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Document Tracking Application
Keyword Search for Documents

Search Parameters: Author= ''; Doc #=''; Series=''; Doc Type=' '; Level= ''; Originator=''; Status=''; Title='HEAT EXCHANGER'; Between dates 1/1/1963 and 12/31/1964

Document Number / Alternate Document #	Series	Document Type	Author / Originator	Lvl/Cat	Sigmas	Status	Document Date	Title
8247 - PHOTO	-	PHOTOGRAPH	STAFF GE	UNCL	00000000	DCL	01/03/1963	109N HEAT EXCHANGER BUILDING PIPING AND VALVE INSTALLATION CELL NUMBER 5 - VIEW LOOKING SOUTH
8248 - PHOTO	-	PHOTOGRAPH	STAFF GE	UNCL	00000000	DCL	01/03/1963	109N HEAT EXCHANGER BUILDING PIPING AND VALVE INSTALLATION CELL NUMBER 5 - VIEW LOOKING NORTH
8249 - PHOTO	-	PHOTOGRAPH	STAFF GE	UNCL	00000000	DCL	01/03/1963	109N HEAT EXCHANGER BUILDING PIPING AND VALVE INSTALLATION CELL NUMBER 4 - VIEW LOOKING NORTH
8250 - PHOTO	-	PHOTOGRAPH	STAFF GE	UNCL	00000000	DCL	01/03/1963	109N HEAT EXCHANGER BUILDING PIPING AND VALVE INSTALLATION CELL NUMBER 3 - VIEW LOOKING SOUTH
8251 - PHOTO	-	PHOTOGRAPH	STAFF GE	UNCL	00000000	DCL	01/03/1963	109N HEAT EXCHANGER BUILDING PIPING AND VALVE INSTALLATION CELL NUMBER 3 - VIEW LOOKING NORTH
8252 - PHOTO	-	PHOTOGRAPH	STAFF GE	UNCL	00000000	DCL	01/03/1963	109N HEAT EXCHANGER BUILDING PIPING AND VALVE INSTALLATION CELL NUMBER 2 - VIEW LOOKING SOUTH
8253 - PHOTO	-	PHOTOGRAPH	STAFF GE	UNCL	00000000	DCL	01/03/1963	109N HEAT EXCHANGER BUILDING PIPING AND VALVE INSTALLATION CELL NUMBER 2 - VIEW LOOKING NORTH
8254 - PHOTO	-	PHOTOGRAPH	STAFF GE	UNCL	00000000	DCL	01/03/1963	109N HEAT EXCHANGER BUILDING PIPING AND VALVE INSTALLATION CELL NUMBER 1 - VIEW LOOKING NORTH
8256 - PHOTO	-	PHOTOGRAPH	STAFF GE	UNCL	00000000	DCL	01/03/1963	109N HEAT EXCHANGER BUILDING PIPING AND VALVE INSTALLATION CELL NUMBER 1 - VIEW LOOKING SOUTH
8257 - PHOTO	-	PHOTOGRAPH	STAFF GE	UNCL	00000000	DCL	01/03/1963	109N HEAT EXCHANGER BUILDING PIPING, VALVE AND EQUIPMENT INSTALLATION AUXILIARY CELL
8258 - PHOTO	-	PHOTOGRAPH	STAFF GE	UNCL	00000000	DCL	01/03/1963	109N HEAT EXCHANGER BUILDING PIPE GALLERY VIEW LOOKING WEST
8265 - PHOTO	-	PHOTOGRAPH	STAFF GE	UNCL	00000000	DCL	01/03/1963	109N HEAT EXCHANGER BUILDING VIEW LOOKING WEST ELEV. +39 ROOF OF BUILDING
8279 - PHOTO	-	PHOTOGRAPH	STAFF GE	UNCL	00000000	DCL	01/30/1963	109N HEAT EXCHANGER BUILDING VIEW OF VALVE INSTALLATION NORTH END OF CELL NO. 1
8280 - PHOTO	-	PHOTOGRAPH	STAFF GE	UNCL	00000000	DCL	01/30/1963	109N HEAT EXCHANGER BUILDING PIPING INSTALLATION CELL NO. 1 VIEW LOOKING FROM NORTH TO SOUTH
8281 - PHOTO	-	PHOTOGRAPH	STAFF GE	UNCL	00000000	DCL	01/30/1963	109N HEAT EXCHANGER BUILDING PIPING INSTALLATION CELL NO. 2 VIEW LOOKING FROM NORTH TO SOUTH
8282 - PHOTO	-	PHOTOGRAPH	STAFF GE	UNCL	00000000	DCL	01/30/1963	109N HEAT EXCHANGER BUILDING PIPING INSTALLATION CELL NO. 3 VIEW LOOKING FROM NORTH TO SOUTH
8283 - PHOTO	-	PHOTOGRAPH	STAFF GE	UNCL	00000000	DCL	01/30/1963	109N HEAT EXCHANGER BUILDING PIPING INSTALLATION CELL NO. 3 VIEW LOOKING FROM NORTH TO SOUTH
8284 - PHOTO	-	PHOTOGRAPH	STAFF GE	UNCL	00000000	DCL	01/30/1963	109N HEAT EXCHANGER BUILDING PIPING INSTALLATION CELL NO. 5 VIEW LOOKING FROM NORTH TO SOUTH
8285 - PHOTO	-	PHOTOGRAPH	STAFF GE	UNCL	00000000	DCL	01/30/1963	109N HEAT EXCHANGER BUILDING VIEW OF PIPE GALLERY - VIEW LOOKING FROME AST TO WEST
8288 - PHOTO	-	PHOTOGRAPH	STAFF GE	UNCL	00000000	DCL	01/30/1963	109N HEAT EXCHANGER BUILDING HIGH PRESSURE STEAM PIPING ON ROOF DECK
8346 - PHOTO	-	PHOTOGRAPH	STAFF GE	UNCL	00000000	DCL	02/28/1963	109N HEAT EXCHANGER BUILDING PRIMARY PIPING CELL NO. 2 VEIW LOOKING SOUTH
8347 - PHOTO	-	PHOTOGRAPH	STAFF GE	UNCL	00000000	DCL	02/28/1963	109N HEAT EXCHANGER BUILDING PRIMARY COOLANT PUMP AND PIPING CELL NO. 3

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8348 - PHOTO	-	PHOTOGRAPH	STAFF GE	UNCL	00000000	DCL	02/28/1963	109N HEAT EXCHANGER BUILDING GRAPHITE COOLING PIPING AUXILIARY SYSTEMS CELL
8349 - PHOTO	-	PHOTOGRAPH	STAFF GE	UNCL	00000000	DCL	02/28/1963	109N HEAT EXCHANGER BUILDING PIPE GALLERY VIEW LOOKING EAST
8356 - PHOTO	-	PHOTOGRAPH	STAFF GE	UNCL	00000000	DCL	02/28/1963	109N HEAT EXCHANGER BUILDING PRIMARY COOLANT SUPPLY VALVE 203 AND PIPING - CELL NO. 1
8357 - PHOTO	-	PHOTOGRAPH	STAFF GE	UNCL	00000000	DCL	02/28/1963	109N HEAT EXCHANGER BUILDING PRIMARY PIPING INSTALLATION CELL NO. 1 - VIEW LOOKING SOUTH
8358 - PHOTO	-	PHOTOGRAPH	STAFF GE	UNCL	00000000	DCL	02/28/1963	109N HEAT EXCHANGER BUILDING PRIMARY COOLANT VALVE INSTALLATION NORTH END OF CELL NO. 1
8359 - PHOTO	-	PHOTOGRAPH	STAFF GE	UNCL	00000000	DCL	02/28/1963	109N HEAT EXCHANGER BUILDING PRIMARY COOLANT SUPPLY VALVE 203 AND PIPING - CELL NO. 2
8360 - PHOTO	-	PHOTOGRAPH	STAFF GE	UNCL	00000000	DCL	02/28/1963	109N HEAT EXCHANGER BUILDING PRIMARY COOLANT VALVE INSTALLATION NORTH END OF CELL NO. 2
8361 - PHOTO	-	PHOTOGRAPH	STAFF GE	UNCL	00000000	DCL	02/28/1963	109N HEAT EXCHANGER BUILDING PRIMARY COOLANT SUPPLY VALVE 203 AND PIPING - CELL NO. 3
8362 - PHOTO	-	PHOTOGRAPH	STAFF GE	UNCL	00000000	DCL	02/28/1963	109N HEAT EXCHANGER BUILDING PRIMARY COOLANT VALVE INSTALLATION NORTH END OF CELL NO. 3
8363 - PHOTO	-	PHOTOGRAPH	STAFF GE	UNCL	00000000	DCL	02/28/1963	109N HEAT EXCHANGER BUILDING PRIMARY COOLANT VALVE INSTALLATION NORTH END OF CELL NO. 4
8364 - PHOTO	-	PHOTOGRAPH	STAFF GE	UNCL	00000000	DCL	02/28/1963	109N HEAT EXCHANGER BUILDING PRIMARY COOLANT PIPING - CELL NO. 4 VIEW LOOKING SOUTH
8365 - PHOTO	-	PHOTOGRAPH	STAFF GE	UNCL	00000000	DCL	02/28/1963	109N HEAT EXCHANGER BUILDING PRIMARY COOLANT SUPPLY VALVE 203 AND PIPING - CELL NO. 4
8366 - PHOTO	-	PHOTOGRAPH	STAFF GE	UNCL	00000000	DCL	02/28/1963	109N HEAT EXCHANGER BUILDING PRIMARY COOLANT PUMP AND PIPING CELL NO. 4
8367 - PHOTO	-	PHOTOGRAPH	STAFF GE	UNCL	00000000	DCL	02/28/1963	109N HEAT EXCHANGER BUILDING PRIMARY COOLANT PUMP AND PIPING CELL NO. 5
8368 - PHOTO	-	PHOTOGRAPH	STAFF GE	UNCL	00000000	DCL	02/28/1963	109N HEAT EXCHANGER BUILDING PRIMARY COOLANT SUPPLY VALVE 203 AND PIPING - CELL NO. 5
8369 - PHOTO	-	PHOTOGRAPH	STAFF GE	UNCL	00000000	DCL	02/28/1963	109N HEAT EXCHANGER BUILDING PRIMARY PIPING - CELL NO. 5 VIEW LOOKING SOUTH
8370 - PHOTO	-	PHOTOGRAPH	STAFF GE	UNCL	00000000	DCL	02/28/1963	109N HEAT EXCHANGER BUILDING PRIMARY COOLANT VALVE INSTALLATION NORTH END OF CELL NO. 5
8371 - PHOTO	-	PHOTOGRAPH	STAFF GE	UNCL	00000000	DCL	02/28/1963	109N HEAT EXCHANGER BUILDING EAST SUPPLY AND RETURN HEADERS PIPE GALLERY
8372 - PHOTO	-	PHOTOGRAPH	STAFF GE	UNCL	00000000	DCL	02/28/1963	109N HEAT EXCHANGER BUILDING WEST SUPPLY AND RETURN HEADERS PIPE GALLERY
8436 - PHOTO	-	PHOTOGRAPH	STAFF GE	UNCL	00000000	DCL	03/29/1963	109N HEAT EXCHANGER BUILDING PRIMARY COOLANT VALVE INSTALLATION NORTH END - CELL NO. 1
8437 - PHOTO	-	PHOTOGRAPH	STAFF GE	UNCL	00000000	DCL	03/29/1963	109N HEAT EXCHANGER BUILDING PRIMARY PIPE INSTALLATION - CELL NO. 1 VIEW LOOKING SOUTH
8438 - PHOTO	-	PHOTOGRAPH	STAFF GE	UNCL	00000000	DCL	03/29/1963	109N HEAT EXCHANGER BUILDING PRIMARY COOLANT PIPING INSTALLATION SOUTH END OF CELL NO. 3

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8439 - PHOTO	-	PHOTOGRAPH	STAFF GE	UNCL	00000000	DCL	03/29/1963	109N HEAT EXCHANGER BUILDING PRIMARY COOLANT SUPPLY AND RETURN PIPING - VIEW LOOKING WEST - PIPE GALLERY
8449 - PHOTO	-	PHOTOGRAPH	STAFF GE	UNCL	00000000	DCL	03/29/1963	109N HEAT EXCHANGER BUILDING PIPING AND EQUIPMENT INSTALLATION CELL NO. 1
8450 - PHOTO	-	PHOTOGRAPH	STAFF GE	UNCL	00000000	DCL	03/29/1963	109N HEAT EXCHANGER BUILDING PRIMARY COOLANT PIPING CELL NO. 1
8451 - PHOTO	-	PHOTOGRAPH	STAFF GE	UNCL	00000000	DCL	03/29/1963	109N HEAT EXCHANGER BUILDING PRIMARY PIPING INSTALLATION CELL NO. 1 - VIEW LOOKING SOUTH
8452 - PHOTO	-	PHOTOGRAPH	STAFF GE	UNCL	00000000	DCL	03/29/1963	109N HEAT EXCHANGER BUILDING VALVE INSTALLATION - NORTH END CELL NO. 2
8453 - PHOTO	-	PHOTOGRAPH	STAFF GE	UNCL	00000000	DCL	03/29/1963	109N HEAT EXCHANGER BUILDING PIPING AND EQUIPMENT INSTALLATION CELL NO. 2
8454 - PHOTO	-	PHOTOGRAPH	STAFF GE	UNCL	00000000	DCL	03/29/1963	109N HEAT EXCHANGER BUILDING PRIMARY PIPING INSTALLATION CELL NO. 3 VIEW LOOKING SOUTH
8455 - PHOTO	-	PHOTOGRAPH	STAFF GE	UNCL	00000000	DCL	03/29/1963	109N HEAT EXCHANGER BUILDING VALVE INSTALLATION CELL NO. 3
8456 - PHOTO	-	PHOTOGRAPH	STAFF GE	UNCL	00000000	DCL	03/29/1963	109N HEAT EXCHANGER BUILDING PRIMARY COOLANT PIPING INSTALLATION - CELL NO. 4
8457 - PHOTO	-	PHOTOGRAPH	STAFF GE	UNCL	00000000	DCL	03/29/1963	109N HEAT EXCHANGER BUILDING PRIMARY COOLANT PIPING INSTALLATION - CELL NO. 4 VIEW LOOKING SOUTH
8458 - PHOTO	-	PHOTOGRAPH	STAFF GE	UNCL	00000000	DCL	03/29/1963	109N HEAT EXCHANGER BUILDING PIPING AND EQUIPMENT INSTALLATION CELL NO. 4
8459 - PHOTO	-	PHOTOGRAPH	STAFF GE	UNCL	00000000	DCL	03/29/1963	109N HEAT EXCHANGER BUILDING VALVE INSTALLATION NORTH END - CELL NO. 4
8460 - PHOTO	-	PHOTOGRAPH	STAFF GE	UNCL	00000000	DCL	03/29/1963	109N HEAT EXCHANGER BUILDING VALVE INSTALLATION NORTH END - CELL NO. 5
8461 - PHOTO	-	PHOTOGRAPH	STAFF GE	UNCL	00000000	DCL	03/29/1963	109N HEAT EXCHANGER BUILDING PRIMARY COOLANT PIPING INSTALLATION VIEW LOOKING SOUTH - CELL NO. 5
8462 - PHOTO	-	PHOTOGRAPH	STAFF GE	UNCL	00000000	DCL	03/29/1963	109N HEAT EXCHANGER BUILDING PIPING INSTALLATION CELL NO. 5
8463 - PHOTO	-	PHOTOGRAPH	STAFF GE	UNCL	00000000	DCL	03/29/1963	109N HEAT EXCHANGER BUILDING PRIMARY COOLANT SUPPLY AND RETURN HEADERS WEST END - PIPE GALLERY
8464 - PHOTO	-	PHOTOGRAPH	STAFF GE	UNCL	00000000	DCL	03/29/1963	109N HEAT EXCHANGER BUILDING PRIMARY COOLANT SUPPLY AND RETURN HEADERS EAST END - PIPE GALLERY
8527 - PHOTO	-	PHOTOGRAPH	STAFF GE	UNCL	00000000	DCL	04/26/1963	109N HEAT EXCHANGER BUILDING JUNCTION BOX - WEST IN CELL NO. 5
8528 - PHOTO	-	PHOTOGRAPH	STAFF GE	UNCL	00000000	DCL	04/26/1963	109N HEAT EXCHANGER BUILDING JUNCTION BOX - EAST IN CELL NO. 5
8529 - PHOTO	-	PHOTOGRAPH	STAFF GE	UNCL	00000000	DCL	04/26/1963	109N HEAT EXCHANGER BUILDING JUNCTION BOX - EAST IN CELL NO. 5
8541 - PHOTO	-	PHOTOGRAPH	STAFF GE	UNCL	00000000	DCL	04/26/1963	109N HEAT EXCHANGER BUILDING PIPING AND EQUIPMENT INSTALLATION CELL NO. 1 - VIEW LOOKING NORTH

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8542 - PHOTO	-	PHOTOGRAPH	STAFF GE	UNCL	00000000	DCL	04/26/1963	109N HEAT EXCHANGER BUILDING PIPING AND EQUIPMENT INSTALLATION CELL NO. 3 - VIEW LOOKING NORTH
8543 - PHOTO	-	PHOTOGRAPH	STAFF GE	UNCL	00000000	DCL	04/26/1963	109N HEAT EXCHANGER BUILDING PIPING AND EQUIPMENT INSTALLATION CELL NO. 4 - VIEW LOOKING NORTH
8544 - PHOTO	-	PHOTOGRAPH	STAFF GE	UNCL	00000000	DCL	08/27/1963	109N HEAT EXCHANGER BUILDING MAIN STEAM & CONDENSATE PIPING ABOVE EAST END OF ROOF START OF PIPING INSULATION
8695 - PHOTO	-	PHOTOGRAPH	STAFF GE	UNCL	00000000	DCL	08/27/1963	109N HEAT EXCHANGER BUILDING MAIN STEAM & CONDESATE PIPING ABOVE EAST END OF ROOK START OF PIPING INSULATION
8698 - PHOTO	-	PHOTOGRAPH	STAFF GE	UNCL	00000000	DCL	08/27/1963	109N HEAT EXCHANGER BUILDING PIPE GALLERY - WEST END OF PIPING INSULATION - 24" & 26" PRIMARY COOLANT PIPING
DDTS-GENERATED-01132	-		HG JOHNSON GE	UNCL	00000000	DCL	10/29/1964	N REACTOR PRIMARY LOOP OPERATING PRESSURES WITH SIX HEAT EXCHANGER CELLS AND POWER LEVELS UP TO 120 PERCENT OF DESIGN
HAN-91354 HW-82536-J	-	REPORT	KL BERRETT, AJ EBENS AEC	UNCL	00000000	DCL	08/19/1964	FINAL REPORT DIVERSION SYSTEM RECUPERATIVE HEAT EXCHANGER AND SPILL COOLER TEST STARTUP TEST N-2, LOW POWER TESSTING PROGRMA STEP 32
HW-79104 HAN-86466	-	REPORT	JW VANDERBEEK, RE TRUMBLE GE	UNCL	00000000	DCL	10/17/1963	CONSEQUENCES OF HEAT EXCHANGER TUBE RUPTURE AT N-REACTOR (U)

RHO-Historical "HEAT" PG 1/1

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HIST0005521	HAZARDS	SUPPLEMENTAL CMC HAZARDS CONTROL SPECIFICATIONS@ TRANSPORTATION AND STORAGE OF URANIUM-233 SOLUTION
HIST0006238	HAZARDS	PUREX PLANT SEISMIC HAZARDS RISK ANALYSIS AND COST BENEFIT STUDIES BASED ON OFFSITE DOSE COMMITMENT
HIST0006248	HAZARDS	PUREX PLANT SEISMIC HAZARDS ONSITE RISK ANALYSIS
HIST0010287	HAZARDS	SUPPLEMENTAL CRITICAL MASS AND CHEMICAL HAZARDS CONTROL SPECIFICATIONS SLUDGE DISSOLUTION FROM REDO
HIST[illegible]87	HCP-687	ADDM TO ARH-LD-124 FINAL SAFETY ANALYSIS REPORT CONTAMINATED SOIL REMOVAL FACILITY 216-Z-9 ENCLOSED
HIST0004460	HEAD	RE[illegible]EW OF REDOX PLANT HEAD END TREATMENT
HIST0005391	HEAD-END	LOGBOOK - PUREX - HEAD-END MEASUREMENT LOG
HIST0002129	HEADEND	HEADEND TREATMENT OF A1W REACTOR U-NB-ZR ALLOY FUELS IN THE HANFORD PUREX PLANT
HIST0002839	HEADER	CONTAINMENT OF THE DETERIORATED VAPOR EXHAUST HEADER IN 241-AX TANK FARM
HIST0001384	HEADQUARTERS	VU-GRAPHS PRESENTED AT HEADQUARTERS PRODUCTION DIVISION FY 1971-72 BUDGET REVIEW
HIST0001678	HEADQUARTERS	VU-GRAPHS PRESENTED AT HEADQUARTERS PRODUCTION DIVISION FY 1972-73 BUDGET REVIEW
HIST0001800	HEADQUARTERS	VU-GRAPHS PRESENTED TO HEADQUARTERS WASTE MANAGEMENT AND TRANSPORTATION DIV WASTE MANAGEMENT PROGRA
HIST0008135	HEADQUARTERS	CORRECTIVE ACTIONS TO THE 1984 OPSEC ASSESSMENT OF THE U.S. DEPARTMENT OF ENERGY - HEADQUARTERS (
HIST0008136	HEADQUARTERS	CORRECTIVE ACTIONS TO THE 1984 OPSEC ASSESSMENT OF THE U.S. DEPARTMENT OF ENERGY - HEADQUARTERS (
HIST0008296	HEADQUARTERS	SECURITY PLAN FOR CLASSIFIED PERSONAL COMPUTER LOCATED IN PATROL HEADQUARTERS (2721-E)
HIST0011039	HEAL	DENIAL OR SANITIZATION RECOMMENDATIONS FOR HEAL FREEDOM OF INFORMATION ACT (FOIA) REQUEST
HIST0011040	HEAL	DENIAL OR SANITIZATION RECOMMENDATIONS FOR HEAL FREEDOM OF INFORMATION ACT (FOIA) REQUEST
HIST0005980	HEALTH	QUARTERLY PROGRESS REPORT APRIL, MAY, JUNE 1972 PRODUCT AND HEALTH PHYSICS RESEARCH
HIST0010008	HEARING	TRANSCRIPT - CONTINUANCE OF 5/7/87 CLOSED HEARING ON DOE'S PER
HIST0010093	HEARING	SUBCOMMITTEE ON OVERSIGHT & INVESTIGATIONS HEARING, E. V. BADOLATO/M. J. LAWRENCE (COPY 2 HAS 7
HIST0000017	HEAT	DCM-55-2160 VOL. 5 "CALCULATIONS OF HEAT GENERATION, NEUTRON & GAMMA DOSE"
HIST0003122	HEAT	FINAL REPORT-STRESS : HEAT TRANSFER ANALYSIS OF FISSION PRODUCTS SHIPPING CONTAINER
HIST0003403	HEAT	CLASSIFICATION GUIDE FOR ISOTOPIC HEAT SOURCE INFORMATION
HIST0003561	HEAT	CALCULATIONS OF HEAT GENERATION NEUTRON AND GAMMA DATA
HIST0004726	HEAT	A COMPARISON OF TITANIUM & STAINLESS STEEL AS MATERIALS OF CONSTRUCTION FOR HAPO SEPARATIONS
HIST0003562	HEATING	CALCULATION OF NEUTRON AND GAMMA DOSES AND DOSE RATES AND HEATING EFFECTS FROM A ARGE NEUTRON BURST
HIST0010505	HEAVY	LOW TEMPERATURE HEAVY WATER REACTOR, REPLACEMENT PRODUCTION REACTOR CONCEPT DESCRIPTION
HIST0010527	HEAVY	HIGH TEMPERATURE HEAVY WATER REACTOR, REPLACEMENT PRODUCTION REACTOR CONCEPT DESCRIPTION
HIST0000019	HEDL	PHYSICAL SECURITY APPRAISAL OF HEDL, MAY 1, 1979 TO JULY 31, 1980 RESPONSES TO RECOMMENDATIONS
HIST0004206	HEDL	CLASSIFIED PAGES TO HEDL REPORT ON MULTI-MEGAWATT FUELS & IRRADIATION TESTING HEDL-TC-2936
HIST0004296	HEDL	REPORT OF HEDL VISIT TO SAVANNAH RIVER
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HIST0010161	HEDL-810613	EXEMPTION TO DOE ORDER 5632.4 FOR THE FFTF - REF: HEDL-810613
HIST0000011	HEDL-MCJC-5	REVISIONS TO HEDL-MCJC-5 AND HEDL-TC-1144
HIST0000011	HEDL-TC-1144	REVISIONS TO HEDL-MCJC-5 AND HEDL-TC-1144
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HIST0004239	HEHF	OTHER I&E ISSUES HEHF, JAJ, KEH & PNL AS OF 4/20/87
HIST0008268	HEIGHTENED	HEIGHTENED FACILITY SECURITY MEASURES
HIST0008269	HEIGHTENED	HEIGHTENED FACILITY SECURITY MEASURES
HIST0000417	HELD	ENRICHED URANIUM HELD ON PROJECT H-25000-00-08 APRIL 30, 1968.*
HIST0004951	HELD	NOTES ON PLUTONIUM SCRAP RECOVERY DISCUSSIONS HELD AT HQ-GERMANTOWN, JULY 17&18, 1961
HIST0004997	HELD	PROCEEDINGS OF THE PLUTONIUM INFORMATION MEETING HELD AT HANFORD ATOMIC PRODUCTS OPERATION ON FEB 6
HIST0007891	HELD	LETTER TO WC WALKER CALIBRATION AND MAINTENANCE OF HAND HELD SNM DETECTORS
HIST0008085	HELICOPTER	HELICOPTER APPLICATIONS STUDY
HIST0008299	HELICOPTER	COMPREHENSIVE SECURITY PLAN FOR HANFORD PATROL HELICOPTERS, HELICOPTER FACILITY & FIRE TEAM
HIST0008299	HELICOPTERS	COMPREHENSIVE SECURITY PLAN FOR HANFORD PATROL HELICOPTERS, HELICOPTER FACILITY & FIRE TEAM
HIST0004447	HELIUM	RECOMMENDATION TO SUBSTITUTE CARBON DIOXIDE FOR HELIUM IN THE FABRICATION PROCESS.
HIST0004481	HELIUM	EVALUATION OF CARBON DIOXIDE AS REPLACEMENT FOR HELIUM IN THE MACHINING, BRIQUETTING AND RECOVERY
HIST0004483	HELIUM	EVALUATION OF CARBON DIOXIDE AS REPLACEMENT FOR HELIUM IN THE MACHINING, BRIQUETTING : RECOVERY
HIST0005317	HENRY	U-233 FABRICATION DISCUSSIONS WITH C. HENRY
HIST0007037	HEUSSER	PRESENTATION TO RK HEUSSER PRF & RMC FEED & PRODUCT PRF/RMC CONCURRENT OPERATIONS

HAZARDS * HEUSSER

RHO - HISTORICAL "EXCHANGER(S)" PG 1/1

KEYWORD INDEX

REF NUMBER		
HIST0000792	EXCERPT	EXCERPT - 200 AREAS OPERATION MONTHLY REPORT FEBRUARY 1969
HIST0000795	EXCERPT	EXCERPT - 200 AREAS OPERATION MONTHLY REPORT MARCH 1969
HIST0000798	EXCERPT	EXCERPT - 200 AREAS OPERATION MONTHLY REPORT
HIST0000801	EXCERPT	EXCERPT - 200 AREAS OPERATION MONTHLY REPORT MAY 1969
HIST0000804	EXCERPT	EXCERPT - 200 AREAS OPERATION MONTHLY REPORT JUNE 1969
HIST0000807	EXCERPT	EXCERPT - 200 AREAS OPERATION MONTHLY REPORT JULY 1969
HIST0000810	EXCERPT	EXCERPT - 200 AREAS OPERATION MONTHLY REPORT AUGUST 1969
HIST0000813	EXCERPT	EXCERPT - 200 AREAS OPERATION MONTHLY REPORT SEPTEMBER 1969
HIST0000816	EXCERPT	EXCERPT - 200 AREAS OPERATION MONTHLY REPORT OCTOBER 1969
HIST0000819	EXCERPT	EXCERPT - 200 AREAS OPERATION MONTHLY REPORT NOVEMBER 1969
HIST0000822	EXCERPT	EXCERPT - 200 AREAS OPERATION MONTHLY REPORT DECEMBER 1969
HIST0001075	EXCERPT	EXCERPT - 200 AREAS OPERATION MO RPT JAN, 1970.*
HIST0001084	EXCERPT	EXCERPT - 200 AREAS OPERATION MONTHLY REPORT, APRIL 1970.*
HIST0001087	EXCERPT	EXCERPT - 200 AREAS OPER RPT - MAY 1970
HIST0001090	EXCERPT	EXCERPT - 200 AREAS OPERATION MONTHLY REPORT JUNE, 1970.
HIST0001093	EXCERPT	EXCERPT - 200 AREAS OPERATION MONTHLY REPORT JULY 1970.
HIST0001096	EXCERPT	EXCERPT - 200 AREAS OPERATION MONTHLY REPORT AUGUST, 1970.
HIST0001099	EXCERPT	EXCERPT - 200 AREAS OPERATION MONTHLY REPORT SEPTEMBER, 1970.
HIST0001102	EXCERPT	EXCERPT - 200 AREAS OPERATION MONTHLY REPORT OCTOBER 1970
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HIST0001454	EXCERPT	EXCERPT - 200 AREAS OPERATION MONTHLY REPORT - JANUARY 1971
HIST0001463	EXCERPT	EXCERPT - 200 AREAS OPERATION MONTHLY REPORT - APRIL 1971
HIST0001466	EXCERPT	EXCERPT - 200 AREAS OPERATION MONTHLY REPORT - MAY 1971
HIST0001469	EXCERPT	EXCERPT - 200 AREAS OPERATION MONTHLY REPORT - JUNE 1971
HIST0002710	EXCERPTS	EXCERPTS FROM ARH-CD-320 - PAGES 61-62-63-64-65
HIST0008020	EXCERPTS	EXCERPTS FROM VOL1 & VOL2, HANFORD LASER ISOTOPE SEPARATION DEPLOYMENT PROJECT PRELIMINARY CDR
HIST0000406	EXCHANGE	LARGE ION EXCHANGE COLUMN FOR PU-238, NP-237 - DEVELOPMENT GUIDELINES.*
HIST0004407	EXCHANGE	USE OF ION EXCHANGE IN RECUPLEX PROCESS
HIST0004440	EXCHANGE	CONCENTRATION AND DECONTAMINATION OF PLUTONIUM PROCESS SOLUTIONS BY ION EXCHANGE
HIST0004523	EXCHANGE	PLUTONIUM CONCENTRATION & PURIFICATION BY CONTINUOUS ION EXCHANGE IN THE PUREX PLANT
HIST0004542	EXCHANGE	RECOVERY OF PLUTONIUM FROM PUREX IWW BY ANION EXCHANGE
HIST0004549	EXCHANGE	PUREX ION EXCHANGE
HIST0004602	EXCHANGE	CONTINOUS CONCENTRATION OF CATION EXCHANGE PRODUCT
HIST0004660	EXCHANGE	THE RECOVERY, PURIFICATION, AND CONCENTRATION OF PLUTONIUM BY ANION EXCHANGE IN NITRIC ACID.
HIST0004877	EXCHANGE	ANALYTICAL METHODS USED FOR PU METAL EXCHANGE PROGRAM
HIST0005003	EXCHANGE	ANION EXCHANGE FLOW SHEETS AND EQUIPMENT FOR RECOVERY OF TASK I FILTRATES
HIST0005050	EXCHANGE	Z PLANT FILTRATE ION EXCHANGE FACILITY - CGC-978 - STARTUP FLOWSHEET
HIST0008003	EXCHANGE	SIS TECHNOLOGY ISSUE EXCHANGE MEETING BETWEEN LLNL & ROCKWELL, SEPTEMBER 26 & 27, 1983
HIST0008004	EXCHANGE	SIS TECHNOLOGY ISSUE EXCHANGE MEETING BETWEEN LLNL & ROCKWELL, SEPTEMBER 26 & 27, 1983
HIST0004726	EXCHANGERS	A COMPARISON OF TITANIUM & STAINLESS STEEL AS MATERIALS OF CONSTRUCTION FOR HAPO SEPARATIONS
HIST0004438	EXCLUDING	REVISED SPECIFICATIONS OF PUREX PLANT SOLVENT EXTRACTION COLUMNS EXCLUDING IBS, 2A AND 2B
HIST0000014	EXECUTIVE	TRANSMITTAL OF AECEP EXECUTIVE SUMMARY
HIST0004222	EXECUTIVE	SAS EXECUTIVE SUMMARY - SEC. 1
HIST0004227	EXECUTIVE	SAS EXECUTIVE SUMMARY - SEC. 1
HIST0004228	EXECUTIVE	SAS EXECUTIVE SUMMARY - SEC. 1
HIST0004229	EXECUTIVE	SAS EXECUTIVE SUMMARY - SEC. 1
HIST0007406	EXECUTIVE	200 AREA PLATEAU PLAN EXECUTIVE SUMMARY
HIST0008018	EXECUTIVE	HANFORD LASER ISOTOPE SEPARATION DEPLOYMENT PROJECT PRELIMINARY CONCEPTUAL DESIGN REPORT EXECUTIVE
HIST0008019	EXECUTIVE	HANFORD LASER ISOTOPE SEPARATION DEPLOYMENT PROJECT PRELIMINARY CONCEPTUAL DESIGN REPORT EXECUTIVE
HIST0010499	EXECUTIVE	EXECUTIVE SUMMARY
HIST0010560	EXECUTIVE	N REACTOR MASTER SAFEGUARDS AND SECURITY AGREEMENT - EXECUTIVE SUMMARY
HIST0010561	EXECUTIVE	N REACTOR MASTER SAFEGUARDS AND SECURITY AGREEMENT - EXECUTIVE SUMMARY
HIST0010562	EXECUTIVE	N REACTOR MASTER SAFEGUARDS AND SECURITY AGREEMENT - EXECUTIVE SUMMARY

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REF NUMBER		
00000000040	HEALTH	HEALTH INSTRUMENT "ENVIRONS" REPORT FOR 1ST HALF OF SEPTEMBER 1946
00000000042	HEALTH	HEALTH INSTRUMENT SECTION REPORT FOR SEPTEMBER 1946
00000000053	HEALTH	HEALTH INSTRUMENT SECTION REPORT FOR NOVEMBER 1946
00000000061	HEALTH	HEALTH INSTRUMENT SECTION REPORT FOR DECEMBER 1946
[illegible]	HEALTH	HEALTH INSTRUMENT SECTION REPORT FOR JANUARY 1946
00000000069	HEALTH	HEALTH INSTRUMENT SECTION REPORT FOR FEBRUARY 1947
00000000075	HEALTH	HEALTH INSTRUMENT SECTION REPORT FOR MARCH 1947
00000000078	HEALTH	HEALTH INSTRUMENT SECTION REPORT FOR APRIL 1947
00000004287	HEALTH	ARHCO SAFETY AND HEALTH STANDARDS COMPLIANCE INSPECTION OF CENTRAL LANDFILL FACILITY
00000006047	HEALTH	TALK TO BE PRESENTED AT THE OCCUPATIONAL HEALTH NURSING COURSE.
00000016524	HEALTH	HEALTH, PHYSICS & BIOLOGY BRANCH WEEKLY & MONTHLY REPORTS - 1950
00000016525	HEALTH	HEALTH PHYSICS & BIOLOGY BRANCH WEEKLY & MONTHLY REPORTS - 1951
00000016794	HEALTH	MONITORING FOR NUC WEA TEST & LIAISON WITH PUBLIC HEALTH OFFICIALS
00000019468	HEALTH	MINUTES OF MEETING OF RLO & US PUBLIC HEALTH SERVICE ON COLUMBIA RIVER CONTAMINATION
00000019486	HEALTH	CLASSIFIED INFORMATION MEETING HEALTH PHYSICS OPERATIONS STANDPOINT
00000049149	HEALTH	OPERATIONAL HEALTH PHYSICS PRACTICES MANUAL
00000049150	HEALTH	OPERATIONS HEALTH PHYSICS PROCEDURES MANUAL
00000049151	HEALTH	OPERATIONS HEALTH PHYSICS PROCEDURES MANUAL 100 AREA
00000049152	HEALTH	OPERATIONS HEALTH PHYSICS PROCEDURES MANUAL 200 AREA
00000049153	HEALTH	OPERATIONS HEALTH PHYSICS PROCEDURES MANUAL 300 AND 400 AREA
00000049154	HEALTH	OPERATIONAL HEALTH PHYSICS ADMINISTRATIVE GUIDE
00000016174	HEARING	WAHLUKE SLOPE HEARING
00000040614	HEARING	STATEMENT OF E. V. BADOLATO - HEARING ON ADEQUACY OF SAS - 3/6/86
00000040615	HEARING	HEARING ON THE ADEQUACY OF SAS AT DOE NUCLEAR WEAPONS FACILITIES
00000040756	HEARING	TRANSCRIPT - CONTINUANCE OF 5/7/87 CLOSED HEARING ON DOE'S PERSONNEL CLEARANCE PROGRAM 7/15/87
00000045871	HEARING	TRANSCRIPT - MARCH 6, 1986, SUBCOMMITTEE ON OVERSIGHT & INVESTIGATIONS HEARING
00000020026	HEARINGS	ANALYSIS OF LINE 60 AND PU SCRAP INVENTORY FOR JCAE HEARINGS
00000020027	HEARINGS	ANALYSIS OF LINE 60 & PU SCRAP INVENTORY FOR JCAE HEARINGS
00000000103	HEAT	DCM-65-2160 VOL. 5 "CALCULATIONS OF HEAT GENERATION, NEUTRON & GAMMA DOSE"
00000000219	HEAT	PU-238 HEAT SOURCE PROGRAMS
00000001290	HEAT	PROJECT PROPOSAL HCP-638, FIRE SAFE HEAT TREATING FACILITY, 272-W.
00000003085	HEAT	HEAT CALCULATIONS FOR THE UNDERGROUND SYST EM
00000003520	HEAT	HEAT OF COMBUSTION OF SOLVENTS USED IN NUCLEAR FACILITIES.
00000003770	HEAT	HEAT TRANSMISSION TEST OF AN L-10 CLASS II SHIPPING CONTAINER
00000003854	HEAT	HEAT TRANSMISSION TEST OF AN L-3 CLASS II SHIPPING CONTAINER
00000004022	HEAT	CALCULATED EQUILIBRIUM HEAT LOSSES FROM 241-SX S AND U TANKS
00000004076	HEAT	DEPENDENCE OF STEADY-STATE PEAK CONCRETE TEMPERATURE UPON SALT CAKE HEAT GENERATION RATE FOR
00000004129	HEAT	DEPENDENCE OF STEADY-STATE PEAK CONCRETE TEMP UPON SALT CAKE AND SLUDGE HEAT GENERATION RATES IN
00000004166	HEAT	ESTIMATION OF UNDERGROUND STORAGE TANK SLUDGE HEAT FLUX
00000004328	HEAT	UNDERGROUND STORAGE TANKS HEAT TRANSFER ANALYSIS
00000004448	HEAT	ALTERNATIVES FOR THE REDUCTION OF HEAT IN THE AX TANK FARM SLUDGE
00000004538	HEAT	HEAT TRANSFER ANALYSES OF AIR COOLING DOUBLE-SHELL TANKS
00000004825	HEAT	HEAT TRANSFER ANALYSIS OF PLUTONIUM STORAGE CONTAINERS
00000005835	HEAT	FINAL REPORT-STRESS & HEAT TRANSFER ANALYSIS OF FISSION PRODUCTS SHIPPING CONTAINER
00000005836	HEAT	FINAL REPORT-STRESS & HEAT TRANSFER ANALYSIS OF FISSION PRODUCTS SHIPPING CONTAINER - APPENDICES D,
00000006085	HEAT	PROTOTYPE HEAT EXCHANGER FOR COOLING RADIOACTIVE SATURATED SOLUTIONS
00000006635	HEAT	BNIR-00129, S-36, 630, ALPHA EMITTING ISOTOPIC HEAT SOURCE
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00000007028	HEAT	APPARENT HIGH LEVEL WASTE HEAT INV IN WEST SX TANKS
00000007582	HEAT	RTG HEAT SOURCE PRODUCTION GUIDANCE (UNCL)
00000007931	HEAT	THE DISSIPATION OF REACTOR HEAT AT THE SAVANNAH RIVER PLANT
00000008303	HEAT	COBALT IRRADIATION HEAT TRANSFER
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00000008587	HEAT	PRODUCTION TEST AUTHORIZATION -023 HDS HEAT TREATMENT VARIABLES
00000008757	HEAT	HEAT TRANS CALCUL FOR PROD TEST AUTHORIZATION -021
00000009084	HEAT	HEAT LOAD ON CONFINEMENT SYSTEM FILTERS K REACTORS
00000009307	HEAT	INTERIM RPT ON IN-REACTOR HEAT GENERATION RATE OF NONFISSIONABLE MATERIALS
[illegible]09331	HEAT	RESULTS OF PTA-068, D-REACTOR HEAT DECAY
00000009403	HEAT	HEAT GENERATION IN UNCLOOLED DY203 HCR
00000009782	HEAT	REACTOR-TO RIVER EFFLUENT HEAT LOSSES
00000010093	HEAT	PTA-172, K REACTOR FULL FLOW HEAT TEST
00000010255	HEAT	SUMMARY OF PTA-023 HDS HEAT TREATMENT VARIABLES
00000010592	HEAT	FULL FLOW HEAT DECAY TEST: NUMERICAL RESULTS
00000011287	HEAT	NOTEBOOK - DEPLETED HEAT TREAT TEST, PT-093
00000013927	HEAT	HEAT SINK AND SHIPPING SUPPORT (APERATURE CARD)
00000013929	HEAT	HEAT SINK SANL 815-006 (APERATURE CARD)
00000013930	HEAT	HEAT SINK AND SHIPPING SUPPORT (APERATURE CARD)
00000013939	HEAT	HEAT SINK AND SHIPPING SUPPORT SANL 815-021-3 (APERATURE CARD)
00000013944	HEAT	HEAT SINK SANL 908-003 (APERATURE CARD)
00000013943	HEAT	HEAT SINK PELICAN 45 (APERATURE CARD)
00000017797	HEAT	PRODUCTION REACTOR EVALUATION PROJECT FINAL REPORT PT 5 HEAT TRANSFER & PHYSICS ANALYSIS
00000018792	HEAT	A FEASIBILITY STUDY APPLICATION FOR COOLING TOWERS FOR REDUCTION OF HANFORD HEAT LOAD COLUMBIA RIVE
00000018828	HEAT	DECAY HEAT TEST AT DR REACTOR
00000019217	HEAT	AUDIT OF HEAT TREATMENT AND AGING OPERATIONS, MC-1807 PROGRAM
00000019421	HEAT	AUDIT OF HEAT TREATING OPERATIONS 74-C PROGRAM
00000039975	HEAT	KFK-2857 CALCULATIONS OF HEAT GENERATION DURING STORAGE AND SOLIDIFICATION OF MEDIUM AND LOW-LEVEL
00000041623	HEAT	EVALUATION OF OVER-ALL HEAT TRANSFER COEFFICIENTS PUREX E-F6 AND E-H4 CONCENTRATORS PRELIMINARY
00000041907	HEAT	PROGRAMMED TUBE TO TUBESHEET WELDING ON HANFORD HEAT EXCHANGERS USED IN NUCLEAR PROCESSING SERVICE
00000042984	HEAT	SPECIAL STUDY INTERMEDIATE POWER LEVEL REACTOR POWER RECOVERY SYSTEM HEAT BALANCE #1 (APERATURE
00000043001	HEAT	GRAPHITE D.P.R. PLANT STUDY 55 HEAT BALANCE DIAGRAM NO. 2 (APERATURE CARD)
00000043002	HEAT	GRAPHITE D.P.R. PLANT STUDY 55 HEAT BALANCE DIAGRAM NO. 3 (APERATURE CARD)
00000043013	HEAT	GRAPHITE CONVECTION BOILING REACTOR HEAT BALANCE DIAGRAM (APERATURE CARD)
00000043062	HEAT	POWER RECOVERY HEAT BALANCE CASE #1 (APERATURE CARD)
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00000043079	HEAT	POWER RECOVERY STUDY #2 HEAT BALANCE CASE "C" (APERATURE CARD)
00000043087	HEAT	POWER RECOVERY STUDY #2 HEAT BALANCE CASE "B" (APERATURE CARD)
00000043088	HEAT	POWER RECOVERY STUDY #2 HEAT BALANCE CASE "D" (APERATURE CARD)
00000043089	HEAT	POWER RECOVERY STUDY #2 HEAT BALANCE CASE "D" (APERATURE CARD)
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00000043185	HEAT	HEAT BALANCE INITIAL INSTALLATION (APERATURE CARD)
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00000043246	HEAT	SYSTEM HEAT BALANCE PARALLEL HEAT EXCHANGERS (APERATURE CARD)
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00000011352	HEATED	COLUMBIA RIVER MODEL STUDIES, K-REACTOR DISPERSION OF HEATED PLUME
00000001420	HEATER	ELECTRIC IMMERSION HEATER FAILURES IN HANFORD WASTE SOLIDIFICATION PROGRAM - TASK FORCE REPORT
00000010015	HEATERS	ARGON PRESSURIZED HEATERS REQUEST FOR INFORMATION

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KEYWORD INDEX

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00000043507	EXCHANGE	PROCESS FLOW DIAGRAM NO. 7 OF 15 CESIUM ION EXCHANGE (APERATURE CARD)
000000[illegible]3508	EXCHANGE	PROCESS FLOW DIAGRAM CESIUM ION EXCHANGE (APERATURE CARD)
0[illegible]71	EXCHANGE	EXCHANGE OF DATA WITH U.K.
00000045192	EXCHANGE	[illegible]ANGE OF DATA WITH U.K.
00000045547	EXCHANGE	US/UK MATERIALS EXCHANGE
00000046371	EXCHANGE	ION EXCHANGE SYSTEM CONCEPTUAL DESIGN RPT PROJ H-501 N REACTOR SUPPLEMENTAL IRRADIATED FUEL STORAGE
00000048337	EXCHANGE	DRAFT AGENDA FOR TECHNICAL EXCHANGE MEETING (U)
00000050033	EXCHANGE	WAESD/HEDL TECHNCIAL EXCHANGE MEETING
00000015844	EXCHANGE-STATIS	URANIUM SAMPLE EXCHANGE-STATISTICAL ANALYSIS OF 2ND GROUP OF SAMPLE
00000005197	EXCHANGER	ION EXCHANGE COMPUTER PROGRAM FOR ZEOLON 900 CATION EXCHANGER
00000006085	EXCHANGER	PROTOTYPE HEAT EXCHANGER FOR COOLING RADIOACTIVE SATURATED SOLUTIONS
00000007008	EXCHANGER	CESIUM PURIFICATION WITH ZEOLON-900 CATION EXCHANGER
00000041907	EXCHANGERS	PROGRAMMED TUBE TO TUBESHEET WELDING ON HANFORD HEAT EXCHANGERS USED IN NUCLEAR PROCESSING SERVICE
00000043246	EXCHANGERS	SYSTEM HEAT BALANCE PARALLEL HEAT EXCHANGERS (APERATURE CARD)
00000006032	EXCITATION	D.C. ARC EXCITATION OF IMPURITIES IN PLUTONIUM DIOXIDE USING CARRIER DISTILLATION TECHNIQUES.
00000018979	EXCLUDING	SUMMARY OF PRODUCTION AND COST EXCLUDING DEPRECIATION
00000018980	EXCLUDING	DETAILS OF PRODUCTION AND COSTS EXCLUDING DEPRECIATION
00000019070	EXCLUDING	CASE X SUMMARY AND 100 AREAS ANNUAL COSTS, EXCLUDING DEPRECIATION
00000019166	EXCLUDING	SUMMARY OF UNIT COSTS EXCLUDING DEPRECIATION
00000016339	EXCLUSION	PROPOSED PLANS FOR THE 108-B EXCLUSION AREA
00000019247	EXCLUSION	EXCLUSION AREA EVALUATION
00000017547	EXCURSION-	SPECIAL INCIDENT REPORT POWER EXCURSION- H-REACTOR 9/29/57
00000039629	EXE	CPS/PC AUTOCAD CPSPC.EXE
00000040274	EXEC	PREDECISIONAL DRAFT INFORMATION - SIA:F VOL. 1 - EXEC. SUMMARY & TASK FORCE REPORT
00000040780	EXEC	SIA:F VOL 1, EXEC SUMMARY & TASK FORCE REPORT - FINAL DRAFT - DEC 1987
00000020304	EXECUTION-DUN	ANNUAL APPRAISAL BUDGET PREPARATION AND EXECUTION-DUN
00000000100	EXECUTIVE	TRANSMITTAL OF AFCEP EXECUTIVE SUMMARY
00000007231	EXECUTIVE	MATERIALS MANAGEMENT EXECUTIVE COMMITTEE (MMEC)
00000007234	EXECUTIVE	MATERIALS MANAGEMENT EXECUTIVE COMMITTEE (MMEC)
00000007235	EXECUTIVE	MATERIALS MANAGEMENT EXECUTIVE COMMITTEE (MMEC)
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00000007237	EXECUTIVE	MATERIALS MANAGEMENT EXECUTIVE COMMITTEE (MMEC)
00000007238	EXECUTIVE	MATERIAL MANAGEMENT EXECUTIVE COMMITTEE (MMEC)
00000007239	EXECUTIVE	MATERIALS MANAGEMENT EXECUTIVE COMMITTEE (MMEC)
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00000007241	EXECUTIVE	MATERIALS MANAGEMENT EXECUTIVE COMMITTEE (MMEC)
00000007243	EXECUTIVE	MATERIALS MANAGEMENT EXECUTIVE COMMITTEE (MMEC)
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00000007245	EXECUTIVE	MATERIALS MANAGEMENT EXECUTIVE COMMITTEE (MMEC)
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00000007248	EXECUTIVE	MATERIALS MANAGEMENT EXECUTIVE COMMITTEE (MMEC)
00000007251	EXECUTIVE	MATERIALS MANAGEMENT EXECUTIVE COMMITTEE (MMEC) SHIPPING GROUP PROGRESS REVIEW - SEPTEMBER 1987
00000007984	EXECUTIVE	OCTOBER 1986 MATERIALS MANAGEMENT EXECUTIVE COMMITTEE (MMEC) REPORT
00000007985	EXECUTIVE	NOVEMBER 1986 MATERIALS MANAGEMENT EXECUTIVE COMMITTEE (MMEC) REPORT
00000008131	EXECUTIVE	EXTENDED AUGMENTED MATERIALS PRODUCTION STUDY, VOL1, PT1, EXECUTIVE SUMMARY
00000008135	EXECUTIVE	EXTENDED AUGMENTED MATERIALS PRODUCTION STUDY VOL 1, PT 1 EXECUTIVE SUMMARY
00000008805	EXECUTIVE	DISCHARGE OF SODIUM DICHROMATE SOLUTION IN COMPLIANCE WITH EXECUTIVE ORDER 11258
00000039157	EXECUTIVE	EXECUTIVE PHONE DIRECTORY - BUILD YOUR OWN
00000039158	EXECUTIVE	EXECUTIVE PHONE DIRECTORY WITH MESSAGE FEATURE
00000039389	EXECUTIVE	EXECUTIVE OFFICE
00000040064	EXECUTIVE	MATERIALS MANAGEMENT EXECUTIVE COMMITTEE
00000040303	EXECUTIVE	HANFORD RESPONSE TO AL BACKUP PIT PRODUCTION FEASIBILITY STUDY SITE & ALTERNATIVE EVALUATION,

EXCHANGE * EXECUTIVE

UNC/DUN

KEYWORD
DOCUMENT-NUMBER DOC-DATE
------- D O C U M E N T -- T I T L E ---
******* A U T H O R (S) ***

HEAT DISSIPATION SYSTEM
RL-NRD-00148 01/05/65
N-REACTOR DEPARTMENT DESIGN COUNCIL MEETING NO. 4, DECEMBER 30, 1964.

MCMAHON, J S

RL-NRD-00671 09/01/65
TEMPERATURE DISTRIBUTION ALONG PATH OF REACTOR COOLANT.

BOCKER, R P

HEAT EXCHANGER TUBING
UNI-00044 07/18/73
RUPTURE MONITOR HEAT EXCHANGER COOLING WATER TREATMENT

RICHARDSON, C A · KRATZER, W K

UNI-00074 09/19/73
PRODUCTION TEST N-342 EVALUATION OF CHEMICAL ADDITION TO N REACTOR RUPTURE MONITOR HEAT EXCHANGER COOLING WATER

KRATZER, W K

UNI-00074 A 03/26/74
TEST CHANGE 1, ADD1 PRODUCTION TEST N-342 EVALUATION OF CHEMICAL ADDITION TO N REACTOR RUPTURE MONITOR HEAT EXCHANGER COOLING WATER
KRATZER, W K

UNI-00074 B 06/06/74
SUPPLEMENT 1, PRODUCTION TEST N-342 EVALUATION OF CHEMICAL ADDITION TO N REACTOR RUPTURE MONITOR HEAT EXCHANGER COOLING WATER
KRATZER, W K

UNI-00074 C 02/13/75
SUPPLEMENT 2, PRODUCTION TEST N-342, EVALUATION OF CHEMICAL ADDITION TO N REACTOR RUPTURE MONITOR HEAT EXCHANGER COOLING WATER
KRATZER, W K

UNI-00074 D 08/31/76
INTERIM REPORT, PRODUCTION TEST N-342, EVALUATION OF CHEMICAL ADDITION TO N REACTOR RUPTURE MONITOR HEAT EXCHANGER COOLING WATER
KRATZER, W K

UNI-00074 E 08/31/76
SUPPLEMENT 3, PRODUCTION TEST N-342, EVALUATION OF CHEMICAL ADDITION TO N REACTOR RUPTURE MONITOR HEAT EXCHANGER COOLING WATER
KRATZER, W K

KEYWORD
DOCUMENT-NUMBER DOC-DATE
------- D O C U M E N T -- T I T L E ---
******* A U T H O R (S) ***

HEAT EXCHANGER TUBING
UNI-02183 09/29/82
ENGINEERING STUDY GRAPHITE COOLING SYSTEM HEAT EXCHANGER NPFR PROJECT H-600 WBS 1.1.2.1.8 C.A. GB-50 P-210
RAINEY, T E

HEAT EXCHANGER VALVES
UNI-M-00082 REV1 02/05/82
SURVEILLANCE & SERVICES MAINTENANCE PROCEDURES

MARQUARD, M W

HEAT EXCHANGERS
DUN-05874 06/02/69
GRAPHITE COOLING SYSTEM HEAT EXCHANGER DECONTAMINATION PROCEDURE.

CLAUSING, J C JUNGHANS, C A

DUN-05876 06/06/69
OPERATING CONDITIONS AND REQUIREMENTS FOR DECONTAMINATING AN N REACTOR GRAPHITE COOLING SYSTEM HEAT EXCHANGER AT BLDG. 189 F.
KRATZER, W K

HW-82536 J 08/19/64
FINAL REPORT - DIVERSION SYSTEM RECUPERATIVE HEAT EXCHANGER AND SPILL COOLER TEST STARTUP TEST N-2, LOW POWER TESTING PROGRAM STEP 32.
EBENS, A J BERRETT, K L

RL-NRD-00014 10/19/64
A STUDY OF N-REACTORS REQUIRED PRIMARY LOOP OPERATING PRESSURES AND LIMITS FOR PHASE I AND PHASE II OPERATIONS WITH FIVE HEAT EXCHANGER CELLS.
JOHNSON, H G

RL-NRD-00353 05/06/65
MAIN HEAT EXCHANGERS - 100-N AREA.

DICKEMAN, R L

UNI-00109 12/14/73
TRIP REPORT: CURRENT OPERATING PRACTICES IN REACTOR FUEL STORAGE BASINS

LARRICK, A P GYDESEN, C H PETERSON, R S

UNI-00259 REV1 03/21/75
TDS (TEMPERATURE DATA SCAN) PROGRAM

ROBERTS, S G

UNITED STATES
ATOMIC ENERGY COMMISSION
RICHLAND OPERATIONS OFFICE
P. O. BOX 550
RICHLAND, WASHINGTON

RECEIVED
OCT 10 1963
R. L. DICKEMAN

IN REPLY REFER TO:
ECO:JMD

OCT 9 1963

General Electric Company
Hanford Atomic Products Operation
Richland, Washington

Attention: R. L. Dickeman, General Manager
N-Reactor Department

Subject: REPAIR OF HEAT EXCHANGER UNIT 4A - NEW PRODUCTION REACTOR

Gentlemen:

Burns and Roe, Inc. has been relieved of the responsibility for inspection and other engineer-ing activity for the repair of Heat Exchanger Unit Number 4A, effective as of October 14, 1963.

It is requested that the following engineering services be performed by General Electric Company to the extent necessary to complete the Heat Exchanger Unit repair:

1. Supervise the execution of repairs so as to assure adherence to approved drawings and specifications and repair procedures.

2. Check and approve all shop and working drawings and repair procedures submitted in connection with repair work to assure that they conform to repair criteria.

3. Make or procure such field or laboratory tests of workmanship and materials, and equipment, as the Commission may require or approve.

4. Inspect workmanship and materials, and equipment, and report to the Commission as to their conformity or nonconformity to the approved drawings and specifications and repair procedures.

5. Prepare reports and make recommendations on status of deliveries of materials and equipment as the Commission may require or approve.

6. Prepare monthly and other reports of the progress of repairs, as may be required and partial, interim, and final estimates and reports of quantities and values of repair work performed, for payment or other purposes.

7. Furnish record drawings, in such form and quantity as the Commission may require, showing repairs as actually accomplished.

8. Prepare the preliminary repair schedules for the Unit 4A Heat Exchanger covered by request and integrate these schedules with your operating schedules for the reactor plant: collaborate with and assist the general (CPFF) construction contractor in the preparation and modification of the construction schedules.

Burns and Roe, Inc. will be available for consultation as may be required.

Mr. George W. Wyss of our NPR Engineering Branch has been designated as the AEC Liaison Engineer.

Very truly yours,

John H. Krema

John H. Krema, Director
Construction Engineering
Division

54—4000—002

N-REACTOR DEPARTMENT

GENERAL ELECTRIC

RICHLAND, WASHINGTON
99352

ACCENT ON VALUE

October 8, 1963

A. B. Carson
M. H. Russ
E. M. Kratz
W. J. Mundt
W. D. Bainard
G. R. Hosack
W. D. Gilbert
W. R. Conley
J. M. Fox, Jr.
W. J. Love

HEAT EXCHANGER TUBING

Prior to operation, stress corrosion cracking has been detected inside the tube mouth of one of the primary loop heat exchangers and a novel type of intergranular attack has been encountered along the length inside a number of tubes of several primary loop heat exchangers.

Questions have been asked regarding the selection of 304 stainless tubing and the fabrication procedures which result in the 304 stainless steel being in a sensitized state. The two letters attached show the types of questions that are being asked.

Can you help us reconstruct the record leading to:

(a) The selection of 304 stainless steel tubing;

(b) Acceptance of 304 stainless steel tubing in a sensitized state?

In particular, we are interested in any contacts with Combustion Engineering, Burns and Roe, Kaiser Engineers, or the Atomic Energy Commission which could be interpreted that Combustion Engineering should or could use sensitized 304 stainless steel.

Should you have questions concerning this letter please call me on 942-1111 Extension 6-4033 - Area Code 509.

WM Harty

Manager
Process Design
N-Reactor Project
N-Reactor Department

WM Harty:rd
Attachments
cc: RL Dickeman
JS McMahon
CE Love
NO Strand
WM Harty-File
WM Harty-LB

RECEIVED
OCT 11 1963
R. L. DICKEMAN

50612175

UNITED STATES
ATOMIC ENERGY COMMISSION
Richland Operations Office
P.O. Box 550
Richland, Washington

In Reply Refer to
GC:CGB

September 12, 1963

General Electric Company
Hanford Atomic Products Operation
Richland, Washington

Attention: R. L. Dickeman, General Manager
N Reactor Department

Subject: NPR HEAT EXCHANGERS - USE OF 304 STAINLESS STEEL TUBING

Gentlemen:

It is apparent that, in analyzing the heat exchangers problem, and in further discussions of it with Combustion Engineering, we should have full knowledge of the position taken by all parties with respect to the advisability of using 304 stainless steel tubing. Although we have been given copies of minutes of some negotiating meetings in which this subject was discussed, it is quite possible that these minutes may be incomplete on this point. Furthermore, we believe other meetings were held or conversations occurred in which the use of 304 stainless steel was discussed where no minutes were kept.

It is requested that you discuss this problem with your personnel and give me a written report of any discussions they may have had or may have heard engaged in by others with Combustion Engineering either prior to or after the award of the purchase order with respect to the advisability of using 304 stainless steel tubing. It will be helpful if such report indicates whether such discussions related to manufacturing problems, operational problems, or both.

Very truly yours,

/s/ H. H. SCHIPPER

H. H. Schipper
Assistant Manager for
Technical Operations

C - O - P - Y

N-REACTOR DEPARTMENT
GENERAL ELECTRIC
Richland, Washington

September 16, 1963

J. S. McMahon, Manager
N-Reactor Project

NPR HEAT EXCHANGERS
USE OF 304 STAINLESS STEEL TUBING

I will need the record reconstructed during the period just preceding and following the award of the heat exchanger contract. This should include three elements: 1) a chronology setting forth all contracts, both formal and informal, written and verbal, between our responsible people and Combustion Engineering and/or Burns and Roe during this period, 2) a copy of all documentation or correspondence which sets forth an official company position, and 3) a statement from each of the General Electric personnel who could be considered to hold a responsible position, which records in detail the nature of any contacts which may have been held during this period; meeting minutes, if available, are also appropriate. We should attempt to have this material available by September 27, and from this a response to the Commission request will be generated.

/s/ R. L. DICKEMAN

General Manager

RL Dickeman:bs

Attach.

cc: CH Crandall
J Milne
RLD-2

C - O - P - Y

UNITED STATES
ATOMIC ENERGY COMMISSION
RICHLAND OPERATIONS OFFICE
P. O. BOX 550
RICHLAND, WASHINGTON

IN REPLY REFER TO:
GC:CGB

SEP 12 1963

RECEIVED
SEP 16 1963
R. L. DICKEMAN

J - 9-22

General Electric Company
Hanford Atomic Products Operation
Richland, Washington

Attention: R. L. Dickeman, General Manager
N Reactor Department

Subject: NPR HEAT EXCHANGERS - USE OF 304 STAINLESS STEEL TUBING

Gentlemen:

It is apparent that, in analyzing the heat exchangers problem, and in further discussions of it with Combustion Engineering, we should have full knowledge of the position taken by all parties with respect to the advisability of using 304 stainless steel tubing. Although we have been given copies of minutes of some negotiating meetings in which this subject was discussed, it is quite possible that these minutes may be incomplete on this point. Furthermore, we believe other meetings were held or conversations occurred in which the use of 304 stainless steel was discussed where no minutes were kept.

It is requested that you discuss this problem with your personnel and give me a written report of any discussions they may have had or may have heard engaged in by others with Combustion Engineering either prior to or after the award of the purchase order with respect to the advisability of using 304 stainless steel tubing. It will be helpful if such report indicates whether such discussions related to manufacturing problems, operational problems, or both.

Very truly yours,

H. H. Schipper
Assistant Manager for
Technical Operations

September 12, 1963

J. S. McMahon
Manager
N-Reactor Project
N-Reactor Department

RECEIVED
SEP 17 1963
R. L. DICKEMAN

HISTORY
HEAT EXCHANGER TUBING SPECIFICATION

May 15, 1959 — Specification HWS-6650, paragraph 7.1.b, "Tubing used for heat transfer shall be in accordance with Specification No. HWS-6853, for composition 304 corrosion-resisting steel. . . ."

Specification HWS-6853 "covers the manufacture of seamless and welded tubes and pipes, as specifically applied to Type 304 austenitic steel, ..." Amendment No. 1 to HWS-6853 dated June 18, 1959, "Delete 'as specifically applied to Type 304' and add the following, 'as applied to Types 304 and 316.'"

August 10, 1959 — Combustion Engineering offered 304, 304-L, 347, 316 stainless steel tubing.

September 8, 1959 — Burns and Roe classified tubing proposals as follows:
- Acceptable - Type 304
- Unacceptable - 304 ELC or 347
- Not tabulated - 3rd alternate

October 14, 1959 — Combustion Engineering quoted on use of 304 stainless steel material.

December 3, 1959 — C. R. Qualheim requested A. B. Carson for specific wording for alternate materials such as Inconel and carbon steel for use in negotiations with the successful heat exchanger vendor. A. B. Carson replied on December 9, 1959.

December 22, 1959 — Heat Exchanger Contract awarded.

January 25, 1960 — In a letter from J. S. McMahon to A. J. Loiacono of Burns and Roe, no further consideration was judged to be necessary for Combustion Engineering's proposals for Inconel tubing (increased cost $882,652) and carbon steel tubing ($504,700 reduction and eight weeks delay).

WM Harty:rd

Manager - Process Design
N-Reactor Project

cc: RL Dickeman
NO Strand
CE Love
WM Harty-File
WM Harty-LB

50612179

September 10, 1963

RECEIVED
SEP 1[illegible] 1963
R. L. DICKEMAN

J. S. McMahon (3)
Manager
N-Reactor Project

HEAT EXCHANGER TUBING INSPECTION

Appended is a copy of a report from J. E. Dempsey and J. C. Hamilton on "Resume of Tube Manufacture - Wallingford Steel Co.," dated July 3, 1963. Included are the bases for inspection, a description of fabrication steps not subjected to inspection, and tests made and/or observed by General Electric Inspection.

ORIGINAL SIGNED BY
W. M. HARTY

Manager
Process Design
N-Reactor Project

WM Harty:rd

cc: [illegible] Bush
→ RL Dickeman
JC Hamilton
CE Love
[illegible] Strand
WM Harty-File
WM Harty-LB

July 3, 1963

RESUME OF TUBE MANUFACTURE
WALLINGFORD STEEL CO.
5/8" OD - .049"/.053" Wall

This report will furnish the best information possible on the subject, and will include portions of the process for which Inspection was not responsible but did observe to some degree, for information only. Concurrent with the G. E. Inspection, Combustion Engineering assigned one to two senior representatives in the Wallingford plant. From the beginning of tube manufacture at Wallingford, G. E. Company had from one to four inspectors assigned to the inspection of tubing at the Wallingford plant. The basis for G. E. Inspection was Combustion's P.O. on Wallingford; B & R specs.; Combustion procedures; and Wallingford procedures.

Material Type 304 S/S coils were furnished from Allegheny Steel Co. to Wallingford specs. Coils were slit (rotary shears) into six strips. Strips in lengths sufficient to produce approximately 300 tubes were delivered to the tube department where it was cleaned and pickled and sometimes sanded, as required. It was then delivered to the two-sided welding mills for forming and welding. Forming was accomplished by drawing strip through forming rolls into dry box, Tungsten inert gas welding, no metal added. Tube at this point was 1-1/4" OD x .083" wall. Welding was a continuous process and ends of strips were tack welded together. As the tube progressed past the welding operation, it entered a booth containing two belt polishers which removed only the crown of the weld. Tube then passed through sizing rolls, then the tube was cut into 18' lengths. During most of the production, Wallingford elected to perform an OD dye check on the cut tubes. Other physical testing was performed by Wallingford including flare test, a crush test, and flattening test.

Tubes were cleaned, annealed, de-scaled by immersion in a salt bath, washed, soaped in a bath, set in a dry box and thoroughly dried.

Tube end was swaged and drawing commenced. From three to four draws were performed with cleaning, annealing and soaping between each draw. Soap used was a commercial soap with Wallingford proprietary additives added which caused adhesion of the soap to the ID and OD walls of the tube. Purpose of the soap was solely for draw lubrication.

The final anneal was a bright anneal in the muffle furnace. Finished drawn tubes were approximately 60' long. Tubes were straightened in Sutton-roll-type Straightener. The OD was polished by one pass through a belt polisher which was a coarse and fine belt.

Tube was then pickled and washed. These operations included agitation of pickling and washing fluids through the tube ID. Pickling resulted in a satin finish on tube ID and OD. The pickling solution was proprietary information.

Tubes were dried by air jets and blowing felt plugs through each tube until the plug came out dry.

Work accomplished to this stage of the fabrication was observed but not a part of our inspection responsibility.

The following physical tests were made and observed by G. E. Inspection:

1. 45° flare on each end of tube.
2. 180° bend on a 2" radius with weld on outside of bend. One from each tube.
3. Reverse bend of weld from each tube.
4. Two samples from each heat were macro-etched.

Failures were observed on Item 1 above, as well as Item 3. No failures were observed on Items 2 and 4, above. No failures resulted in rejection of total lot.

Tubing was then cut to lengths, according to the Combustion cutting schedule. Tubing was then subjected to the following non-destructive tests:

1. Dye check of OD.
2. Hydrostatic test, tap water used.
3. Eddy current test per specifications and standards supplied by Combustion.
4. X-ray, 0° and 90°, 0° being the weld.
5. Dimensional inspection, OD, wall, length and surface finish, electro-etch, heat, lot, tube number, etc.

The inspector observed indications resulting from above items as follows:

1. During the dye check inspection, indications were observed which were small, both linear and pits. All indications were explored by removal of metal by filing, redeveloping the surface and continuing until no indication was evident. A re-dye check of the area was then performed and if no indication was evident, the area was cleaned and observed by a 10X magnifying glass for evidence of a surface defect. If no evidence was present and minimum tube wall not impaired, the tube was considered acceptable to dye check inspection. Approximately 20% of the tubes inspected were rejected by dye check inspection because dye check indications could not be removed within minimum wall limitations. Certain lots of tubes displayed an appreciable quantity of this type defect on OD only while other lots had practically no tubes with this type defect. During the period when x-ray indications were being investigated, 25 to 35 tubes were split and dye checked on the ID. No indications were observed.

See Inspection Report 4-27-60. (Not appended)

2. Approximately six tubes of 20,000 accepted failed the Hydrostatic test. These were due to mechanical damage.

3. The loss of tubes due to failure of Eddy Current Test was minor in number.

4. Wallingford personnel, although not highly skilled in evaluating x-ray film, did perform an evaluation prior to submission to G. E. Co.. One-hundred per cent of all x-ray film was read by G. E. inspectors and the rejection of tubes by our reading approximated 2%. Several of the x-ray rejects were cut up to determine type of defect observed and in all cases we were unable to identify the indication shown by the x-ray. We are not aware of the number of tubes rejected by Wallingford inspectors prior to their submission to G. E.

5. Dimensional inspection presented no problem in inspection.

The tubes were then wiped clean with a cloth dampened with a cleaning solvent, wrapped in gummed-edge paper, boxed and shipped to Combustion Engineering. The ends of the tubes were sealed with a male plug at completion of the dimensional inspection.

Exhibit A attached is a tabulation of the yield from heat expressed in number of tubes by slab and heat. (Not appended)

Exhibit B attached is same data as Exhibit A converted to the average number of tubes per slab and expressing the yield in total number of feet per heat in the "as welded" condition, or 1 1/4" x .083" wall x 18' long. (Not appended)

Exhibit C attached tabulates all heat numbers from which we received finished tubing in the order they were released from the tube mill. (Not appended)

:mm

Attachments

cc: JR Dempsey
WM Hunt
Wallingford File

•4-4000-103 (11-62)
AEC-GE RICHLAND, WASH

GENERAL ELECTRIC
COMPANY

RICHLAND, WASHINGTON . . . TELEPHONE - AREA CODE 509, 942-1111

HANFORD ATOMIC
PRODUCTS OPERATION

N - REACTOR
DEPARTMENT

September 5, 1963

U.S. Atomic Energy Commission
Richland Operations Office
Richland, Washington

Attention: Mr. H.H. Schipper, Assistant Manager
for Technical Operations

Gentlemen:

TECHNICAL SUMMARY - N-REACTOR HEAT EXCHANGERS

Transmitted herewith are four (4) copies of a technical appraisal of the corrosion effects observed in the primary heat exchangers for N-Reactor. This appraisal has been prepared by Dr. S.H. Bush and derives from a thorough evaluation of the data we have obtained during on-site investigations and the technical facets of the fabrication history as we know them through inspection reports, certain documentation and verbal communication.

The present condition of each heat exchanger has now been well characterized. Although a conclusive "theory of the case", from a vigorous technical viewpoint, is not yet available the considerable body of evidence now available strongly suggests fabrication process related causes. Further, we find no plausible technical grounds for concluding that operational or environmental conditions introduced on-site have contributed measurably to the corrosion we observe.

Very truly yours,

R L Dickeman

General Manager

RL Dickeman:bs

Attach.

cc: 1-3. AEC-RLOO: Attn: Mr. HH Schipper

54-3000-084 (3-61)

GENERAL ELECTRIC

bcc: WE Johnson
H Fulton
GW Willis
JS McMahon - NO Strand
HM Parker - SH Bush
RLD-2
Record Center

PROJECT CAI-816

NEW PRODUCTION REACTOR

STEAM GENERATORS

MECHANISMS AND CAUSES OF TUBING FAILURES

September 5, 1963

Prepared By

S. H. Bush
Consulting Metallurgist
Reactor and Fuels Laboratory
Hanford Laboratories

September 5, 1963

MECHANISMS AND CAUSES OF TUBING FAILURES

INTRODUCTION

The following represents an analysis of the mechanisms and most probable causes of failure in the 304 stainless steel tubing contained in the "N" reactor steam generators. Two forms of attack have been observed: (1) Stress corrosion at the mouth of the tubes; (2) A form of localized intergranular attack occurring throughout the length of the tube.

This analysis is based on the latest available data. Obviously future results may invalidate or revise the hypotheses advanced at this time.

STRESS CORROSION

Classical stress corrosion can occur in many metals and alloys both ferrous and non-ferrous. In all instances two factors must be satisfied. There must be a tensile stress either uniaxial or multiaxial and there must be a suitable environment. In the case of austenitic stainless steels several environments are known to cause stress corrosion with the most common being halogens such as chlorides or fluorides in the presence of oxygen, or strong hydroxides with or without oxygen present.

The stress corrosion observed in this case was immediately adjacent to the weld which attached the 304 stainless steel tube to the tube sheet. A cross section of the tube-to-tube sheet geometry is given in Figure 1. Because of the fabrication history of these steam generators, a pronounced stress gradient exists in the vicinity of the tube mouth as axial and hoop stresses. An idealized sketch of the stress distribution is given in Figure 1. The stresses resulted from the tube being rolled into the carbon steel sheet, welded in place, then the entire vessel was subjected to a heat treatment to stress relieve the welds in the carbon steel. This heat treatment at 1125-1150 F for 6-10 hours relieved the weld stresses, but it also thoroughly sensitized the 304 stainless steel by precipitating the carbides and generated severe residual stresses because of the dissimilar coefficients of thermal expansion of carbon and stainless steels. The calculated stresses are well above the elastic limit of the 304 stainless steels so that it is highly probable that there is a high level of residual stress near the tube mouth, decaying rapidly to values near zero within the first 0.5-1.0 inch. Therefore, the first requirement for stress corrosion is known to exist in all the steam generators.

Corrosive Environment

An examination of potential corrosive environment reveals several possibilities: (1) Fluorides were present in the coating of the weld electrodes used in joining the tubes to the tube sheet. In several instances flux deposits have been observed in metallography specimens; (2) Chattanooga city water is high in chlorides and there was definite evidence of retention of water in the tube-to-tube sheet annulus; (3) The tube rolling lubricant is known to contain a variable but substantial amount of chlorides; (4) The vapor phase inhibitor (VPI) introduced at Hanford contains both chlorides and fluorides; (5) Several steps at the tube mill were potential sources of contamination if the tube surfaces were not cleaned adequately; in this category one would include drawing lubricants (chlorides or hydroxides), descaling baths (hydroxides), and pickling baths (fluorides); (6) The soap solution used in bubble testing 3B; (7) The chemicals and other materials used in cleaning the steam generators; and (8) Various sources not directly listed such as inhibitors or materials introduced by accident.

Failure History

While it appears that all of the steam generators have been exposed to the necessary conditions of stress and corrosive environment, only unit 3B has been found to contain stress corrosion cracking to an observable degree based on fluorescent penetrant examination, partial eddy current testing, and extensive metallographic investigation of selected sections from all steam generators.

The attack in 3B occurred in more than one-half of the tube ends and was limited to the first 0.5 to 1.0 inch of tube measuring from the weld. Extensive cracking exists on the inner surface of the tubes in this region; equally extensive cracking has been observed on the outer surfaces of several tubes removed from the tube sheet of 3B. In most but not all instances where cracking occurred on both surfaces, there had been complete penetration of the tube wall by one or more stress corrosion cracks.

Examination of the stress corrosion cracks revealed both transgranular and intergranular attack. Both of these are possible in tubing with such a history. The transgranular cracking can occur in highly stressed areas in sensitized or in stressed unsensitized tubing. Not too surprisingly the transgranular cracks occur near the surface and as they approach the neutral axis often change to intergranular cracks which are most common in a sensitized stainless steel. The cracks are oriented axially in most instances, indicating that the hoop stresses are controlling rather than the axial bending stresses. In some instances 45 degree cracks bear out the combined effects of hoop and axial stresses. Normally these are near the tube mouth. Typical examples of stress corrosion cracking are given in Figure 1.

Unit 3B History

Since the stress corrosion cracking is limited to unit 3B, the question arises concerning differences in fabrication history in this unit compared to the others. There appear to be several factors meriting close examination. These are: (1) Unit 3B was the first steam generator built; even so this was only slightly ahead of 3A, the second unit; (2) One heat of steel 26469 was used solely in 3B based on CE records; (3) At least one tube from 3B, heat number unknown, displayed an unduly high corrosion rate in the Huey test, possibly indicating the presence of foreign elements in the steel; (4) The soap bubble test for leaks was limited to 3B and soap contains hydroxyl ions; (5) The cleaning of this unit was quite unsatisfactory. After two water cleanings, a grease-like residue remained so that steam cleaning had to be used ultimately; (6) Different cleansers and inhibitors were used in 3B than in the other units. For example, the citric acid, pH, and ammonia content varied; (7) The response of the inhibitor film to the boiling nitric acid in the Huey test was much different from that observed in the other Huey tests; the film was very tenacious and resistant to attack. Several hours elapsed before it began to strip off and dissolve. This indicates differences in film and/or substrate composition.

These differences are quite real, but it is difficult to assess their significance in generating stress corrosion cracks. The most suspicious condition is the cleaning operation. The lack of success, greasy residue reported, and response in the Huey test leads one to suspect this step.

Probable Causes

If one analyzes all of the steam generators, the obvious conclusion is that they have the built-in stress distribution and have seen agents known to cause stress corrosion cracking; yet such attack is limited to 3B. This limitation tends to invalidate conditions after arrival at Hanford unless something unique can be established in treatment or exposure. All units were exposed to VPI for comparable periods; all units saw rolling lubricants. The unique difference appears to be in the heat of steel or in the cleaning. Belief that the Heat 26469 was responsible is stultified by the cracking noted in the short K-7 and K-8 lengths, since no tubes made of these lengths were fabricated from this heat. It appears as if an agent could be sealed in on both the primary and secondary sides of the tubes. This appears to be most feasible if one analyzes the crack distribution in the failed tubes. If the corrodent is limited to one face, either primary or secondary, one must assume a mobility of the agent in the absence of other than trace quantities of water. This agent must progress through the crack until penetration occurs then diffuse along the wall and around the circumference to generate the observed pattern of cracks. While this is remotely possible, it appears much more improbable than does the case where the corrodent was in place on both surfaces as a result of fabrication followed by inadequate cleaning. The extended periods at temperatures exceeding 100 F during layup could have resulted in penetration of cracks.

It appears highly unlikely that an agent introduced dry on the primary side or accidentally on the secondary could penetrate the annular crack to the vicinity of the weld; rather one suspects an agent already there.

Conclusions

The limiting of stress corrosion to unit 3B whereas the stress pattern and potential corrodents exist in all units points to specific differences in the fabrication history of unit 3B compared to the others. The most probable cause is believed to be in the cleaning process. A less likely source is the composition of the major heat of steel used in this unit. The pattern of attack both ID and OD, absence in other units, and lack of gross wetness during layup points to a contaminant introduced during fabrication rather than to one during layup.

INTERGRANULAR CORROSION

The intergranular attack originally detected by eddy current tests appears to be relatively unique. A search of the literature as well as extended conversations with experts in the field of corrosion has not revealed similar cases. Representative examples of such attack are presented in Figure 2. In essence the regions of attack are roughly hemispherical in shape. There appears to be no directionality axially. Penetrations as great as 80-90 per cent of the wall have been observed. In every instance checked metallographically the attack was limited to the grain boundaries with pronounced intergranular attack noted in the etched and unetched conditions.

Pattern of Attack

Two units, 2A and 4A, appear to be most severely affected by the IG attack. Penetrations through the tube wall exceed 80 per cent in better than 16 per cent of the tubes in 2A and approach 50 per cent in 4A.

There are several factors observed in these units (2A and 4A) that tend to establish when the corrodent was introduced, but not necessarily what corrodent was responsible. Before considering these factors, the probable causes of such attack should be analyzed. A critical step in such attack in all probability was the sensitization of the tubing through the stress relief heat treatment. While it is known that unsensitized stainless steels can be attacked intergranularly by strong caustics, such attack is much more probable in the sensitized state, and many more chemical agents are known to attack austenitic stainless steels while in this state. For example many of the strong acids such as nitric, hydrofluoric, and hydrochloric will selectively attack the grain boundaries in the sensitized state.

Returning to a listing of the unique features observed in the intergranular attack, these are: (1) A great majority of the tubes tested have IG attack in one half, but not the other; such attack occurring in part of a tube but not the other leads one to suspect an inadequate rinsing procedure after pickling, or to inadequate cleaning in a late stage of tube fabrication; (2) The essentially circular shape observed on the inner surface of the tube is indicative of a corrodent deposited in or after the final stages of fabrication. Attack during earlier stages of fabrication or selective attack of impurities should result in axial extension of the areas of attack. This was not observed; (3) Many tubes reveal several areas of IG attack aligned linearly; these regions of linear alignment varied in o'clock position from tube to tube in the steam generator. For example, one tube may have IG attack at 12 o'clock, the next 6, another 9, etc. Such a pattern is strongly indicative of introduction of the corrodent prior to rather than after installation of the tubes into the steam generator; (4) In almost every instance the attack originates on the inside rather than the outside of the tube. Of the many thousands of areas mapped in unit 2A, only three have been determined to have originated on the outer surface. This isn't too surprising when one considers the difficulty of cleaning the inside of a tube compared to the outside. If such attack was due to an agent introduced after shipment, a logical question is why isn't there a great deal more attack on the external surface, assuming that both sides saw the agent, or if only the inner surface saw the agent, why should there be any attack on the outside. The probability of such attack being initiated in the tube mill due to inadequate cleaning is felt to be quite high; (5) The severe stratification of attack in the longer tubes in unit 2A is indicative of lack of cleaning, again due to the difficulty in tubes exceeding 50 feet in length. Such a stratification is not at all compatible with the premise of an introduction of a corrodent after installation of the units. Particularly striking is the overall pattern in 2A where a majority of the longer tubes in the upper bank display areas of IG attack; the exception noted in the upper central section of the tube bank is balanced by a similar attack at the other ends of these tubes. Such a pattern is strongly indicative of a corrodent introduced prior to installation of the tubes. In fact it can be accepted as prima-facie evidence that the corrodent must have been introduced prior to installation in the tube sheet; (6) There is a possibility that selective carburization of the inner surfaces occurred during the cracked ammonia heat treatment. This can neither be confirmed nor denied at this time.

Possible Causes

If one considers the preceding factors, the most probable culprits must be introduced in the final stages of tube fabrication but prior to installation. An obviously suspicious step is the final bright pickle consisting of immersion in a nitric - 3 per cent hydrofluoric acid bath followed by washing. There is no doubt that the tubes, which were supposedly thoroughly dried after washing, were still wet. A substantial number were rejected during the ultrasonic test due to water. This was observed in tubes containing end caps at the tube mill which had not been removed from that time until after the ultrasonic test.

Another interesting item also detected in the ultrasonic test was the substantial rejection rate due to a loss of signal caused by excessive roughness of the ID. Such roughness is strongly indicative of overetching during or after the bright pickle. Apparently the crux of such an attack was in the sensitization of the tubes. If a corrodent still existed in a concentrated state, such as dried droplets, then the sensitizing heat treatment would put the tubing in a condition for rapid, selective, intergranular attack rather than a bulk type of attack. Obviously this assumes several things: (1) The introduction of a corrodent; (2) Its inadequate removal during washing; (3) Its retention as a deposit in the quiescent state; (4) Retention of the corrodent during heat treatment; (5) Eventual reactivation of the corrodent during cleaning or hydro testing. This chain of events has not been confirmed, but it does appear possible. How possible is yet to be established.

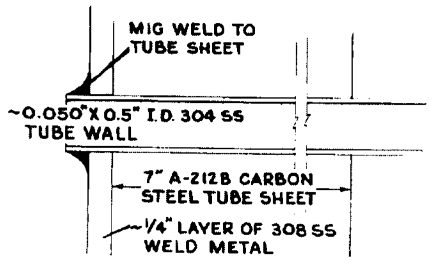
If one assumes the retention of a corrodent in roughened areas of the tube, then the key steps leading to the attack would be the sensitization heat treatment, reactivation of corrodent, and sufficient time to permit reaction of the corrodent. The latter might occur in a relatively short period with strong acids.

Conclusions

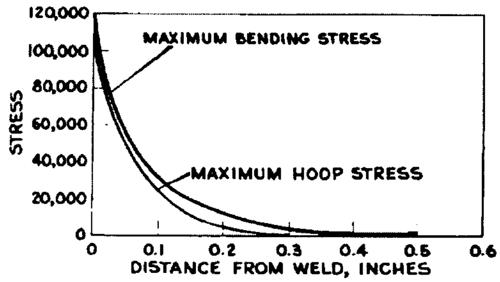
The attack pattern noted in the overall tube sheet, selective stratification, linearity of attack in any one tube but random pattern from tube to tube, location on the inner surfaces of the tubing, and preferential locations at one end of the tube all confirm the hypothesis of a corrodent introduced in the tube mill during the final stages of tube fabrication rather than at the fabrication site or at the installation site. A major factor in the intergranular attack was the sensitization of the tubes. The role of time cannot be assessed but it is believed to be a minus factor. It is probable that the original corrodent has reacted and is no longer a factor; however, there is the possibility of introducing other corrodents into the attacked areas resulting in enlargement and eventual penetration of the tubes.

STRESS CORROSION CRACKING

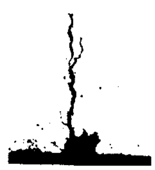
N REACTOR STEAM GENERATOR 3B
MATERIAL 304 STAINLESS STEEL



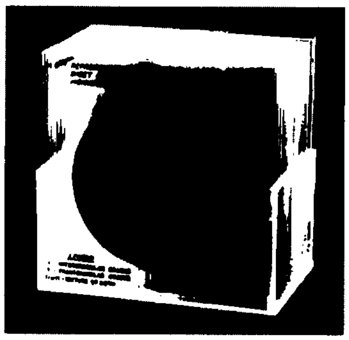
CROSS SECTION OF TUBE JOINT



CALCULATED STRESS DISTRIBUTION IN TUBE AFTER HEAT TREATMENT



TRANSGRANULAR STRESS CORROSION CRACK INITIATED AT PIT MAG. 250X



DISTRIBUTION OF STRESS CORROSION CRACKS IN A TYPICAL TUBE FROM 3B

TRANSGRANULAR CRACK CHANGING TO INTERGRANULAR MAG. 50X

TRANSGRANULAR CRACK INITIATING ON INTERNAL SURFACE AND PROPAGATING ACROSS TUBE WALL MAG. 100X

EXAMPLE OF CRACKING OF TUBE & 308 WELD OVERLAY MAG. 250X

INTERGRANULAR CRACK INITIATING ON OUTER SURFACE AND PROPAGATING NEARLY THROUGH TUBE WALL MAG. 100X

TRANSGRANULAR CRACK INITIATED AT PIT ON INNER SURFACE MAG. 500X

CONTRIBUTING FACTORS IN STRESS CORROSION OF AUSTENITIC STAINLESS STEELS (1) TENSILE STRESSES, (2) CORROSIVE ENVIRONMENT SUCH AS CHLORIDE OR FLUORIDE, (3) OXYGEN

G-102-600

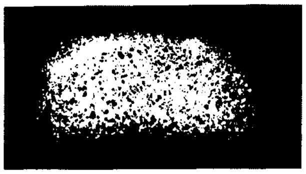
GENERAL ELECTRIC COMPANY
PHOTOGRAPHY OPERATION
300 AREA, 3706 BLDG.
HANFORD ATOMIC PRODUCTS OPERATION
REQUEST NO. 0631588-10

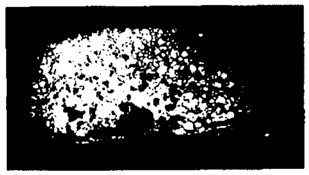
50612196

INTERGRANULAR CORROSION

"N" REACTOR STEAM GENERATORS 2A & 4A—MATERIAL - 304 STAINLESS STEEL TUBING

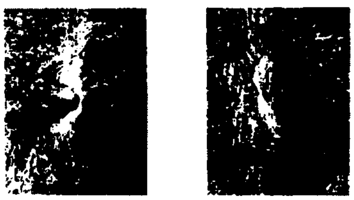
THIS ATTACK HAS BEEN LOCALIZED IN NATURE AND HAS NEVER BEEN OBSERVED ON THE OUTER SURFACE.





REPRESENTATIVE EXAMPLES OF INTERGRANULAR ATTACK IN TRANSVERSE SECTIONS. MAG. 50X

REPRESENTATIVE EXAMPLES OF I.G. ATTACK IN LONGITUDINAL SECTION SECTIONS. MAG. 50X



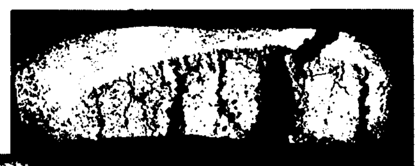
OUTER SURFACE
MAG. 22 X

TYPICAL FAILURES IN SECTIONS CONTAINING I.G. DEFECTS AFTER HYDRAULIC LOADING

INNER SURFACE
MAG. 22X

INNER SURFACE- 22X

CROSS SECTION - MAG. 50X



CROSS SECTION- MAG. 50X

LONGITUDINAL SECTION - MAG. 50X

FAILURE OCCURRED AT HOOP STRESSES OF 34,000 AND 42,000 PSI AT 300 C VS ANTICIPATED VALUES OF 80,000 - 90,000 PSI

HYDRAULIC PRESSURES WERE 6800-8400 PSI, MUCH GREATER THAN OPERATING PRESSURES.

G-102-601

FIGURE 2

GENERAL ELECTRIC COMPANY
PHOTOGRAPHY OPERATION
300 AREA, 3706 BLDG.
HANFORD ATOMIC PRODUCTS OPERATION
REQUEST NO. 0631588-9

ADDRESS REPLY TO
FIELD OFFICE:
P. O. BOX 788
RICHLAND, WASHINGTON

BURNS AND ROE, INC.
ENGINEERS AND CONSTRUCTORS
160 WEST BROADWAY
NEW YORK 13, N. Y.
TEL. RECTOR 2-7000

NEW PRODUCTION REACTOR PROGRAM
U.S. ATOMIC ENERGY COMMISSION
RICHLAND, WASHINGTON

KE requested Graver Tank Co. to repair painting in demineralizer tank by letter dated 9/3/63
Q 9/11/63

September 4, 1963

SUBJECT: W. O. 1849 - NPR - HAN
Contract No. AT(45-1) 1239
New Production Reactor Program
AFTERHEAT REMOVAL AND DEMINERALIZED WATER STORAGE TANK

REF: 1. AEC Ltr, 7-12-63, HH Schipper to GW Willis, RL Dickeman and H Fulton
2. B&R Ltr, 8-23-63, GW Willis to HH Schipper
3. AEC Ltr, 8-28-63, JH Krema to GW Willis

Construction Engineering Division
Atomic Energy Commission
P. O. Box 550
Richland, Washington

Attn: John H. Krema, Director
Construction Engineering Division

Gentlemen:

We have reviewed our letter of August 23, 1963, reference 2, and we feel that the question asked in your letter of July 12, 1963, reference 1, was answered.

In order to comply with the requirements of your letter of August 28, 1963, reference 3, we will re-phrase certain opinions expressed in our letter of August 23, 1963, reference 2, in the following manner:

1. From July 25, 1963 through August 6, 1963, the membrane or diaphragm was operated in the Demineralized Water Tank to the extent necessary to demonstrate design compliance with the technical specifications.

2. Prior to July 25, 1963 a sample of the membrane material was tested for strength at General Electric laboratory and found to meet specification requirements.

3. Prior to July 25, 1963 Burns and Roe Title III inspectors had accepted Graver Tank Company's installation as complying with plans and specifications.

It is the opinion of Burns and Roe, Inc., that Graver Tank Company has satisfied the technical contract specifications for the design, furnishing and installation of the membrane or diaphragm.

In regards to the application of the protective coating on the interior of the subject tanks, it is Burns and Roe, Inc.'s opinion that the Graver Tank Company has not satisfied the technical requirements of the contract specification, refer to Burns and Roe, Inc.'s letter of August 23, 1963, reference 2.

The A. E. C. letter of July 12, 1963 requests a reply as to whether Graver Tank Company has satisfactorily completed its contractual obligations. Burns and Roe, Inc.'s opinion is that Graver Tank Company has not satisfactorily completed their contractual obligations.

Very truly yours,

Giles W. Willis
Resident Project Manager

GWW:db

94-4000-102 (11-62)
AEC-GE RICHLAND, WASH

GENERAL ELECTRIC
COMPANY

RICHLAND, WASHINGTON . . . TELEPHONE - AREA CODE 509, 942-1111

HANFORD ATOMIC
PRODUCTS OPERATION

N - REACTOR
DEPARTMENT

September 3, 1963

Mr. John T. Conway
Executive Director
Joint Committee on Atomic Energy
Capitol Building
Washington 25, D.C.

Dear Mr. Conway:

STATUS OF HEAT EXCHANGERS - N-REACTOR

I am submitting a brief summary of the results of our studies of the heat exchangers provided for N-Reactor (New Production Reactor) in accordance with your recent discussions with Mr. W. E. Johnson.

Physical Description

The heat in the primary coolant is removed through steam generated in ten horizontally oriented U tube type heat exchangers. During the production-only phase of operations the steam is quenched in condensers cooled by Columbia River water; in an electrical power generating phase of operations (dual-purpose or power-only) the steam is passed through the turbines being provided by the Washington Public Power Supply System and condensed upon discharge.

Each heat exchanger contains 2000 horizontal U-tubes of type 304 stainless steel which are about 0.5 inches in diameter, possess a 0.050 inch wall and average about fifty feet in over-all length. Both the inlet and outlet ends of the U-tubes carrying the primary coolant are attached to a centrally located cylindrical manifold, or tube sheet, of carbon steel which is some six inches thick. The 304 stainless steel tubes are rolled into penetrations in this manifold and fixed with a fillet weld to a quarter inch 304 stainless steel manifold lining provided for this purpose. In this design the residual stresses in the stainless steel tubing are concentrated in the region of the tube end to manifold weld. It is also pertinent that the entire heat exchanger was heat treated after assembly under time-temperature conditions which placed the 304 steel tubes in the sensitized condition.

The heat exchangers function as pairs in a parallel relationship with each of the five pairs physically isolated to permit maintenance while the reactor is operating. A reduction in reactor output is necessary when heat exchanger units are removed from service but the full impact of a reactor outage does not result. Conversely, during the initial startup period the full complement of heat exchangers is not required under this arrangement.

Physical Condition

Hydrostatic tests at 2740 pounds pressure (versus 1820 pounds maximum operating pressure) revealed leakage from the primary to the secondary side in two of the ten exchangers. Very intensive metallurgical studies have since been carried forward using dye penetrant methods, refined eddy-current testing techniques and metallographic examinations in an effort to characterize the problem.

A) Stress Corrosion

One of the ten exchangers (Unit 3B) was found to contain severe stress corrosion in the 304 steel tubes at the fillet weld location; that is, the location of maximum residual stress. The stress corrosion is of both the transgranular and intergranular type, is localized in the initial 0.5 inch of tube length and radiates from both the internal and external tube surfaces at this location. In addition to stress, oxygen and a reagent, such as a chloride, are required to promote this type of corrosion. Nine of the ten units are free of this type of attack and the source of the problem in Unit 3B most probably resides at some point in the fabrication history.

B) Intergranular Corrosion

During the investigations for stress corrosion our eddy current techniques revealed a rather widespread intergranular corrosion attack of a unique nature. This consists of localized spots of intergranular corrosion which are about 0.150 inches at the base and which penetrate into the tube wall. The incidence of tubes containing one or more "spots" of severe localized attack varies widely among heat exchangers. This general type of corrosion is rather common in a sensitized high carbon stainless steel which has been subjected to a corrosive media, such as an etching acid, with incomplete rinsing and passivation steps. The localized "spotting", however, is unusual and as yet a complete theory of the case is not available.

C) <u>Status Summary</u>

The detailed examinations have now been largely completed and the condition of these units is summarized as follows:

1) <u>Cell #5 - (Units 5A and 5B)</u>

Heat exchangers 5A and 5B successfully withstood the hydrostatic test and are judged to be free of stress corrosion. Fewer than one per cent of the tubes have been determined to contain severe intergranular attack and both heat exchangers have been placed in service.

2) <u>Cell #1 - (Units 1A and 1B)</u>

Heat exchangers 1A and 1B also successfully withstood the hydrostatic test and were found to be free of stress corrosion. As was true of the units above, less than one per cent of the tubes in these units were determined to contain severe intergranular attack and both of these heat exchangers have now been placed in service.

3) <u>Cell #2 - (Units 2A and 2B)</u>

Heat exchangers 2A and 2B successfully completed the hydrostatic test and were free of stress corrosion. Less than one per cent of the tubes in Unit 2B contained severe intergranular corrosion attack; however, sixteen per cent of the tubes in Unit 2A do contain localized attack.

GENERAL ELECTRIC

We have elected to place the cell #2 heat exchangers in service on the basis that the performance of Unit 2A should provide a valuable correlation between non-destructive test results and actual tube failure experience. The risks are low in that the tubes indicated as defective can be plugged at any time the tube failure experience should develop adversely. This plugging operation is inexpensive and the reduction in heat transfer surface is in the order of the excess above design level available in that Unit.

4) Cell #3 -(Units 3A and 3B)

Unit 3A has successfully passed all tests and is considered to be available for service. However, the companion unit (Unit 3B) contains the extensive and severe stress corrosion at the tube mouth location; this unit must be repaired before Cell #3 can be placed in service.

Several alternate repair methods are available; we expect to adopt a simple method of rolling a short inconel sleeve into the tube mouth - thus lining the correded portion of the stainless steel tube with the inconcel insert. Thus, repair can be accomplished without dismantling the exchanger and should be completed by December 31, 1963 at a cost estimated to be less than $100,000.

5) Cell #4 - (Units 4A and 4B)

Heat exchanger 4B has successfully passed all tests and is now available for service. However, the companion unit in this cell (Unit 4A) is severely attacked by intergranular corrosion; approximately fifty per cent of the tubes contain at least one point at which intergranular corrosion has progressed through fifty per cent or more of the tube wall. The decision relative to corrective measures on the 4A unit should be made by September 15.

54-3000-084 (3-61)

GENERAL ELECTRIC

D) **Status Summary**

We have now determined that eight of the ten heat exchangers are serviceable without repair. One (Unit 3B) is severely attacked by stress corrosion but at a location which lends itself to prompt and relatively inexpensive repairs; the repair should be completed this year. The second (Unit 4A) is severely attacked by intergranular corrosion; it may be necessary to retube this unit and, if this is necessary, a period of about one year will be required to return the unit to service.

Program Impact

We now judge that the heat exchanger problem will have no significant adverse impact on the attainment of operational schedules and objectives. This favorable judgment obtains because the requirements during the next year can be satisfied with less than the installed capacity. The program schedule, number of units required and number expected to be available are shown on the attached chart for your detailed information.

Three cells have now been released for service; these will satisfy the pre-operational testing needs and will carry the reactor to about 65 per-cent of rated power. The fourth cell (Cell #3) will be in service by December 31, 1963 and the capacity to achieve 85 per cent of rated reactor power is then available. The scheduled availability of the fifth cell (Cell #4) depends upon the action we deem appropriate in the case of unit 4A; however, even a one year retubing program will make this cell available well before it is demanded by the power ascension program. Of course, the sixth cell being installed by the Washington Public Power Supply System provides further capacity and flexibility.

The impact on project cost should not be major. Specifically, the correction of this problem is not expected to generate an overrun relative to the Project Estimate provided earlier this year by the Atomic Energy Commission.

GENERAL ELECTRIC

One further observation is pertinent. The heat exchangers for N-Reactor have now been researched more thoroughly than any previously fabricated to our knowledge. It is quite probable that many of the units in service are operating satisfactorily with defects comparable in severity to those we observe. We are proceeding cautiously but are encouraged by the ability to accommodate the problem without major adverse impact on schedules or objectives.

Very truly yours,

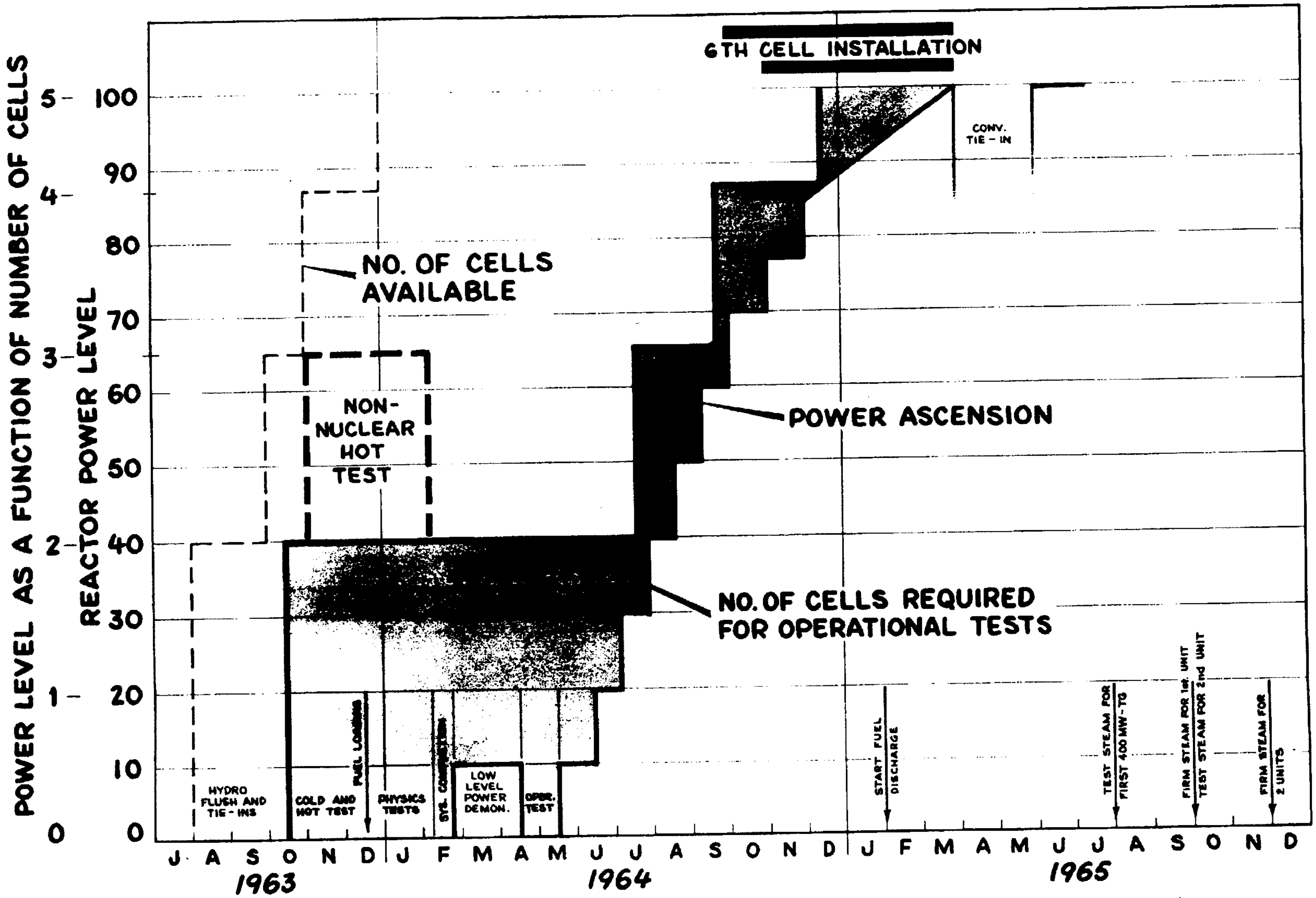
General Manager
N-Reactor Department

RL Dickeman:bs

Attach.

cc: WE Johnson (2)
HH Schipper
RLD-2

EFFECT OF STEAM GENERATOR OUTAGE ON REACTOR STARTUP



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54-4000-102 (11-62)
AEC-GE RICHLAND, WASH

GENERAL ELECTRIC
COMPANY

RICHLAND, WASHINGTON . . . TELEPHONE - AREA CODE 509, 942-1111

HANFORD ATOMIC
PRODUCTS OPERATION

N - REACTOR
DEPARTMENT

September 3, 1963

Mr. John T. Conway
Executive Director
Joint Committee on Atomic Energy
Capitol Building
Washington 25, D.C.

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The heat exchangers function as pairs in a parallel relationship with each of the five pairs physically isolated to permit maintenance while the reactor is operating. A reduction in reactor output is necessary when heat exchanger units are removed from service but the full impact of a reactor outage does not result. Conversely, during the initial startup period the full complement of heat exchangers is not required under this arrangement.

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4) Cell #3 -(Units 3A and 3B)

Unit 3A has successfully passed all tests and is considered to be available for service. However, the companion unit (Unit 3B) contains the extensive and severe stress corrosion at the tube mouth location; this unit must be repaired before Cell #3 can be placed in service.

Several alternate repair methods are available; we expect to adopt a simple method of rolling a short inconel sleeve into the tube mouth thus lining the corroded portion of the stainless steel tube with the inconcel insert. Thus, repair can be accomplished without dismantling the exchanger and should be completed by December 31, 1963 at a cost estimated to be less than $100,000.

5) Cell #4 - (Units 4A and 4B)

Heat exchanger 4B has successfully passed all tests and is now available for service. However, the companion unit in this cell (Unit 4A) is severely attacked by inter-granular corrosion; approximately fifty per cent of the tubes contain at least one point at which intergranular corrosion has progressed through fifty per cent or more of the tube wall. The decision relative to corrective measures on the 4A unit should be made by September 15.

GENERAL ELECTRIC

D) Status Summary

We have now determined that eight of the ten heat exchangers are serviceable without repair. One (Unit 3B) is severely attacked by stress corrosion but at a location which lends itself to prompt and relatively inexpensive repairs; the repair should be completed this year. The second (Unit 4A) is severely attacked by intergranular corrosion; it may be necessary to retube this unit and, if this is necessary, a period of about one year will be required to return the unit to service.

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Very truly yours,

General Manager
N-Reactor Department

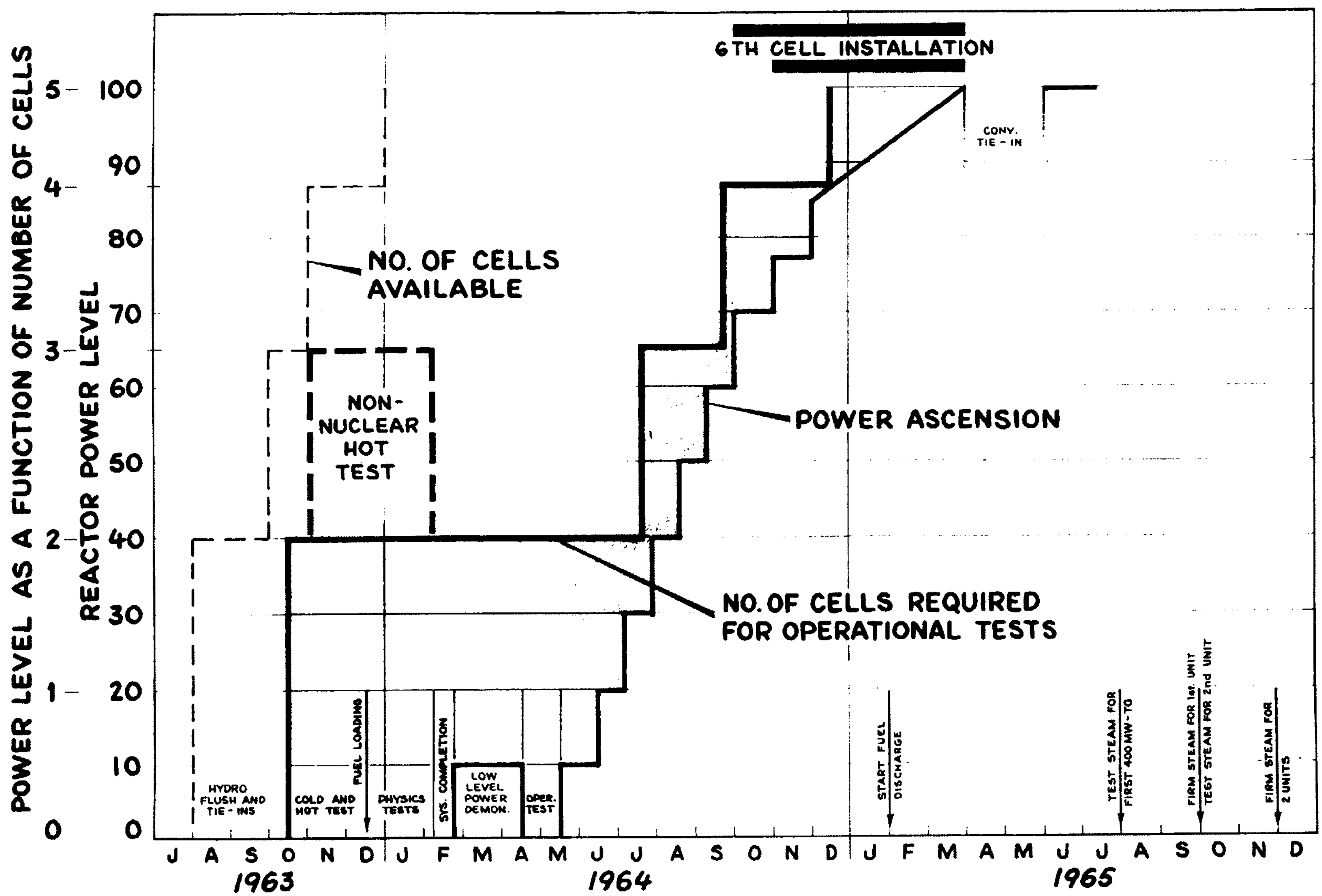
RL Dickeman:bs

Attach.

cc: WE Johnson (2)
HH Schipper
RLD-2

bcc: J Barnard
VS Mullaney

EFFECT OF STEAM GENERATOR OUTAGE ON REACTOR STARTUP



33122-1

54-3000-101 (9-59)

DON'T SAY IT --- Write It!

DATE August 28, 1963

TO R. L. Dickeman, General Manager
N-Reactor Department

FROM H. H. Schipper
Assistant Manager for Technical Operations

The attached draft language was sent by Kaiser to Combustion Engineering as a first step only. I would appreciate it if you would keep this matter fairly close to yourself for the present time.

Attachments:

1. Cy Article 29, Warranty
2. Cy Article 8, Inspection
3. Cy Article 38, Special Warranty

RECEIVED
AUG 30 1963
R. L. DICKEMAN

"SAFETY IS NO ACCIDENT"

50612217

August 16, 1963

Article 29: WARRANTY: The Seller warrants to the Buyer that the heat exchangers supplied under this Purchase Order will be free from defects in material, workmanship and title and will perform in accordance with the requirements of this Purchase Order; Provided, however, that this warranty does not extend (a) to corrosion or indications of corrosion existing at the time of acceptance or to any subsequently occurring progressive growth thereof; (b) to new areas of corrosion or of indications of corrosion subsequently occurring which are caused by the corrodent or corrodents which caused the corrosion or indications of corrosion existing at time of acceptance; or (c) to failures of any heat exchanger to perform in accordance with the Purchase Order requirements (or such lesser standard as may be satisfactory to the Buyer for purposes of acceptance in accordance with Article 8) due to any corrosion hereinabove described. The warranties specified in this Article (other than with respect to title, which warranty shall have no limitation) will, with respect to each heat exchanger, extend for a period of one year from the date of acceptance of such heat exchanger in accordance with Article 8; Provided, (a) that such defects or failures which may appear during said warranty period are not proximately caused by a failure to operate such heat exchanger in accordance with the conditions of service specified hereinbelow, (b) that the Buyer promptly notifies the Seller in writing when such defects or failures to perform become apparent, and (c) that all testing and operations data, if any, directly pertinent to any defects or failures in said heat exchanger during the warranty period shall be made available to the Seller for its inspection and review.

If it appears during the warranty period that any heat exchanger does not meet the warranties specified above, and the Buyer notifies the Seller promptly, the Seller shall thereupon correct any defect or failure, at its option, either by repairing any defective part or parts in place or by providing and installing a repaired or replacement part or parts, at the Seller's expense (including transportation charges to and from the Hanford Works jobsite), subject to the provisions of the clause herein entitled "REIMBURSEMENT"; provided that in no event shall the Seller be responsible for or bear the cost of decontaminating any heat exchanger which, by reason of special nuclear, source or by-product materials (as those terms are defined in the Atomic Energy Act of 1954, as amended), becomes contaminated. In the event any heat exchanger becomes contaminated, such heat exchanger shall promptly be decontaminated to the extent deemed by the Commission to be desirable or practicable and the Seller shall, upon notification of such decontamination, promptly proceed to carry out its duties and obligations under this Article. Extra costs, approved by the Buyer and incurred by the Seller in the performance of the work covered by this Article which are attributable solely to radiation remaining in any heat exchanger which has been decontaminated in accordance with this Article and which would not have been incurred by the Seller if no radiation remained shall be paid directly to the Seller and will not operate to diminish the Seller's right to reimbursement established by the clause herein entitled "REIMBURSEMENT". The determination of cost as that term is used in the preceding sentence shall be made in accordance with the provisions of "Appendix A" of this Purchase Order.

The Seller shall be liable for any damage (other than contamination damage to Government property caused by or resulting from special nuclear, source or by-product materials, as those terms are defined in the Atomic Energy Act of 1954, as amended), to other property resulting from such defects or failures as are within the terms of this warranty. This paragraph shall not impair any rights the Seller may have as a derivative indemnitee under any indemnity arrangements incorporated in the Commission's prime contract for the operation of the Hanford Works.

The conditions of service hereinabove mentioned are as follows: (a) the heat exchanger is properly installed, operated and maintained, and (b) is operated in accordance with the operating conditions specified for said heat exchanger in this Purchase Order.

The above provisions and the provisions of Article 38 - Special Warranty - state the Seller's entire liability on warranties and guaranties with respect to the heat exchangers, and are in lieu of all other warranties or guaranties, expressed or implied, including without limitation warranties relative to workmanship, material, performance and fitness for any intended purpose or use.

The Seller is not responsible for nor shall the Seller bear the cost of effecting reasonable access to any heat exchanger, if required, or of any reconstruction work, other than upon such heat exchanger, made necessary by reason of such access to such heat exchanger.

AL_ST 16, 1963

(ARTICLE 8 - INSPECTION - new Section D)

D. Acceptance of the supplies covered by this Purchase Order will occur, with respect to each heat exchanger, within a reasonable time, which shall not be less than thirty (30) days, in any event, after the Buyer's determination (a) that such heat exchanger complies with the requirements of this Purchase Order except for corrosion or indications of corrosion, (b) through in-place functional testing, that it appears that such heat exchanger is capable for a sustained period, of operation in accordance with the requirements of this Purchase Order or, if not, in a manner satisfactory to the Buyer, notwithstanding the presence of corrosion or indications of corrosion, and (c) not to reject such heat exchanger because of corrosion or indications of corrosion and to put it into operation. Such acceptance shall be final except for latent defects, fraud, or such gross mistakes as are tantamount to fraud and except for any rights of the Buyer or the Government under any warranties or guaranties contained in this Purchase Order. The provisions of paragraphs A, B, and C of this Article 8 shall remain in full force and effect, with respect to each heat exchanger, until acceptance by the Buyer of such heat exchanger.

Article 38 - SPECIAL WARRANTY: A. It is recognized by the parties that the corrosion or indications of corrosion in the heat exchangers supplied by the Seller to the Buyer under this Purchase Order existing at the time of their acceptance by the Buyer in accordance with Article 8 may thereafter incur progressive growth; that new areas of corrosion or of indications of corrosion may occur subsequent to such acceptance which are caused by the corrodent or corrodents which caused the corrosion or indications of corrosion existing at the time of acceptance; and that, because of any corrosion hereinabove described, one or more of the heat exchangers may fail to perform in accordance with the Purchase Order requirements or such lesser standard as may be satisfactory to the Buyer for the purposes of acceptance (hereinafter referred to as "the lesser standard").

B. With respect to each heat exchanger, the Seller will, for a period of ten years from the date of acceptance, at its expense, affect the necessary repairs or other appropriate corrective action to any heat exchanger which fails to perform in accordance with the Purchase Order requirements or the lesser standard when such failure is due to any corrosion described in Section A of this Article if and to the extent it is determined or agreed that the Seller is responsible for such corrosion. The word "determined" as used in this paragraph B and in paragraphs C and D of this Article means a determination by the appropriate administrative or judicial forum.

C. With respect to each heat exchanger the Buyer will, for a period of ten years after the acceptance of such heat exchanger, promptly inform the Seller of any progressive growth or new areas of corrosion or of indications of corrosion described in Section A of this Article even though such corrosion

50612222

has not then caused such heat exchanger to fail to perform in accordance with the Purchase Order requirements or the lesser standard. If and to the extent it is determined or agreed that the Seller is responsible for such corrosion or indications of corrosion, the Seller will, at its expense, thereupon effect the necessary repairs or other appropriate corrective action, or at its option, may defer such repairs or action until such time, if at all, that the heat exchanger fails to perform in accordance with the Purchase Order requirements or the lesser standard, at which time, whenever it occurs, the Seller will, at its expense, effect the necessary repairs or other appropriate corrective action.

D. If at the time any repairs or other appropriate corrective action described in paragraphs B or C above are required, the extent of the Seller's responsibility, if any, for effecting such repairs or action has not been determined or agreed upon, the Seller will at its expense effect such repairs or action. If and to the extent it is subsequently determined or agreed that the Seller was not obligated under paragraphs B or C, or both, to effect such repairs or action, the Buyer will promptly reimburse the Seller for the reasonable costs necessarily incurred by the Seller in effecting such repairs or action.

E. In effecting any repairs or corrective action in accordance with this Article, the Seller will be entitled to reimbursement under and within the monetary limits of the REIMBURSEMENT clause of this Purchase Order. Neither the Seller's effecting of repairs or corrective action pursuant to paragraph D of this Article nor its receipt of moneys in accordance with the REIMBURSEMENT clause on account thereof will constitute an admission by the Seller of responsibility for the defects or failures.

F. Any repairs or corrective action undertaken by the Seller in accordance with this Article will be accomplished at such time or times as the Buyer establishes to minimize disruption of plant operating and production schedules.

G. It is understood that the Seller's obligation to effect repairs or corrective action or for repairs or corrective action under this Article will not arise unless (a) the Buyer promptly notifies the Seller in writing when any of the above described growths or new areas of corrosion or failures to perform become apparent, and (b) all testing and operations data, if any, directly pertinent to any of said defects or failures are made available to the Seller for its inspection and review.

H. In no event shall the Seller be responsible for or bear the cost of decontaminating any heat exchanger which, by reason of special nuclear, source or by-product materials (as those terms are defined in the Atomic Energy Act of 1954, as amended), becomes contaminated. In the event any heat exchanger becomes contaminated, such heat exchanger shall promptly be decontaminated to the extent deemed by the Commission to be desirable or practicable and the Seller shall, upon notification of such decontamination, promptly proceed to carry out its duties and obligations under this Article. Extra costs, approved by the Buyer and incurred by the Seller in the performance of the work covered by this Article which are attributable solely to radiation remaining in any such heat exchanger which has been decontaminated in accordance with this Article and which would not have been incurred by the

Seller if no radiation remained shall be paid directly to the Seller and will not operate to diminish the Seller's right to reimbursement established by the clause entitled "REIMBURSEMENT". The computation of cost as that term is used in the preceding sentence shall be made in accordance with the provisions of Appendix "A" of this Purchase Order.

I. The Seller is not responsible for nor shall the Seller bear the cost of effecting reasonable access to any heat exchanger, if required, or of any reconstruction work other than upon such heat exchanger, made necessary by reason of such access to such heat exchanger.

Steam Gen.

TUBING MATERIAL

VII.

1. Inspection report of 2-15-60 indicates Wallingford withdrew 50-60,000 feet of tubing from heat 26232 because of dye check indications on 50% of tubing OD.
2. First shipment of 618 tubes made on 3-5-60. All tubes from heat 26469.
3. Second shipment of 785 tubes made on 3-16-60. All tubes from heat 26469. These first two shipments total 1403 tubes. There are 1916 tubes in a unit. The 1403 tubes are 73% of the tubes in Unit 3B.
4. Third shipment of 1084 tubes made on 3-28-60. Of this shipment, 491 tubes were from heat 26469 and the remaining 593 were from a new heat, #26494.
5. Inspection report of 4-27-60 advises of difficulties with reverse bend tests of tubing samples. See attached copy of report. (Reference 7A)
6. Inspection report of 5-13-60 states, "The Vendor is currently experiencing very low losses in dye check."
7. Inspection report of 6-3-60 states, "The Vendor continues to expend considerable effort to improve the quality of their strip and finished tubes."
8. Inspection report of 6-17-60 from Combustion under heading "Tube to tube sheet assembly" reads, "This operation was started on 6-13 (Monday) and stopped on Thursday for lack of tubes . . . The production of the tube line is not sufficient to supply tubes as fast as they can be assembled."
9. Inspection report of 6-25-60 states "Inspection (of tubing) at the present quality level indicates all material to be in compliance with specifications."
10. Inspection report of 6-24-60 from Combustion states "First tube bundle now complete and ready for steam cleaning preparatory to welding."
11. Inspection report of 7-9-60 from Combustion states "Second tube bundle is scheduled for complete rolling of tubes by 7-11-60 and should go to the welding operation same week. Sufficient tubing has been bent, heat-treated and inspected to complete assembly of the third unit.

12. Inspection report of 7-19-60 states, "As a result of heavy losses in the first two lots of heat #319516, careful analysis of three additional lots from the first 15 was made. Losses approximated 60% of the total of 5 lots. The remainder of in-process material was set aside (10 lots) and welding stopped on the balance of this heat."

"A new heat #26541, pilot group showing great improvement, has been started, and production should resume schedule."

"The problem with the heat set aside is dye-check indications related to the parent metal. Rework costs and small final yield make it unfeasible. to continue production by present procedure. The Vendor continues to investigate alternate processes to make reclaiming the balance of the heat practical."

13. Inspection report of 8-1-60 states, "Welding operation has been stopped as of Saturday night, 7-30-60. This action follows extended efforts to improve the quality of the as-welded tube. In attempting to eliminate transverse cracking in the heat affected zone, the job was moved from mill #3, center forming, to mill #2, an edge forming mill with more stands - no luck."

"Trial welding will be resumed on mill #3 Tuesday morning, 8-2-60. Material will be heat #26542 in as-rolled condition. It is remainder of stock used in about the third unit which was discontinued in an attempt to improve the yield in dye-check."

14. Inspection report of 8-5-60 states, "We will have a shutdown of one week to ten days beginning about 8-12 or -15, which will be required by the procurement cycle of a new heat. He further expressed an opinion that the cracking in the heat affected zone may be the result of jogging during the shearing (slitting) operation in the strip mill. Frequent jogging would be required if the strip is stopped for surface inspection while it is being sheared. The new material is scheduled for shearing on a continuous shear which cannot be jogged."

"Another mill source stated that a re-anneal of the present stock was being considered."

15. Inspection report of 8-13-60 states, "Results of test welding this date appear to bear out the Vendor's claim that the problem of transverse cracking in the heat-affected zone has been specifically identified and corrected. One complete lot (approximately 135 tubes) has been welded and the second lot is well under way without experiencing cracking."

"Vendor is treating exact nature of investigation results as Company Confidential."

16. Verbal reports indicate that no dye check was done on tube ID at any stage.

TUBE SHIPMENT SUMMATION

Shipment No.	Date	No. Tubes	Heats Represented
1	3-5-60	618	26469
2	3-16-60	785	26469
3	3-28-60	1084	26469, 26494
4	4-20-60	1888	26494, 26495
5	5-24-60	2135	26494, 26495, 26542
6	6-15-60	1874	11686, 26495, 26542, 346501
7	6-30-60	1127	11686, 26542, 346501, 319516
8	8-3-60	904	26541, 319516, 26542, 346501
9	8-26-60	1507	26541, 319517, 346501, 319516
10	9-21-60	1842	346501, 26541, 319516, 319517, 72531
11	10-12-60	2069	89603, 72531, 319517, 319516
12	11-3-60	2117	26591, 72531, 89603, 319516, 319517
13	11-29-60	1814	26591, 72531, 89603, 319517

54-4000-103 (11-62)
AEC-GE RICHLAND, WASH

N-REACTOR DEPARTMENT

August 16, 1963

J. S. McMahon
Manager, N-Reactor Project

STEAM GENERATORS

The final resolution of the heat exchanger problem requires, of course, not only the definition of courses of corrective action (particularly for units 3B and 4A), but also negotiation of warranties and financial responsibility. As an assist in these negotiations, the Commission will require a technical appraisal and probable causes of the corrosion defects which we observe. I have committed, by September 9, such an appraisal based on the information available; I suggest Neal Strand and Spencer Bush as appropriate collaborators.

This appraisal might concentrate on three points:

1) The technical possibility, or lack of it, for the corrosion defects to have been initiated by chemicals or environmental conditions imposed on these units since they have been opened at Hanford.

2) The technical factors which may have initiated the corrosion conditions during the fabrication and/or assembly stages.

3) The effect of the two-year storage period on the presence and/or magnitude of the corrosion observed; e.g., it may be possible that even had the conditions existed, the corrosion we observe would have been less severe had the units been placed in operation promptly after receipt at Hanford.

It may be appropriate for the four of us to broadly discuss what can be done in this technical appraisal letter early next week.

General Manager
N-Reactor Department

RL Dickeman:bs

cc: JS McMahon - 3
CH Crandall - J Pearlman
RLD-2

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GENERAL ELECTRIC

HANFORD ATOMIC PRODUCTS OPERATION - RICHLAND, WASHINGTON

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TITLE

STEAM GENERATOR EXAMINATION PROGRAM INTERIM REPORT 2 - PROGRAM OUTLINE

AUTHOR

G. T. Haugland

DISTRIBUTION

	NAME	BUILDING	AREA
1.	WD Bainard	762	700
2.	HJ Bellarts	762	700
3.	GC Brockmeier	762	700
4.	LJ Chockie	3706	300
5.	DL Condotta	3702	300
6.	RL Dickeman	1100	100-N
7.	AB Dunning	AB-Y	100-N
8.	JM Fox, Jr.	1760-H	100-H
9.	B Griggs	326	300
10.	RE Hall	1100	100-N
11.	GW Hammett	105-N	100-N
12.	WM Harty	762	700
13.	GT Haugland	AB-Y	100-N
14.	JW Helton	105-N	100-N
15.	WE Johnson	703	700
16.	HR Kosmata	762	700
17.	BS Kosut	ZZ	100-N
18.	EM Kratz	762	700
19.	AP Larrick	1704-K	100-K
20.	MC Leverett	1100	100-N
21.	HL Libby	3707-C	300
22.	LM Loeb	333	300
23.	CE Love	1100	100-N
24.	WJ Love	762	700
25.	WM Mathis	1100	100-N
26.	JS McMahon	1100	100-N
27.	NR Miller	1100	100-N
28.	WJ Morris	762	700
29.	WJ Mundt	762	700
30.	MG Patrick	105-N	100-N
31.	JW Riches	3706	300
32.	DD Stepnewski	762	700
33.	JE Stice	105-N	100-N
34.	NO Strand	AB-Y	100-N
35.	RE Trumble	1100	100-N
36.	JW Vanderbeek	1100	100-N
	Kaiser Engineers		
37.	R Dorr	1101	100-N
38-40.	H Fulton	1101	100-N
41.	GL Roberts	1101	100-N
42.	TE Stevens	1101	100-N
	Atomic Energy Commission		
43.	JH Krema	703	700
44-46.	HH Schipper	1101	100-N
47.	JM Shivley	1101	100-N
48.	GW Wyss	703	700
	Burns and Roe, Incorporated		
49.	P DeRienzo	1101	100-N
50-52.	GW Willis	1101	100-N
	Combustion Engineering		
53-57.	R Marshall	1101	100-N
	Files		
58.	NPR File	762	700
59.	300 Files	3760	300
60.	Record Center	712	700
61-70.	Extra		

ROUTE TO	PAYROLL NO.	LOCATION	FILES ROUTE DATE	SIGNATURE AND DATE

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PROJECT CAI-816 NEW PRODUCTION REACTOR
STEAM GENERATOR EXAMINATION PROGRAM
PROGRAM OUTLINE

August 9, 1963

Prepared by: G. T. Haugland
Special Assignment
Steam Generators
N-Reactor Project

Approved by: N. O. Strand
Special Assignment
Steam Generators
N-Reactor Project

UNCLASSIFIED

PROJECT CAI-816 NEW PRODUCTION REACTOR
STEAM GENERATOR EXAMINATION PROGRAM
PROGRAM OUTLINE

INTRODUCTION

The heat dissipation plant of the N-Reactor contains ten steam generator units located in five separate cells of the 109-N Building. During hydrostatic testing of the primary side of the steam generators leakage to the secondary side was observed. Subsequent examination of the steam generators revealed a condition of intergranular corrosion in tubes of all ten steam generators with considerably greater severity in units 2A and 4A. In addition, a severe stress corrosion cracking condition was found to exist at the tube sheet end of most tubes in steam generator 3B. The results of investigations performed as part of the steam generator test and evaluation program prior to mid-July have previously been reported.[1]

The purpose of this document is to outline the total test and evaluation program--including work already performed, work in progress, and work presently planned or considered for future accomplishment. It is not the purpose of this program document to relate the results of work already performed or to state which portions of the program have been completed. The program presented herein reflects the total program envisioned at the present time in the light of information already obtained. It should be recognized that the program will continuously be reviewed and revised as data are obtained and evaluated.

The importance of the steam generators to operation of the N-Reactor and the limited time available to thoroughly evaluate the condition of the units has required that the test and evaluation program be very extensive, with many facets of the investigation conducted simultaneously. In the following program outline the major objectives are listed by Roman numerals. The tests, studies, or evaluations related to achieving each specific objective are discussed immediately after the statement of the objective.

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1. HW-78258 Steam Generator Examination Program - Interim Report (UNCLASSIFIED) by S. H. Bush, L. J. Chockie, A. P. Larrick, N. O. Strand, dated July 16, 1963.

I. DETERMINE CHARACTER AND EXTENT OF STEAM GENERATOR DEFECTS

In order to determine the extent of defects in steam generator components, in-place nondestructive physical tests are conducted. The characteristics and types of defects are correlated to the test method indications by metallurgical examination of typical components removed from the steam generators.

A. Nondestructive Physical Tests

The nondestructive physical tests programmed include fluorescent penetrant, eddy current, ultrasonic leak detection, and visual inspections.

1. Fluorescent Penetrant--Fluorescent penetrant examinations are conducted for all steam generator units on a) the stainless steel overlay of the tube sheet, b) all tube-to-tube sheet fillet welds, c) the inside surface of all tubes for a distance of eight inches starting at the tube end (this examination employs a black light borescope), and d) the stainless steel sleeve in the primary inlet nozzle.

2. Visual--In addition to a thorough visual examination of directly accessible portions of the steam generator, the inside surface of the tube ends for a distance of approximately twenty inches are visually examined with a white light borescope. This examination reveals pits, rust spots, and other conditions not revealed by fluorescent penetrant examination.

3. Eddy Current--The initial eddy current testing of all heat exchangers is concentrated in those tubes which are readily accessible for removal (for metallurgical tests) from the secondary side of the steam generator. Subsequently, a statistical sample of approximately five to ten per cent of the tubes in each steam generator are eddy current tested with an internal differential type probe; the defect indications are initially categorized as Class I (defect penetrates more than halfway through the tube wall) or Class II (defect penetrates less than halfway through the tube wall). All defects initially classified as Class I defects are retested for verification purposes. Eddy current test results are evaluated to determine whether or not a greater number of tubes must be tested to obtain statistically valid conclusions regarding the defect status of each steam generator.

Complete eddy current testing is performed on all tubes in steam generators which indicate more than one per cent of tubes with Class I defects during the statistical sampling test. All tubes with Class I type defects, in steam generators subjected to 100 per cent eddy current testing, are retested by special eddy current techniques to determine which tubes have defects penetrating more than 80 per cent (plus or minus 5 per cent) of the tube wall. Tubes having defect penetrations greater than 80 per cent of the tube wall are plugged. The remaining tubes with Class I defects are used without repair during initial steam generator operational tests. Upon removal of the temporary strainers from the primary side of heat exchangers all tubes previously having Class I defects are retested to determine whether or not defect propagation has occurred. Results of environmental testing of removed tubing samples are used to decide whether or not additional tubes are to be plugged at that time. Steam generators that are subjected to eddy current testing of 100 per cent of the tubes are also eddy current tested with a tube sheet probe before and after operational tests.

4. Ultrasonic Leak Detection--All tubes in units subjected to 100 per cent eddy current testing, as well as units which leak during hydrostatic and operational tests, are tested for the presence of gas leak passages through the tube walls by ultrasonic leak detection equipment. The test is performed by pressurizing the secondary side of the steam generator with air and detecting the sound of air leakage into defective tubes by means of an ultrasonic converter. This instrument converts the sound of escaping air to an audible frequency and provides amplification. Tubes that exhibit leakage are plugged. Those tubes which leak and are accessible are removed and subjected to environmental testing to determine the change of leakage rate with operating time.

B. Metallurgical Tests

The metallurgical test program consists of obtaining samples containing representative defect indications and determining the nature of such defects.

1. Sampling Program--Metal samples removed from steam generators for metallurgical examination are selected on the basis of nondestructive physical test results. Three different types of samples are removed. They are: a) tube sections of various lengths, b) cored sections of the tube, tube sheet, and tube-to-sheet weld (approximately 7/8 inch diameter and 3/4 to 7/8 inch long), removed from the primary side of the tube sheet, and c) tube-sheet portions of tubes. Samples are marked to maintain identity of their original location and clock position in the steam generator.

2. Metallurgy--The nondestructive physical tests which revealed the original defect indications are repeated in the laboratory to precisely locate each defect and to verify the previous test result. Defect areas are subjected to macro and micro examination. The depth of cracklike defects are determined by sectioning at the defect location or by repeated removal of metal and re-examination. Polished specimens are scanned under a high power microscope and photomicrographs are made to record grain structure, defects and other phenomena observed. A record is made of the size, shape, location (inside or outside diameter) and the orientation (axial, radial, or circumferential) of observed defects. Information on physical dimensions and location are correlated with eddy current data to permit nondestructive evaluation of defects noted in installed tubes.

II. DETERMINE OPERABILITY POTENTIAL

Tests are performed on representative tubing samples to determine the probable operating life of tubes having varying degrees of defect penetration into the tube wall. The results of these tests are compared with analytical calculations of stresses for various defect configurations. The tests programmed include autoclave tests, burst tests and fatigue tests. The results of these tests and analyses are used to determine whether or not additional tubes should be plugged and whether or not special procedures to arrest progressive attack on tubes can or should be employed prior to the start of productive reactor operation.

A. Autoclave Tests

Sections of tubing containing defects are autoclaved under typical N-Reactor conditions for successive periods of time. After each period the tubing is eddy current tested to see if the eddy current defect signals have increased. If the magnitude of the defect signal continually increases after each autoclave period, new tubing samples containing defects are cleaned with a trisodium phosphate solution containing a wetting agent (Dowell F-33) and autoclave tested to see if the cleaning arrests the propagation of typical defects. Tubing subjected to alternate passivating treatments may be similarly tested.

B. Burst Tests

Sections of tubing containing Class I defects are pressurized to 3000 psi at a temperature of 300 C (570 F) for a period of 48 hours. The tubing samples are retested by eddy current techniques to determine whether or not the defect signal has increased. The tubing is burst tested at a temperature of 300 C. The burst pressure is recorded and the fracture and its location relative to the original defect are evaluated.

C. Fatigue Tests

Tubing specimens with defect indications of varying magnitude are subjected to cyclic internal pressure loading to determine fatigue characteristics of defective tubing relative to the characteristics of defect-free tubing.

D. Calculations and Analysis

Stress levels in the tubing at various locations in the steam generators under various assumed operating conditions are calculated. Stress concentration factors are calculated or estimated for the various types of tube defects observed. The values of stress and the stress concentration factors are used in an attempt to correlate and evaluate the results of the destructive tests. These evaluations, together with statistical data on present Class I and Class II defects in existing steam generators and laboratory defect propagation rates, are then used to estimate the operational potential of each steam generator.

III. ASSESS POTENTIAL IMPACT ON CONSTRUCTION, TESTING, AND OPERATION SCHEDULES

The unavailability of heat exchangers, resulting from the need for additional examination and possible repair, affects previous construction, testing, and operation schedules. The available schedules are studied to determine the extent to which such schedules are affected and how they can be modified or rearranged to minimize the overall effect on the Project completion schedule and scheduled operating commitments. Schedules for test and repair of steam generators are sequenced to minimize adverse effects on such schedules. Operational test procedures are modified as necessary to complete operational testing of the system by using available steam generator cells.

Study is given to the capacity of one, two, three and four usable steam generator cells to meet established production and steaming commitments.

The possibility of providing the required heat transfer surface by installing additional steam generators, of the existing or alternate designs, is studied as a means of meeting future commitments.

IV. STUDY REPAIR AND REPLACEMENT METHODS

A. Repair Methods

In order to be able to rapidly and intelligently evaluate repair methods proposed by others and to contribute to the solution of repair problems, it is necessary to be thoroughly familiar with the problem details. From the standpoint of possible future maintenance, it is also desirable to have repair procedures and tooling available which are optimized for use under radioactively contaminated working conditions; therefore, part of the program is primarily applicable to potential future problems rather than the problems presently existing in units 2A, 4A, and 3B.

1. Tube Mouth Repairs--Methods of repairing tube mouth stress corrosion cracking conditions are studied. Prototypical samples are prepared and subjected to environmental testing. Tooling requirements for various methods of repairing unit 3B are considered. The need for development of automated repair equipment is evaluated.

2. Tube Plugging--Preliminary designs are prepared of a machine for automatically welding tube plugs under radiation work conditions.

B. Retubing a Steam Generator

Retubing of a 109-N steam generator involves cutting of the 3-inch thick vessel for access to the tubes, replacement of the tubes in place or removal of the tube sheet for out-of-cell tube replacement, making penetrations in the Zone I confinement wall for material access, etc. Studies of these and other aspects of retubing a unit and associated 109-N Building structural and confinement integrity considerations are included in the program.

C. Additional Capacity and Alternate Designs

If periodic replacement of steam generators is required in the future, it may be necessary to install a spare cell to accommodate production or steaming commitments during replacement periods. Plugging of defective tubes may also bring about the need for additional steam generator capacity. Consideration is given to alternate steam generator designs such as multiple vertical exchangers with greater total heat transfer capacity and greater maintenance flexibility. Studies are made of potential spare cell locations and replacement steam generator designs. Studies are also made of the maximum overload capacity of operable cells to meet operating commitments while steam generators in the other cell or cells are being maintained or replaced.

D. Materials

Mention has been made of Allegheny Ludlum Incoloy-800, various 300 series stainless steels, and Inconel as candidate materials for use as sleeves in tube mouth repairs or in tubes for retubing existing steam generators. Literature reviews and laboratory studies of these materials are conducted to determine suitability of various metals for the above uses. Preliminary material specifications are drafted for promising materials.

E. Defect Propagation Prevention and Unique Repair Techniques

Studies are made of possible methods of preventing propagation of defects by removing or passivating the corrodant with detergent or other chemical flushes. Economic and feasibility studies are made, as time permits, of unique techniques suggested for extending the life of the tubes or for repairing tubes; included in this category are ideas such as metal plating the ID or OD surfaces of defective tubes, and the possibility of developing explosive welding techniques for installing the mouth repair sleeves.

V. DETERMINE CAUSE OF TUBE DEFECTS

A determination of the cause of the various types of tube defects may lead to methods of preventing defect propagation or may suggest methods of preventing similar defects in sixth cell steam generators. For this reason, extensive laboratory tests and studies are performed to determine the cause of each type of tubing defect.

A. Review of Manufacturing Procedures

Details of tube manufacture at the Wallingford Tube Company and steam generator fabrication at Combustion Engineering are reviewed for possible clues to the cause of defects. Pickling and cleaning solutions and procedures used at both plants are determined. Inspection and shipping reports are studied to determine which heats of tubing are installed in each steam generator. Heat numbers on tubes removed from steam generators are used to verify correlations arrived at from the study of shipping reports. Combustion Engineering records of heat numbers of the tubes in each steam generator are sought as a means of determining whether or not the predominance of defects in certain units can be correlated with specific heats of tubing.

B. Review of On-Site Handling

Reviews are made of the history of installation and testing of the steam generators from the time of their arrival to the time when tube defects were detected. The atmosphere in the steam generators upon arrival at Hanford and at subsequent times during installation are reviewed to determine possible effects on tube integrity.

C. Other Installed Exchangers Compared to Steam Generators

The graphite coolant heat exchangers, recuperative heat exchangers, and spill coolers contain 304 stainless steel tubes and were subjected to installation conditions similar to steam generator installation conditions. These heat exchangers are subjected to eddy current testing to determine whether or not similar defects exist in them. Similarities and differences in installation procedures, conditions, and tests are used to evaluate whether or not on-site handling conditions are uniformly deleterious to stainless steel.

D. Chemical Sampling and Analysis

Fluids, residues, and atmospheres are removed from various locations in each steam generator. Residues are scraped from the interface between the tube and tube sheet of removed tubes. The chemical contents of these samples are determined by various laboratory techniques including X-ray diffraction, infra-red absorption, gas chromatograph, wet chemical, and emission spectrophotometer. Special care is taken in determining the content of halogens and other suspect corrodants.

E. Corrosion Studies

Defect-free portions of tubing samples removed from steam generators and other samples of sensitized 304 stainless steel are subjected to corrosion testing with the various pickling, cleaning and other chemical solutions that were used in the manufacture, installation, and testing of the steam generators. These tests are performed in an attempt to duplicate observed defect conditions. In addition, accelerated tests are conducted with Shell VPI-250 to determine if it will in any way lead to the types of corrosion attack found on the steam generators. These tests are performed on highly stressed, sensitized, chemically cleaned 304 stainless steel in atmospheres of as-received and charred Shell VPI-250.

F. Metallurgical and Miscellaneous Evaluations

Additional tests are performed to evaluate compositional variation possibilities such as localized regions with high carbon content or excessive ferrite content, that may be indicated by metallurgical examination of tubing specimens. Huey tests are performed on tubing samples obtained from several steam generators to compare relative corrosion resistance. Electron probe chemical analysis of grain and grain boundary constituents in various types of defects are performed in an attempt to identify the corrodant substance.

Eddy current tests are performed on tubing samples furnished from Combustion Engineering stocks of leftover tubing from steam generator fabrication; tube samples include tubes which were originally classified as acceptable as well as some tubes classified as rejects.

VI. REVIEW NUCLEAR HAZARD POTENTIAL

Studies are conducted to evaluate whether or not the operation of steam generators containing known defects constitutes a potential nuclear hazard to personnel or the environs.

VII. REVIEW TESTING AND OPERATING PROCEDURES

Studies of existing tests are made and necessary changes are incorporated in the procedures to permit separate testing of components and systems which were previously scheduled to be tested with steam generators or cells that are not presently available. Operating procedures and instrumentation requirements are reviewed and analyzed to determine the effect of operating the primary and secondary loops with fewer than five steam generator cells.

VIII. EVALUATE LEAKAGE TO SECONDARY SYSTEM

If existing defects in steam generator tubes propagate during reactor operation, leakage of radioactively contaminated primary loop water to the secondary loop can occur. Adequate safeguards and limits on leakage must be defined.

A. Radiation Monitoring Instrumentation

Studies are conducted on the adequacy of existing secondary loop instrumentation to detect leakage of radioactive water and fission products. Additional instrumentation requirements are established.

B. Effect on WPPSS Facilities

Studies are made of the radiation levels that may be encountered in or near various components of the secondary loop, including the components installed and operated by the Washington Public Power Supply System. These studies include an analysis of 1) the effects of various leakage rates of normal primary loop water on secondary loop radiation levels, and 2) the effects of getting fission product particulate matter and radioactive gases into the secondary side of the steam generators. Proposed designs for the WPPSS facilities are reviewed with the results of these studies in mind.

C. Injection Water Considerations

Studies are made of the effects of significant amounts of leakage to the secondary side on the other requirements of the injection makeup water system. Operating limitations on the number of reactor process tubes that may be diverted to the diversion headers are evaluated.

IX. INITIATE LONG TERM SURVEILLANCE PROGRAM

The existence of defects which may adversely affect production or steaming commitments at a future date makes it necessary to establish a long term surveillance and evaluation program. A schedule of periodic inspection and testing is prepared to define the tests to be performed and the particular reference tubes to be tested. Test records are catalogued to permit comparison of successive test results and to permit plotting of defect propagation, contamination buildup and tube failure rates. Studies are made and procedures prepared for methods of decontaminating the secondary side of the steam generators and the secondary loop.