Ni-alloys are not susceptible to thermal aging embrittlement; CASS components are not subjected to stress levels of sufficient magnitude	4-3 to 4-7	65
Loose part damage.	Not stated	Periodic inspection, monitoring pump performance by plant instrumentation, (More)		NRC recommendation: Evaluate possible adverse effect of HWC on Ni-alloys	5-10, 5-20, 5-21	66
Loose part damage.	Not stated	Not stated		Total fast neutron fluence within the license renewal term is non-significant because it is <5 x 10^20 n/ cm^2 for low stressed components & <10^20 n/ cm^2 for high-stressed components	4-14 to 4-20	67
Loose part damage.	Not stated	Not stated		Non-significant because corrosion rates are very low	4-21, 4-22	68

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Item	System	Structure/Comp	Subcomponent	Materials	Manufacturer	ARD mechanism	ARD effects
69	BWR Vessel Internals	Jet Pump	Not stated	SS, (CASS), Alloy 600, X750	Not stated	ERO/CORR	Wall thinning, loss of material
70	BWR Vessel Internals	Jet Pump	Not stated	SS, (CASS), Alloy 600, X750	Not stated	FAT	Cumulative fatigue damage
71	BWR Vessel Internals	Low Power Range Monitor (LPRM)	Not stated	SS	Not stated	EMBR/IR	Loss of fracture toughness
72	BWR Vessel Internals	Low Power Range Monitor (LPRM)	Not stated	SS	Not stated	EMBR/TE	Loss of fracture toughness
73	BWR Vessel Internals	Low Power Range Monitor (LPRM)	Not stated	SS	Not stated	CORR/IGSCC	Crack initiation & growth
74	BWR Vessel Internals	Low Power Range Monitor (LPRM)	Not stated	SS	Not stated	CORR/IASCC	Crack initiation & growth
75	BWR Vessel Internals	Low Power Range Monitor (LPRM)	Not stated	SS	Not stated	CORR	Loss of material
76	BWR Vessel Internals	Low Power Range Monitor (LPRM)	Not stated	SS	Not stated	ERO/CORR	Wall thinning, loss of material
77	BWR Vessel Internals	Low Power Range Monitor (LPRM)	Not stated	SS	Not stated	FAT	Cumulative fatigue damage
78	BWR Vessel Internals	Orificed Fuel Support	Not stated	SS,CASS	Not stated	EMBR/IR	Loss of fracture toughness
79	BWR Vessel Internals	Orificed Fuel Support	Not stated	SS,CASS	Not stated	EMBR/TE	Loss of fracture toughness
80	BWR Vessel Internals	Orificed Fuel Support	Not stated	SS,CASS	Not stated	CORR/IGSCC	Crack initiation & growth
81	BWR Vessel Internals	Orificed Fuel Support	Not stated	SS,CASS	Not stated	CORR/IASCC	Crack initiation & growth
82	BWR Vessel Internals	Orificed Fuel Support	Not stated	SS,CASS	Not stated	CORR	Loss of material

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Loose part damage.	Not stated	Not stated		Non-significant because SS & Ni-alloys are resistant to E/C, and/or low flow rate, and implementation of HWC which requires oxygen addition in the feedwater line to limit E/C	4-23, 4-24	69
Loose part damage.	Not stated	Periodic inspection, monitoring pump performance by plant instrumentation, (More)		NRC recommendation: Not acceptable without detailed information. Evaluations based on ASME Sect. III, of all safety-related internal components should show a usage of <0.7 for the 60-yr lifetime of the plant	5-4 to 5-10	70
Loss of pressure boundary.	Not stated	Not stated		Non-significant because even though neutron irradiation decreases fracture toughness in SS components, the fracture toughness levels remain adequate even at end of life fluence levels because the applied stresses are low	4-3 to4-7	71
Loss of pressure boundary.	Not stated	Not stated		Non-significant because wrought SS is not susceptible to thermal aging embrittlement	4-3 to 4-7	72
Loss of pressure boundary.	Not stated	Non-significant because LPRMs are replaced due to limited operating life		NRC recommendation: Demonstrate how LPRMs can be qualified in view of Millstone Unit 1 experience	4-11 to 4-20	73
Loss of pressure boundary.	Not stated	Not stated		Total fast neutron fluence within the license renewal term is non-significant because it is <5 x 10^20 n/ cm^2 for low stressed components & <10^20 n/ cm^2 for high-stressed components	4-14 to 4-20	74
Loss of pressure boundary.	Not stated	Not stated		Non-significant because corrosion rates are very low	4-21, 4-22	75
Loss of pressure boundary.	Not stated	Not stated		Non-significant because SS is resistant to E/C, and/or low flow rate, and implementation of HWC which requires oxygen addition in the feedwater line to limit E/C	4-23, 4-24	76
Loss of pressure boundary.	Not stated	Non-significant because LPRMs are replaced due to limited operating life		NRC recommendation: Not acceptable without detailed information. Evaluations based on ASME Sect. III, of all safety-related internal components should show a usage of <0.7 for the 60-yr lifetime of the plant	4-8 to 4-10	77
Flow blockage, loose part damage.	Not stated	Not stated		Non-significant because even though neutron irradiation decreases fracture toughness in SS components, the fracture toughness levels remain adequate even at end of life fluence levels because the applied stresses are low	4-3 to 4-7	78
Flow blockage, loose part damage.	Not stated	Not stated		Non-significant because wrought SS is not susceptible to thermal aging embrittlement; CASS components are not subjected to stress levels of sufficient magnitude	4-3 to4-7	79
Flow blockage, loose part damage.	Not stated	Not stated		Non-significant because made of CASS, and/or subjected to low stresses	4-11 to 4-20	80
Flow blockage, loose part damage.	Not stated	Not stated		Non-significant for low-alloy steels subjected to neutron fluences typical of BWR vessel; & for Ni alloys because total fluence is <10^20 or <5*10^20 n/cm^2, for components subjected to high or low stresses.	4-14 to 4-20	81
Flow blockage, loose part damage.	Not stated	Not stated		Non-significant because corrosion rates are very low	4-21, 4-22	82

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Item	System	Structure/Comp	Subcomponent	Materials	Manufacturer	ARD mechanism	ARD effects
83	BWR Vessel Internals	Orificed Fuel Support	Not stated	SS,CASS	Not stated	ERO/CORR	Wall thinning, loss of material
84	BWR Vessel Internals	Orificed Fuel Support	Not stated	SS,CASS	Not stated	FAT	Cumulative fatigue damage

Document: IR 90-04, PWR Pressure Vessel Industry Report
Reviewed by: Omesh K. Chopra, ANL

Item	System	Structure/Comp	Subcomponent	Materials	Manufacturer	ARD mechanism	ARD effects
1	PWR Pressure Vessel	Closure Head	Dome	SA302-Gr B, SA533-Gr B	Not stated	EMBR/IR	Loss of fracture toughness
2	PWR Pressure Vessel	Closure Head	Dome	SA302-Gr B, SA533-Gr B	Not stated	CORR/IGSCCUnresolved	Crack initiation & growth
3	PWR Pressure Vessel	Closure Head	Dome	SA302-Gr B, SA533-Gr B	Not stated	CORR	Loss of material, corrosion product buildup
4	PWR Pressure Vessel	Closure Head	Dome	SA302-Gr B, SA533-Gr B	Not stated	CORR/BA	Loss of material
5	PWR Pressure Vessel	Closure Head	Dome	SA302-Gr B, SA533-Gr B	Not stated	ERO/CORR	Wall thinning, loss of material
6	PWR Pressure Vessel	Closure Head	Dome	SA302-Gr B, SA533-Gr B	Not stated	WEAR	Fretting
7	PWR Pressure Vessel	Closure Head	Dome	SA302-Gr B, SA533-Gr B	Not stated	CREEP	Change in dimension
8	PWR Pressure Vessel	Closure Head	Dome	SA302-Gr B, SA533-Gr B	Not stated	EMBR/TE	Loss of fracture toughness
9	PWR Pressure Vessel	Closure Head	Dome	SA302-Gr B, SA533-Gr B	Not stated	FATUnresolved	Cumulative fatigue damage
10	PWR Pressure Vessel	Closure Head	Flange	SA336, SA508	Not stated	EMBR/IR	Loss of fracture toughness
11	PWR Pressure Vessel	Closure Head	Flange	SA336, SA508	Not stated	CORR/IGSCCUnresolved	Crack initiation & growth
12	PWR Pressure Vessel	Closure Head	Flange	SA336, SA508	Not stated	CORR	Loss of material, corrosion product buildup

Table B.1 Gall Report for NUMARC Industry Reports

Document: IR 90-03, BWR Vessel Internals Industry Report
Reviewed by: O. Chopra/D. Gavenda, ANL

Effect of Aging on Component Function	Contrib to Failure	Reported progs	Rel.progs	Report Recommendations	Page No.	Item
Flow blockage, loose part damage.	Not stated	Not stated		Non-significant because SS is resistant to E/C, and/or low flow rate, and implementation of HWC which requires oxygen addition in the feedwater line to limit E/C	4-23, 4-24	83
Flow blockage, loose part damage.	Not stated	Non-significant because cyclic stresses are minimal or absent such that ASME (More)		NRC recommendation: Not acceptable without detailed information. Evaluations based on ASME Sect. III, of all safety-related internal components should show a usage of <0.7 for the 60-yr lifetime of the plant	4-8 to 4-10	84

Document: IR 90-04, PWR Pressure Vessel Industry Report
Reviewed by: Omesh K. Chopra, ANL

Effect of Aging on Component Function	Contrib to Failure	Reported progs	Rel.progs	Report Recommendations	Page No.	Item
Loss of pressure boundary.	Not stated	Not stated		Non-significant because neutron fluence is low & is <10^17 n/cm^2 the level above which a surveillance program is required in Appendix H of 10CFR 50	4-2 to4-6	1
Loss of pressure boundary.	Not stated	Non-significant because LAS & SS cladding (>5% ferrite) are not susceptible (More)		NRC recommendation: Low-temperature sensitization of SS cladding is possible. Evaluate the effects of oxygen injection during cooldown. SCC of low alloy steel is unlikely in typical PWR environment, it may not be true under crevice conditions.	4-11 to 4-18	2
Loss of pressure boundary.	Not stated	Not stated		Non significant because cladding is resistant to CORR, removal of cladding results in very low corrosion rates	4-21 to 4-24	3
Loss of pressure boundary.	Not stated	Implementation of Generic Letter 88 05		Recommendations of Generic Letter 88 05 are current & effective program to monitor & control primary coolant leakage	5-22 to 5-24	4
Loss of pressure boundary.	Not stated	Not stated		Non significant because SS or Ni alloy cladding are resistant to ERO/CORR, single phase & low flow, & control of water chemistry	4-25	5
Loss of pressure boundary.	Not stated	Not stated		Non significant because not subject to relative motion	4-26, 4-27	6
Loss of pressure boundary.	Not stated	Not stated		Non significant because operating temp. <427 C (<800 F)	4-20	7
Loss of pressure boundary.	Not stated	Not stated		Non significant because of proper material selection & relatively low operating temp.	4-18 to 4-20	8
Loss of pressure boundary.	Not stated	Fatigue usage factor is anticipated to be <1 for entire license renewal term		NRC recommendation: Until an agreement is reached on the draft staff discussion paper on fatigue, the issue is unresolved	4-7 to 4-11	9
Loss of pressure boundary.	Not stated	Not stated		Non significant because neutron fluence is low & is <10^17 n/cm^2 the level above which a surveillance program is required in Appendix H of 10CFR 50	4-2 to 4-6	10
Loss of pressure boundary.	Not stated	Non significant because LAS & SS cladding (>5% ferrite) are not susceptible (More)		NRC recommendation: Low-temperature sensitization of SS cladding is possible. Evaluate the effects of oxygen injection during cooldown. SCC of low alloy steel is unlikely in typical PWR environment, it may not be true under crevice conditions.	4-11 to 4-18	11
Loss of pressure boundary.	Not stated	Not stated		Non significant because cladding is resistant to CORR, removal of cladding results in very low corrosion rates	4-21 to 4-24	12

Table B.1 Gall Report for NUMARC Industry Reports

Document: IR 90-04, PWR Pressure Vessel Industry Report
Reviewed by: Omesh K. Chopra, ANL

Item	System	Structure/Comp	Subcomponent	Materials	Manufacturer	ARD mechanism	ARD effects
13	PWR Pressure Vessel	Closure Head	Flange	SA336, SA508	Not stated	CORR/BA	Loss of material
14	PWR Pressure Vessel	Closure Head	Flange	SA336, SA508	Not stated	ERO/CORR	Wall thinning, loss of material
15	PWR Pressure Vessel	Closure Head	Flange	SA336, SA508	Not stated	WEAR	Fretting
16	PWR Pressure Vessel	Closure Head	Flange	SA336, SA508	Not stated	CREEP	Change in dimension
17	PWR Pressure Vessel	Closure Head	Flange	SA336, SA508	Not stated	EMBR/TE	Loss of fracture toughness
18	PWR Pressure Vessel	Closure Head	Flange	SA336, SA508	Not stated	FATUnresolved	Cumulative fatigue damage
19	PWR Pressure Vessel	Closure Head	Lifting Lugs	SA302 Gr B, SA533 Gr B	Not stated	EMBR/IR	Loss of fracture toughness
20	PWR Pressure Vessel	Closure Head	Lifting Lugs	SA302 Gr B, SA533 Gr B	Not stated	CORR/IGSCC	Crack initiation & growth
21	PWR Pressure Vessel	Closure Head	Lifting Lugs	SA302 Gr B, SA533 Gr B	Not stated	CORR	Loss of material
22	PWR Pressure Vessel	Closure Head	Lifting Lugs	SA302 Gr B, SA533 Gr B	Not stated	CORR/BA	Loss of material
23	PWR Pressure Vessel	Closure Head	Lifting Lugs	SA302 Gr B, SA533 Gr B	Not stated	ERO/CORR	Wall thinning, loss of material
24	PWR Pressure Vessel	Closure Head	Lifting Lugs	SA302 Gr B, SA533 Gr B	Not stated	WEAR	Fretting
25	PWR Pressure Vessel	Closure Head	Lifting Lugs	SA302 Gr B, SA533 Gr B	Not stated	CREEP	Change in dimension
26	PWR Pressure Vessel	Closure Head	Lifting Lugs	SA302 Gr B, SA533 Gr B	Not stated	EMBR/TE	Loss of fracture toughness
27	PWR Pressure Vessel	Closure Head	Lifting Lugs	SA302 Gr B, SA533 Gr B	Not stated	FATUnresolved	Cumulative fatigue damage
28	PWR Pressure Vessel	Shroud Support Ring	Not stated	SA212 Gr B, SA516 Gr 70	Not stated	EMBR/IR	Loss of fracture toughness
29	PWR Pressure Vessel	Shroud Support Ring	Not stated	SA212 Gr B, SA516 Gr 70	Not stated	CORR/IGSCC	Crack initiation & growth
30	PWR Pressure Vessel	Shroud Support Ring	Not stated	SA212 Gr B, SA516 Gr 70	Not stated	CORR	Loss of material
31	PWR Pressure Vessel	Shroud Support Ring	Not stated	SA212 Gr B, SA516 Gr 70	Not stated	CORR/BA	Loss of material
32	PWR Pressure Vessel	Shroud Support Ring	Not stated	SA212 Gr B, SA516 Gr 70	Not stated	ERO/CORR	Wall thinning, loss of material
33	PWR Pressure Vessel	Shroud Support Ring	Not stated	SA212 Gr B, SA516 Gr 70	Not stated	WEAR	Fretting
34	PWR Pressure Vessel	Shroud Support Ring	Not stated	SA212 Gr B, SA516 Gr 70	Not stated	CREEP	Change in dimension
35	PWR Pressure Vessel	Shroud Support Ring	Not stated	SA212 Gr B, SA516 Gr 70	Not stated	EMBR/TE	Loss of fracture toughness

Table B.1 Gall Report for NUMARC Industry Reports

Document: IR 90-04, PWR Pressure Vessel Industry Report
Reviewed by: Omesh K. Chopra, ANL

Effect of Aging on Component Function	Contrib to Failure	Reported progs	Rel.progs	Report Recommendations	Page No.	Item
Loss of pressure boundary.	Not stated	Implementation of Generic Letter 88 05		Recommendations of Generic Letter 88 05 are current & effective program to monitor & control primary coolant leakage	5-22 to 5-24	13
Loss of pressure boundary.	Not stated	ASME Sect. XI, Subsect. IWB		ASME Sect. XI, Subsect. IWB, examination category B P is current & effective program to manage effects of ERO/CORR	5-24, 5-25	14
Loss of pressure boundary.	Not stated	ASME Sect. XI, Subsect. IWB		ASME Sect. XI, Subsect. IWB, examination category B P is current & effective program to manage effects of WEAR	5-25, 5-26	15
Loss of pressure boundary.	Not stated	Not stated		Non significant because operating temp. <427 C (<800 F)	4-20	16
Loss of pressure boundary.	Not stated	Not stated		Non significant because of proper material selection & relatively low operating temp.	4-18 to 4-20	17
Loss of pressure boundary.	Not stated	Fatigue usage factor is anticipated to be <1 for entire license renewal term		NRC recommendation: Until an agreement is reached on the draft staff discussion paper on fatigue, the issue is unresolved	4-7 to 4-11	18
Damage to reactor vessel & internals.	Not stated	Not stated		Non significant because neutron fluence is low & is <10^17 n/cm^2 the level above which a surveillance program is required in Appendix H of 10CFR 50	4-2 to 4-6	19
Damage to reactor vessel & internals.	Not stated	Not stated		Non significant because not subjected to corrosive environment	4-11 -18	20
Damage to reactor vessel & internals.	Not stated	Not stated		Non significant because not subjected to corrosive environment	4-21 -24	21
Damage to reactor vessel & internals.	Not stated	Not stated		Not susceptible to potential boric acid leak	4-21 -24	22
Damage to reactor vessel & internals.	Not stated	Not stated		Non significant because not in contact with coolant environment	4-25	23
Damage to reactor vessel & internals.	Not stated	Not stated		Non significant because not subject to relative motion	4-26, 4-27	24
Damage to reactor vessel & internals.	Not stated	Not stated		Non significant because operating temp. <427 C (<800 F)	4-20	25
Damage to reactor vessel & internals.	Not stated	Not stated		Non significant because of proper material selection & relatively low operating temp.	4-18 to 4-20	26
Damage to reactor vessel & internals.	Not stated	Fatigue usage factor is anticipated to be <1 for entire license renewal term		NRC recommendation: Until an agreement is reached on the draft staff discussion paper on fatigue, the issue is unresolved	4-7 to 4-11	27
Prevent control rod insertion.	Not stated	Not stated		Non significant because neutron fluence is low & is <10^17 n/cm^2 the level above which a surveillance program is required in Appendix H of 10CFR 50	4-2 to 4-6	28
Prevent control rod insertion.	Not stated	Not stated		Non significant because not subjected to corrosive environment	4-11 -18	29
Prevent control rod insertion.	Not stated	Not stated		Non significant because not subjected to corrosive environment	4-21 -24	30
Prevent control rod insertion.	Not stated	Not stated		Not susceptible to potential boric acid leak	4-21 -24	31
Prevent control rod insertion.	Not stated	Not stated		Non significant because not in contact with coolant environment	4-25	32
Prevent control rod insertion.	Not stated	Not stated		Non significant because not subject to relative motion	4-26, 4-27	33
Prevent control rod insertion.	Not stated	Not stated		Non significant because operating temp. <427 C (<800 F)	4-20	34
Prevent control rod insertion.	Not stated	Not stated		Non significant because of proper material selection & relatively low operating temp.	4-18 to 4-20	35

Table B.1 Gall Report for NUMARC Industry Reports

Document: IR 90-04, PWR Pressure Vessel Industry Report
Reviewed by: Omesh K. Chopra, ANL

Item	System	Structure/Comp	Subcomponent	Materials	Manufacturer	ARD mechanism	ARD effects
36	PWR Pressure Vessel	Shroud Support Ring	Not stated	SA212 Gr B, SA516 Gr 70	Not stated	FATUnresolved	Cumulative fatigue damage
37	PWR Pressure Vessel	Control Rod Drive Mechanism Housing	Not stated	SA182 Types 304 & 316	Not stated	EMBR/IR	Loss of fracture toughness
38	PWR Pressure Vessel	Control Rod Drive Mechanism Housing	Not stated	SA182 Types 304 & 316	Not stated	CORR/IGSCC Unresolved	Crack initiation & growth
39	PWR Pressure Vessel	Control Rod Drive Mechanism Housing	Not stated	SA182 Types 304 & 316	Not stated	CORR	Loss of material, corrosion product buildup
40	PWR Pressure Vessel	Control Rod Drive Mechanism Housing	Not stated	SA182 Types 304 & 316	Not stated	CORR/BA	Loss of material
41	PWR Pressure Vessel	Control Rod Drive Mechanism Housing	Not stated	SA182 Types 304 & 316	Not stated	ERO/CORR	Wall thinning, loss of material
42	PWR Pressure Vessel	Control Rod Drive Mechanism Housing	Not stated	SA182 Types 304 & 316	Not stated	WEAR	Fretting
43	PWR Pressure Vessel	Control Rod Drive Mechanism Housing	Not stated	SA182 Types 304 & 316	Not stated	CREEP	Change in dimension
44	PWR Pressure Vessel	Control Rod Drive Mechanism Housing	Not stated	SA182 Types 304 & 316	Not stated	EMBR/TE	Loss of fracture toughness
45	PWR Pressure Vessel	Control Rod Drive Mechanism Housing	Not stated	SA182 Types 304 & 316	Not stated	FATUnresolved	Cumulative fatigue damage
46	PWR Pressure Vessel	Control Rod Drive Mechanism Housing	Not stated	SB 166	Not stated	EMBR/IR	Loss of fracture toughness
47	PWR Pressure Vessel	Control Rod Drive Mechanism Housing	Not stated	SB 166	Not stated	CORR/IGSCC Unresolved	Crack initiation & growth
48	PWR Pressure Vessel	Control Rod Drive Mechanism Housing	Not stated	SB 166	Not stated	CORR	Loss of material, corrosion product buildup
49	PWR Pressure Vessel	Control Rod Drive Mechanism Housing	Not stated	SB 166	Not stated	CORR/BA	Loss of material
50	PWR Pressure Vessel	Control Rod Drive Mechanism Housing	Not stated	SB 166	Not stated	ERO/CORR	Wall thinning, loss of material
51	PWR Pressure Vessel	Control Rod Drive Mechanism Housing	Not stated	SB 166	Not stated	WEAR	Fretting
52	PWR Pressure Vessel	Control Rod Drive Mechanism Housing	Not stated	SB 166	Not stated	CREEP	Change in dimension
53	PWR Pressure Vessel	Control Rod Drive Mechanism Housing	Not stated	SB 166	Not stated	EMBR/TE	Loss of fracture toughness

Table B.1 Gall Report for NUMARC Industry Reports

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Effect of Aging on Component Function	Contrib to Failure	Reported progs	Rel.progs	Report Recommendations	Page No.	Item
Prevent control rod insertion.	Not stated	Fatigue usage factor is anticipated to be <1 for entire license renewal term		NRC recommendation: Until an agreement is reached on the draft staff discussion paper on fatigue, the issue is unresolved	4-7 to 4-11	36
Loss of pressure boundary.	Not stated	Not stated		Non significant because neutron fluence is low & is <10^17 n/cm^2 the level above which a surveillance program is required in Appendix H of 10CFR 50	4-2 to 4-6	37
Loss of pressure boundary.	Not stated	Implementation of RG 1.44 to avoid sensitization; control of halogens & (More)		NRC recommendation: Evaluate the effects of oxygen injection during cooldown	5-20 to 5-22	38
Loss of pressure boundary.	Not stated	Not stated		Non significant because SS is resistant to CORR	4-21 to 4-24	39
Loss of pressure boundary.	Not stated	Implementation of Generic Letter 88 05		Recommendations of Generic Letter 88 05 are current & effective program to monitor & control primary coolant leakage	5-22 to 5-24	40
Loss of pressure boundary.	Not stated	Not stated		Non significant because SS is resistant to ERO/CORR, single phase & low flow, & control of water chemistry	4-25	41
Loss of pressure boundary.	Not stated	Not stated		Non significant because not subject to relative motion	4-26, 4-27	42
Loss of pressure boundary.	Not stated	Not stated		Non significant because operating temp. <538 C (<1000 F)	4-20	43
Loss of pressure boundary.	Not stated	Not stated		Non significant because of proper material selection & relatively low operating temp.	4-18 to 4-20	44
Loss of pressure boundary.	Not stated	ASME Sect. III, Subsect. NB fatigue analysis; ASME Sect. XI, Subsect. IWB (More)		NRC recommendation: Until an agreement is reached on the draft staff discussion paper on fatigue, the issue is unresolved	5-14 to 5-19	45
Loss of pressure boundary.	Not stated	Not stated		Non significant because neutron fluence is low & is <10^17 n/cm^2 the level above which a surveillance program is required in Appendix H of 10CFR 50	4-2 to 4-6	46
Loss of pressure boundary.	Not stated	ASME Sect. XI, Subsect. IWB, examination category B O & plant specific (More)		NRC recommendation: Alloy 600 should be further evaluated; evaluate the potential of cracking of Inconel 182 based on recent experience of Arkansas Nuclear One Unit 1 described in LER 90 021 00	5-20 to 5-22	47
Loss of pressure boundary.	Not stated	Not stated		Non significant because Ni alloy is resistant to CORR	4-21 to 4-24	48
Loss of pressure boundary.	Not stated	Implementation of Generic Letter 88 05		Recommendations of Generic Letter 88 05 are current & effective program to monitor & control primary coolant leakage	5-22 to 5-24	49
Loss of pressure boundary.	Not stated	Not stated		Non significant because Ni alloy is resistant to ERO/CORR, single phase & low flow, & control of water chemistry	4-25	50
Loss of pressure boundary.	Not stated	Not stated		Non significant because not subject to relative motion	4-26, 4-27	51
Loss of pressure boundary.	Not stated	Not stated		Non significant because operating temp. <538 C (<1000 F)	4-20	52
Loss of pressure boundary.	Not stated	Not stated		Non significant because of proper material selection & relatively low operating temp.	4-18 to 4-20	53

Table B.1 Gall Report for NUMARC Industry Reports

Document: IR 90-04, PWR Pressure Vessel Industry Report
Reviewed by: Omesh K. Chopra, ANL

Item	System	Structure/Comp	Subcomponent	Materials	Manufacturer	ARD mechanism	ARD effects
54	PWR Pressure Vessel	Control Rod Drive Mechanism Housing	Not stated	SB 166	Not stated	FAT Unresolved	Cumulative fatigue damage
55	PWR Pressure Vessel	Refueling Seal Ledge	Not stated	SA212 Gr B, SA516 Gr 70, SA533 Gr B	Not stated	EMBR/IR	Loss of fracture toughness
56	PWR Pressure Vessel	Refueling Seal Ledge	Not stated	SA212 Gr B, SA516 Gr 70, SA533 Gr B	Not stated	CORR/IGSCC Unresolved	Crack initiation & growth
57	PWR Pressure Vessel	Refueling Seal Ledge	Not stated	SA212 Gr B, SA516 Gr 70, SA533 Gr B	Not stated	CORR	Loss of material, corrosion product buildup
58	PWR Pressure Vessel	Refueling Seal Ledge	Not stated	SA212 Gr B, SA516 Gr 70, SA533 Gr B	Not stated	CORR/BA	Loss of material
59	PWR Pressure Vessel	Refueling Seal Ledge	Not stated	SA212 Gr B, SA516 Gr 70, SA533 Gr B	Not stated	ERO/CORR	Wall thinning, loss of material
60	PWR Pressure Vessel	Refueling Seal Ledge	Not stated	SA212 Gr B, SA516 Gr 70, SA533 Gr B	Not stated	WEAR	Fretting
61	PWR Pressure Vessel	Refueling Seal Ledge	Not stated	SA212 Gr B, SA516 Gr 70, SA533 Gr B	Not stated	CREEP	Change in dimension
62	PWR Pressure Vessel	Refueling Seal Ledge	Not stated	SA212 Gr B, SA516 Gr 70, SA533 Gr B	Not stated	EMBR/TE	Loss of fracture toughness
63	PWR Pressure Vessel	Refueling Seal Ledge	Not stated	SA212 Gr B, SA516 Gr 70, SA533 Gr B	Not stated	FATUnresolved	Cumulative fatigue damage
64	PWR Pressure Vessel	Closure Head Stud Assembly	Not stated	SA 540 B23 or B24, SA 320 L43	Not stated	EMBR/IR	Loss of fracture toughness
65	PWR Pressure Vessel	Closure Head Stud Assembly	Not stated	SA 540 B23 or B24, SA 320 L43	Not stated	CORR/IGSCC	Crack initiation & growth
66	PWR Pressure Vessel	Closure Head Stud Assembly	Not stated	SA 540 B23 or B24, SA 320 L43	Not stated	CORR	Loss of material, corrosion product buildup
67	PWR Pressure Vessel	Closure Head Stud Assembly	Not stated	SA 540 B23 or B24, SA 320 L43	Not stated	CORR/BA	Loss of material
68	PWR Pressure Vessel	Closure Head Stud Assembly	Not stated	SA 540 B23 or B24, SA 320 L43	Not stated	ERO/CORR	Wall thinning, loss of material
69	PWR Pressure Vessel	Closure Head Stud Assembly	Not stated	SA 540 B23 or B24, SA 320 L43	Not stated	WEAR	Fretting
70	PWR Pressure Vessel	Closure Head Stud Assembly	Not stated	SA 540 B23 or B24, SA 320 L43	Not stated	CREEP	Change in dimension
71	PWR Pressure Vessel	Closure Head Stud Assembly	Not stated	SA 540 B23 or B24, SA 320 L43	Not stated	EMBR/TE	Loss of fracture toughness

Table B.1 Gall Report for NUMARC Industry Reports

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Effect of Aging on Component Function	Contrib to Failure	Reported progs	Rel.progs	Report Recommendations	Page No.	Item
Loss of pressure boundary.	Not stated	ASME Sect. III, Subsect. NB fatigue analysis; ASME Sect. XI, Subsect. IWB (More)		NRC recommendation: Until an agreement is reached on the draft staff discussion paper on fatigue, the issue is unresolved	5-14 to 5-19	54
Loss of pressure boundary.	Not stated	Not stated		Non significant because neutron fluence is low & is <10^17 n/cm^2 the level above which a surveillance program is required in Appendix H of 10CFR 50	4-2 to 4-6	55
Loss of pressure boundary.	Not stated	Non significant because LAS & SS cladding (>5% ferrite) are not susceptible (More)		NRC recommendation: Low-temperature sensitization of SS cladding is possible. Evaluate the effects of oxygen injection during cooldown. SCC of low alloy steel is unlikely in typical PWR environment, it may not be true under crevice conditions.	4-11 to 4-18	56
Loss of pressure boundary.	Not stated	Not stated		Non significant because cladding is resistant to CORR, removal of cladding results in very low corrosion rates	4-21 to 4-24	57
Loss of pressure boundary.	Not stated	Not stated		Not susceptible to potential boric acid leak	4-21 -24	58
Loss of pressure boundary.	Not stated	Not stated		Non significant because SS or Ni alloy cladding are resistant to ERO/CORR, single phase & low flow, & control of water chemistry	4-25	59
Loss of pressure boundary.	Not stated	Not stated		Non significant because not subject to relative motion	4-26, 4-27	60
Loss of pressure boundary.	Not stated	Not stated		Non significant because operating temp. <427 C (<800 F)	4-20	61
Loss of pressure boundary.	Not stated	Not stated		Non significant because of proper material selection & relatively low operating temp.	4-18 to 4-20	62
Loss of pressure boundary.	Not stated	Fatigue usage factor is anticipated to be <1 for entire license renewal term		NRC recommendation: Until an agreement is reached on the draft staff discussion paper on fatigue, the issue is unresolved	4-7 to 4-11	63
Loss of pressure boundary.	Not stated	Not stated		Non significant because neutron fluence is low & is <10^17 n/cm^2 the level above which a surveillance program is required in Appendix H of 10CFR 50	4-2 to 4-6	64
Loss of pressure boundary.	Not stated	ASME Sect. XI, Subsect. IWB & Reg. Guide 1.65		ASME Sect. XI, Subsect. IWB, examination category B G 1 & guidelines of Reg. Guide 1.65 are current & effective programs	5-20 to 5-22	65
Loss of pressure boundary.	Not stated	Not stated		Non significant because not subjected to corrosive environment	4-21 to 4-24	66
Loss of pressure boundary.	Not stated	Implementation of Generic Letter 88 05		Recommendations of Generic Letter 88 05 are current & effective program to monitor & control primary coolant leakage	5-22 to 5-24	67
Loss of pressure boundary.	Not stated	Not stated		Non significant because not in contact with coolant environment	4-25	68
Loss of pressure boundary.	Not stated	ASME Sect. XI, Subsect. IWB		ASME Sect. XI, Subsect. IWB, examination category B G 1 is current & effective program to manage effects of WEAR	5-25, 5-26	69
Loss of pressure boundary.	Not stated	Not stated		Non significant because operating temp. <427 C (<800 F)	4-20	70
Loss of pressure boundary.	Not stated	Not stated		Non significant because of proper material selection & relatively low operating temp.	4-18 to 4-20	71

Document: IR 90-04, PWR Pressure Vessel Industry Report
Reviewed by: Omesh K. Chopra, ANL

Item	System	Structure/Comp	Subcomponent	Materials	Manufacturer	ARD mechanism	ARD effects
72	PWR Pressure Vessel	Closure Head Stud Assembly	Not stated	SA 540 B23 or B24, SA 320 L43	Not stated	FAT Unresolved	Cumulative fatigue damage
73	PWR Pressure Vessel	Vessel	Flange	SA336, SA508	Not stated	EMBR/IR	Loss of fracture toughness
74	PWR Pressure Vessel	Vessel	Flange	SA336, SA508	Not stated	CORR/IGSCC	Crack initiation & growth
75	PWR Pressure Vessel	Vessel	Flange	SA336, SA508	Not stated	CORR	Loss of material, corrosion product buildup
76	PWR Pressure Vessel	Vessel	Flange	SA336, SA508	Not stated	CORR/BA	Loss of material
77	PWR Pressure Vessel	Vessel	Flange	SA336, SA508	Not stated	ERO/CORR	Wall thinning, loss of material
78	PWR Pressure Vessel	Vessel	Flange	SA336, SA508	Not stated	WEAR	Fretting
79	PWR Pressure Vessel	Vessel	Flange	SA336, SA508	Not stated	CREEP	Change in dimension
80	PWR Pressure Vessel	Vessel	Flange	SA336, SA508	Not stated	EMBR/TE	Loss of fracture toughness
81	PWR Pressure Vessel	Vessel	Flange	SA336, SA508	Not stated	FAT	Cumulative fatigue damage
82	PWR Pressure Vessel	Vessel	Upper (Nozzle) Shell	SA302 Gr B, SA533 Gr B, SA336, SA508	Not stated	EMBR/IR	Loss of fracture toughness
83	PWR Pressure Vessel	Vessel	Upper (Nozzle) Shell	SA302 Gr B, SA533 Gr B, SA336, SA508	Not stated	CORR/IGSCC	Crack initiation & growth
84	PWR Pressure Vessel	Vessel	Upper (Nozzle) Shell	SA302 Gr B, SA533 Gr B, SA336, SA508	Not stated	CORR	Loss of material, corrosion product buildup
85	PWR Pressure Vessel	Vessel	Upper (Nozzle) Shell	SA302 Gr B, SA533 Gr B, SA336, SA508	Not stated	CORR/BA	Loss of material
86	PWR Pressure Vessel	Vessel	Upper (Nozzle) Shell	SA302 Gr B, SA533 Gr B, SA336, SA508	Not stated	ERO/CORR	Wall thinning, loss of material
87	PWR Pressure Vessel	Vessel	Upper (Nozzle) Shell	SA302 Gr B, SA533 Gr B, SA336, SA508	Not stated	WEAR	Fretting

Table B.1 Gall Report for NUMARC Industry Reports

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Reviewed by: Omesh K. Chopra, ANL

Effect of Aging on Component Function	Contrib to Failure	Reported progs	Rel.progs	Report Recommendations	Page No.	Item
Loss of pressure boundary.	Not stated	ASME Sect. III, Subsect. NB fatigue analysis; ASME Sect. XI, Subsect. IWB (More)		NRC recommendation: Until an agreement is reached on the draft staff discussion paper on fatigue, the issue is unresolved	5-14 to 5-19	72
Loss of pressure boundary.	Not stated	Not stated		Non significant because neutron fluence is low & is <10^17 n/cm^2 the level above which a surveillance program is required in Appendix H of 10CFR 50	4-2 to 4-6	73
Loss of pressure boundary.	Not stated	Non significant because LAS & SS cladding (>5% ferrite) are not susceptible (More)		NRC recommendation: Low-temperature sensitization of SS cladding is possible. Evaluate the effects of oxygen injection during cooldown. SCC of low alloy steel is unlikely in typical PWR environment, it may not be true under crevice conditions.	4-11 to 4-18	74
Loss of pressure boundary.	Not stated	Not stated		Non significant because not subjected to corrosive environment	4-21 to 4-24	75
Loss of pressure boundary.	Not stated	Implementation of Generic Letter 88 05		Recommendations of Generic Letter 88 05 are current & effective program to monitor & control primary coolant leakage	5-22 to 5-24	76
Loss of pressure boundary.	Not stated	ASME Sect. XI, Subsect. IWB		ASME Sect. XI, Subsect. IWB, examination category B P is current & effective program to manage effects of ERO/CORR	5-24, 5-25	77
Loss of pressure boundary.	Not stated	ASME Sect. XI, Subsect. IWB		ASME Sect. XI, Subsect. IWB, examination category B P is current & effective program to manage effects of WEAR	5-25, 5-26	78
Loss of pressure boundary.	Not stated	Not stated		Non significant because operating temp. <427 C (<800 F)	4-20	79
Loss of pressure boundary.	Not stated	Not stated		Non significant because of proper material selection & relatively low operating temp.	4-18 to 4-20	80
Loss of pressure boundary.	Not stated	Fatigue usage factor is anticipated to be <1 for entire license renewal term		NRC recommendation: Until an agreement is reached on the draft staff discussion paper on fatigue, the issue is unresolved	4-7 to 4 -1	81
Loss of pressure boundary.	Not stated	Non significant because fluence is low & is <10^17 n/cm^2 the level above (More)		NRC recommendation: Fluence level 10^17 n/cm^2 is the level above which a surveillance program is required & not the threshold for irradiation damage; & definition of beltline should be consistent with the regulations	4-2 to 4-6	82
Loss of pressure boundary.	Not stated	Non significant because LAS & SS cladding (>5% ferrite) are not susceptible (More)		NRC recommendation: Low-temperature sensitization of SS cladding is possible. Evaluate the effects of oxygen injection during cooldown. SCC of low alloy steel is unlikely in typical PWR environment, it may not be true under crevice conditions.	4-11 to 4-18	83
Loss of pressure boundary.	Not stated	Not stated		Non significant because cladding is resistant to CORR, removal of cladding results in very low corrosion rates	4-21 to 4-24	84
Loss of pressure boundary.	Not stated	Not stated		Not susceptible to potential boric acid leak	4-21 -24	85
Loss of pressure boundary.	Not stated	Not stated		Non significant because SS or Ni alloy cladding is resistant to ERO/ CORR, single phase & low flow, & control of water chemistry	4-25	86
Loss of pressure boundary.	Not stated	Not stated		Non significant because not subject to relative motion	4-26, 4-27	87

Table B.1 Gall Report for NUMARC Industry Reports

Document: IR 90-04, PWR Pressure Vessel Industry Report
Reviewed by: Omesh K. Chopra, ANL

Item	System	Structure/Comp	Subcomponent	Materials	Manufacturer	ARD mechanism	ARD effects
88	PWR Pressure Vessel	Vessel	Upper (Nozzle) Shell	SA302 Gr B, SA533 Gr B, SA336, SA508	Not stated	CREEP	Change in dimension
89	PWR Pressure Vessel	Vessel	Upper (Nozzle) Shell	SA302 Gr B, SA533 Gr B, SA336, SA508	Not stated	EMBR/TE	Loss of fracture toughness
90	PWR Pressure Vessel	Vessel	Upper (Nozzle) Shell	SA302 Gr B, SA533 Gr B, SA336, SA508	Not stated	FAT	Cumulative fatigue damage
91	PWR Pressure Vessel	Vessel	Intermediate & Lower Shell	SA302 Gr B, SA533 Gr B, SA336, SA508	Not stated	EMBR/IR	Loss of fracture toughness
92	PWR Pressure Vessel	Vessel	Intermediate & Lower Shell	SA302 Gr B, SA533 Gr B, SA336, SA508	Not stated	CORR/IGSCC	Crack initiation & growth
93	PWR Pressure Vessel	Vessel	Intermediate & Lower Shell	SA302 Gr B, SA533 Gr B, SA336, SA508	Not stated	CORR	Loss of material, corrosion product buildup
94	PWR Pressure Vessel	Vessel	Intermediate & Lower Shell	SA302 Gr B, SA533 Gr B, SA336, SA508	Not stated	CORR/BA	Loss of material
95	PWR Pressure Vessel	Vessel	Intermediate & Lower Shell	SA302 Gr B, SA533 Gr B, SA336, SA508	Not stated	ERO/CORR	Wall thinning, loss of material
96	PWR Pressure Vessel	Vessel	Intermediate & Lower Shell	SA302 Gr B, SA533 Gr B, SA336, SA508	Not stated	WEAR	Fretting
97	PWR Pressure Vessel	Vessel	Intermediate & Lower Shell	SA302 Gr B, SA533 Gr B, SA336, SA508	Not stated	CREEP	Change in dimension
98	PWR Pressure Vessel	Vessel	Intermediate & Lower Shell	SA302 Gr B, SA533 Gr B, SA336, SA508	Not stated	EMBR/TE	Loss of fracture toughness
99	PWR Pressure Vessel	Vessel	Intermediate & Lower Shell	SA302 Gr B, SA533 Gr B, SA336, SA508	Not stated	FAT	Cumulative fatigue damage
100	PWR Pressure Vessel	Primary Coolant Nozzles* (* Includes safety injection nozzles on some vessels)	Not stated	SA336, SA508	Not stated	EMBR/IR	Loss of fracture toughness
101	PWR Pressure Vessel	Primary Coolant Nozzles* (* Includes safety injection nozzles on some vessels)	Not stated	SA336, SA508	Not stated	CORR/IGSCC	Crack initiation & growth
102	PWR Pressure Vessel	Primary Coolant Nozzles* (* Includes safety injection nozzles on some vessels)	Not stated	SA336, SA508	Not stated	CORR	Loss of material, corrosion product buildup

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Reviewed by: Omesh K. Chopra, ANL

Effect of Aging on Component Function	Contrib to Failure	Reported progs	Rel.progs	Report Recommendations	Page No.	Item
Loss of pressure boundary.	Not stated	Not stated		Non significant because operating temp. <427 C (<800 F). No significant effect of irradiation	4-20	88
Loss of pressure boundary.	Not stated	Not stated		Non significant because of proper material selection & relatively low operating temp.	4-18 to 4-20	89
Loss of pressure boundary.	Not stated	Fatigue usage factor is anticipated to be <1 for entire license renewal term		NRC recommendation: Until an agreement is reached on the draft staff discussion paper on fatigue, the issue is unresolved	4-7 to 4-11	90
Loss of pressure boundary.	Not stated	Appendices G & H of 10CFR50 & RG 1.99 & 1.154. Recom. of NUREG 0244, SRP (More)		NRC recommendation: Definition of beltline should be consistent with the regulations. Effectiveness of ISI of vessel components should be addressed & should incorporate requirements of ASME Sect. XI, Appendices VII & VIII	5-3 to 5-13	91
Loss of pressure boundary.	Not stated	Non significant because LAS & SS cladding (>5% ferrite) are not susceptible (More)		NRC recommendation: Low-temperature sensitization of SS cladding is possible. Evaluate the effects of oxygen injection during cooldown. SCC of low alloy steel is unlikely in typical PWR environment, it may not be true under crevice conditions.	4-11 to 4-18	92
Loss of pressure boundary.	Not stated	Not stated		Non significant because cladding is resistant to CORR, removal of cladding results in very low corrosion rates	4-21 to 4-24	93
Loss of pressure boundary.	Not stated	Not stated		Not susceptible to potential boric acid leak	4-21 -24	94
Loss of pressure boundary.	Not stated	Not stated		Non significant because SS or Ni alloy cladding is resistant to ERO/CORR, single phase & low flow, & control of water chemistry	4-25	95
Loss of pressure boundary.	Not stated	Not stated		Non significant because not subject to relative motion	4-26, 4-27	96
Loss of pressure boundary.	Not stated	Not stated		Non significant because operating temp. <427 C (<800 F). No significant effect of irradiation	4-20	97
Loss of pressure boundary.	Not stated	Not stated		Non significant because of proper material selection & relatively low operating temp.	4-18 to 4-20	98
Loss of pressure boundary.	Not stated	Fatigue usage factor is anticipated to be <1 for entire license renewal term		NRC recommendation: Until an agreement is reached on the draft staff discussion paper on fatigue, the issue is unresolved	4-7 to 4-11	99
Loss of pressure boundary.	Not stated	Non significant because fluence is low & is <10^17 n/cm^2 the level above (More)		NRC recommendation: Fluence level 10^17 n/cm^2 is the level above which a surveillance program is required & not the threshold for irradiation damage; & definition of beltline should be consistant with the regulations	4-2 to 4-6	100
Loss of pressure boundary.	Not stated	Non significant because LAS & SS cladding (>5% ferrite) are not susceptible (More)		NRC recommendation: Low-temperature sensitization of SS cladding is possible. Evaluate the effects of oxygen injection during cooldown. SCC of low alloy steel is unlikely in typical PWR environment, it may not be true under crevice conditions.	4-11 to 4-18	101
Loss of pressure boundary.	Not stated	Not stated		Non significant because cladding is resistant to CORR, removal of cladding results in very low corrosion rates	4-21 to 4-24	102

Document: IR 90-04, PWR Pressure Vessel Industry Report
Reviewed by: Omesh K. Chopra, ANL

Item	System	Structure/Comp	Subcomponent	Materials	Manufacturer	ARD mechanism	ARD effects
103	PWR Pressure Vessel	Primary Coolant Nozzles* (* Includes safety injection nozzles on some vessels)	Not stated	SA336, SA508	Not stated	CORR/BA	Loss of material
104	PWR Pressure Vessel	Primary Coolant Nozzles* (* Includes safety injection nozzles on some vessels)	Not stated	SA336, SA508	Not stated	ERO/CORR	Wall thinning, loss of material
105	PWR Pressure Vessel	Primary Coolant Nozzles* (* Includes safety injection nozzles on some vessels)	Not stated	SA336, SA508	Not stated	WEAR	Fretting
106	PWR Pressure Vessel	Primary Coolant Nozzles* (* Includes safety injection nozzles on some vessels)	Not stated	SA336, SA508	Not stated	CREEP	Change in dimension
107	PWR Pressure Vessel	Primary Coolant Nozzles* (* Includes safety injection nozzles on some vessels)	Not stated	SA336, SA508	Not stated	EMBR/TE	Loss of fracture toughness
108	PWR Pressure Vessel	Primary Coolant Nozzles* (* Includes safety injection nozzles on some vessels)	Not stated	SA336, SA508	Not stated	FAT Unresolved	Cumulative fatigue damage
109	PWR Pressure Vessel	Leakage Monitoring Tubes	Not stated	SA 312 Type 316	Not stated	EMBR/IR	Loss of fracture toughness
110	PWR Pressure Vessel	Leakage Monitoring Tubes	Not stated	SA 312 Type 316	Not stated	CORR/IGSCC	Crack initiation & growth
111	PWR Pressure Vessel	Leakage Monitoring Tubes	Not stated	SA 312 Type 316	Not stated	CORR	Loss of material, corrosion product buildup
112	PWR Pressure Vessel	Leakage Monitoring Tubes	Not stated	SA 312 Type 316	Not stated	CORR/BA	Loss of material
113	PWR Pressure Vessel	Leakage Monitoring Tubes	Not stated	SA 312 Type 316	Not stated	ERO/CORR	Wall thinning, loss of material
114	PWR Pressure Vessel	Leakage Monitoring Tubes	Not stated	SA 312 Type 316	Not stated	WEAR	Fretting
115	PWR Pressure Vessel	Leakage Monitoring Tubes	Not stated	SA 312 Type 316	Not stated	CREEP	Change in dimension
116	PWR Pressure Vessel	Leakage Monitoring Tubes	Not stated	SA 312 Type 316	Not stated	EMBR/TE	Loss of fracture toughness
117	PWR Pressure Vessel	Leakage Monitoring Tubes	Not stated	SA 312 Type 316	Not stated	FAT	Cumulative fatigue damage
118	PWR Pressure Vessel	Leakage Monitoring Tubes	Not stated	SB 166, SB 167	Not stated	EMBR/IR	Loss of fracture toughness
119	PWR Pressure Vessel	Leakage Monitoring Tubes	Not stated	SB 166, SB 167	Not stated	CORR/IGSCC	Crack initiation & growth