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October 8, 1980

Director, Office of Nuclear Reactor Regulation
Attention: D. M. Crutchfield, Chief
Operating Reactors Branch No. 5
Division of Licensing
U. S. Nuclear Regulatory Commission
Washington, D.C. 20555

NOV 18 PM 4 50

SERVICES

Gentlemen:

Subject: Docket No. 50-206 S
Failure of the Salt Water Cooling System
San Onofre Nuclear Generating Station
Unit 1

By letter dated August 29, 1980, you requested further information for your review of the failure of the Salt Water Cooling System at San Onofre Unit 1 on March 10, 1980. Your letter requested information concerning time and temperature limits, equipment design limitations, desiccant contamination, and preventive maintenance programs. Further, you asked us to provide the information within 20 days of receipt of the letter, which would have been September 24, 1980. Our letter dated September 24, 1980 postponed the response to October 8, 1980.

The responses below follow the format of the questions in your letter of August 29, 1980, which asked us to provide the following information:

1. The supporting calculations and data used in determining the time and temperature limits cited in the response. Of particular interest is the basis for the 200°F limit indicated for the component cooling water system. Equipment design limitations should be explicitly referenced.

Response: The supporting calculations and data used in determining the time and temperature limits are contained in Enclosure 1, Design Calculation No. DC814-1, "Component Cooling Water/Loss of Salt Water Cooling Pumps," dated July 22, 1980 and revised July 30, 1980. In this calculation, the assumption was made that total loss of the salt water cooling system occurs, as directed by Item 4 of your letter dated June 20, 1980. It should be noted that the station operating procedures require that both salt water cooling pumps be in operation prior to commencing cooldown below 350°F; thus, reliability is increased by operating both pumps rather than relying on automatic circuitry to start a second pump if the operating pump fails.

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ADD:

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ED JORDAN	1	1
Bob Riggs	1	1
Mike Wilbur	1	1

295 B S

The basis for the 200°F limit for the component cooling water system (CCWS) includes (1) the setpoint of relief valves in the CCWS, (2) flange ratings of the CCWS, (3) design temperatures of the heat exchangers, (4) the design temperature of the CCW pumps, and (5) the limiting temperature of reactor coolant pump bearings. Items (1) and (2) are designated 150 psig, which sets the system design pressure. A typical code would allow a temperature of 440°F with an operating pressure of 150 psig, and higher temperatures at lower pressures. This sets the upper temperature limit for the flanges of the CCWS (flanges are usually the limiting component in a system). The CCWS design pressure of 150 psig is also supported by the design pressure of the CCW pumps and seven heat exchangers, all of which have a design pressure of 150 psig. Of the seven heat exchangers utilizing CCWS, 4 have a design temperature of 200°F, 2 of 250°F, and one of 350°F. Additionally, the CCW pump has a design temperature of 200°F. Thus, the upper limit for temperature is reduced to 200°F. For these reasons, the design temperature limit of the CCWS was determined to be 200°F, in response to your letter of June 20, 1980, on this subject. Later consultation with the system designer provides the assurance that this limit is conservative and that material compatibility for all cooled components should not present a problem at 200°F.

2. The following information regarding the desiccant in the compressed air system referenced in the response to Question 2.B:

2.a When the desiccant presence was identified.

Response: The first documented instance of desiccant presence in the air system was the failure of CV-537, isolation valve for service water to containment, on December 12, 1979. However, discussions with station personnel indicate that the desiccant probably started showing up around the time of the refueling outage in October, 1978. The presence of desiccant was not reported at that time as the affected equipment (feedwater regulator) was not safety related and the extent of the problem was believed to be limited to that equipment.

2.b Any evaluation performed to determine the effects of the desiccant on equipment performance; particularly common mode failures, and/or the extent of the contamination.

Response: The presence of desiccant in the instrument air system at San Onofre Unit 1 has been attributed to the breakdown of silica gel desiccant crystals in the instrument air dryers. The breakdown process results in a material resembling fine sand. These small particles are able to gradually bypass the downstream instrument air filters and spread throughout the air system. The exact distribution of the particles is not known but it appears that desiccant collects in areas where air flow or line geometry promotes accumulation.

Our experience concerning the effects of desiccant on equipment performance indicates that there are two predominant mechanisms in which the presence of desiccant may lead to equipment failures. The first mechanism identified is one where the desiccant enters a solenoid core in sufficient quantities to prevent proper operation. The second mechanism involves the gradual wear of solenoid components due to the abrasive action of the desiccant on moving parts.

The first failure mechanism was identified when containment isolation valve CV-537 failed to close during isolation valve testing. At the time of the failure it was determined that desiccant had entered the solenoid core and prevented proper operation. However, a more recent investigation has revealed that the desiccant was not the only contributing factor to the solenoid failure. It was discovered that the solenoid was undersized for the air pressure in the system. This condition alone could cause the solenoid to malfunction or operate sluggishly. In view of this and the fact that desiccant has been discovered at inlets to other safety related solenoid valves which have no history of failure, it is believed that the operation of solenoid valves is not particularly sensitive to the presence of desiccant.

The second mechanism was identified when the failure of the salt water cooling system valve POV-5 was attributed to the failure of the solenoid O-ring. Since it is now known that desiccant was present in the air lines supplying the air, it is suspected that desiccant may have contributed to excessive O-ring wear.

Although additional desiccant related equipment failures have not been recorded, we are currently evaluating the effects desiccant might have on air operated pilot valves and pneumatic instrumentation.

Additionally, we are currently checking to determine whether any other solenoids are undersized, checking solenoids for the presence of desiccant, and ensuring that solenoid valves are supplied with the proper air pressure. These actions are scheduled to be completed prior to the end of the present refueling outage.

2.c Any actions taken to remove the desiccant and prevent recurrence of the contamination.

Response: As reported in LER 80-03 transmitted by letter dated February 5, 1980, initial action, upon identification of the problem, was to install temporary filters to prevent additional desiccant from entering the instrument air system.

Actions taken to remove desiccant from the instrument air header included a blowdown of the header at numerous points selected to ensure complete removal of the desiccant from air headers and secondary supply lines. Individual air supply lines supplying safety related valves were also included in the blowdown.

To prevent additional desiccant from entering the instrument air header, temporary filter pads were installed in the air filter housings to prevent desiccant from by-passing the main filters. A clear plastic see-through filter housing was added to provide a visual indication of any desiccant that enters the filter elements. As an interim measure the filter pads are changed at frequent intervals (approximately 3 to 4 times per month) to ensure that any desiccant entering the air filters is promptly removed. Future corrective action will include the installation of a positive seal type filter unit.

The breakdown of the desiccant has been attributed to the excessive service life between replacement intervals. The defective desiccant has been replaced and maintenance procedures are scheduled to be completed prior to the end of the present refueling to ensure that the desiccant is maintained in a serviceable condition which will meet or exceed the manufacturer's recommendations. Since the desiccant breakdown and by-passing of the air filter is a gradual process, the above actions will ensure additional desiccant does not enter the air system.

2.d A list of safety-related equipment presently supplied by the compressed air system. Those pieces of equipment where the desiccant contamination has been identified should also be noted.

Response: A list of air operated valves which were included in the scope of our air system blowdown is provided in Enclosure 2. The list includes all safety related air operated valves. The equipment where desiccant contamination has been identified are indicated with an asterisk. A list of safety related pneumatic instrumentation is provided in Enclosure 3.

3. Any plans to extend the preventative maintenance programs to areas outside the salt water cooling system.

Response: An outside contractor (NUS) is currently being engaged to provide a detailed, comprehensive, and integrated preventative maintenance program for safety related equipment. All active valves and all air-operated valves will be included in this program; however, certain items, such as pipes, will not be included. The scope of this program is scheduled to be completed by November 30, 1980, with full implementation scheduled for August 1, 1981. When this program is completed, it will include frequency of maintenance and procedures for performance of the preventative maintenance tasks and will be integrated into maintenance planning programs now being developed.

If you have any questions or desire additional information concerning this subject, please contact me.

Very truly yours,

KPBaskin /

Enclosures

Enclosure 1

Design Calculation No. DC814-1
Component Cooling Water/Loss of Salt Water Cooling Pumps
Original Calculation July 22, 1980
Revision One July 30, 1980

DC 814

CALCULATION SHEET
TITLE PAGE

Project SONGS 1 Job No. 6308 Discipline Mechanical

Subject: Component Cooling Water / Loss of Salt Water Cooling Pumps

Calculation No. 814 Qual. Class SR Seis. Class — No. Pages 29

Originator (signature) George J Stawniczy Date 7-22-80

Checker (signature) Date 7-23-80

Original Issue

	NAME	DATE	SIGNATURE
Group Leader	RH Verbeck	7/24/80	RVerbeck
Discipline Sup. Engr.	GH Fehrenbach	7/24/80	GH Fehrenbach
P.E.			
Other			

Record of Revisions

NO.	REVISION	DATE	ENGR.	CKR	GL	DSE	PE
1	ADDED CASES 4a, 4b, 4c, 5a, 5b	7/30/80	GJ [illegible]	KE	RV 7/31/80	GHF [illegible]/80	

ENGINEERING DEPARTMENT

CALCULATION SHEET

SUBJECT: LOSS OF SALT WATER COOLING PUMPS

DESIGN CALCULATION NO. DC 814 - 1

J.O. NO. 6308

MADE BY

DATE 7-30-80

CHK. BY

DATE 7/30/80

REVISION 1: Added Cases 4a, 4b, 4c, 5a, 5b

Revised Pages 4, 5, 6, 12, 17

Added Pages 1A, 3A, 5A, 14A, 26A, 26B, 26C, 29A

DWG. NO.

DESIGN INPUT SHEET

☒ Design Requirements
☐ Design Input Change

PAGE 2	OF 29	DESIGN CALCULATION NO. DC 814-0

SUBJECT LOSS OF SALT WATER COOLING PUMPS		PROJECT SONGS 1
QUALITY CLASS SR	SEISMIC CLASS N/A	SPECIFICATION REFERENCE N/A

Design Input

1. SPENT FUEL PIT DIMENSIONS: 68' x 21' x40'; [REF. 5] VOL. I, Pg. 8-6
2. FUEL ASSEMBLY DIMENSIONS: (SEE BODY OF CALCULATION); [REF. 2] Pgs. 2-16, 2-17
3. SPENT FUEL PIT DESIGN TEMPERATURE: 120°F; [REF. 5] VOL. I, Pg. 8-6
4. SPENT FUEL PIT HEAT PRODUCTION: 3.0×10^6 BTU/hr; [REF. 1]
5. RECIRC. HEAT EXCHANGER INLET TEMPERATURES: [REF. 1]

@ 1250 sec	163°F
3500 sec	172°F
7000 sec	182°F
15,000 sec	204°F
30,000 sec	225°F
50,000 sec	241°F
90,000 sec	250°F
150,000 sec	245°F

6. NEGLECT BORON C_p FOR HEAT CAPACITY AND HEAT TRANSFER CALCULATIONS
7. ASSUME HEAT INPUT FROM SHIELD COILS IS CONSTANT 2.5×10^5 BTU/hr UNTIL CCWS REACHES 140°F, AND ZERO FOR GREATER CCWS TEMPERATURES
8. ASSUME BULK CCWS TEMP IS INITIALLY AT AVG OF INLET AND OUTLET TEMP.
9. SPENT FUEL PIT HEAT EXCHANGER PARAMETERS: [REF. 5] VOL III, PG 2-13

FLOW - SPENT FUEL SIDE - 390,000 lb/hr, TEMP. 120°F IN, 101°F OUT

FLOW - CCWS - 400,000 lb/hr, TEMP. 73.3°F IN, 92.2°F OUT

$U = 310 \frac{Btu}{ft^2 \cdot °F \cdot hr}$, $A = 948\ ft^2$

EDO RESPONSIBLE ENGINEER	DATE 7/15/80	REVIEW ENGINEER	DATE 7/23/80	EDO RESPONSIBLE GROUP LEADER	DATE 7/24/80

DESIGN INPUT SHEET

☒ Design Requirements
☐ Design Input Change

PAGE 3 OF 29

DESIGN CALCULATION NO. DC814 — 0

SUBJECT: LOSS OF SALT WATER COOLING PUMPS

PROJECT: SONGS 1

QUALITY CLASS: SR

SEISMIC CLASS: N/A

SPECIFICATION REFERENCE: N/A

Design Input

10. RECIRCULATION HEAT EXCHANGER PARAMETERS: [REF. 5] VOL. III, Pg. 3-7

FLOW: RECIRC SIDE - 713 gpm* CCWS - 1000 gpm

U = 335 BTU/ft²-°F-hr A = 595 ft²

* FROM [REF. 1].

11. COMPONENT COOLING WATER HEAT EXCHANGER PARAMETERS: [REF. 5] VOL III, PG 2-2, 2-

FLOW - CCWS - 1850 gpm, 150 ft pump dif. head, SW FLOW 3140 GPM (APPROX)

U = 281.8 BTU/ft²-°F-hr A = 2707 ft²

12. AUX. SALT WATER COOLING PUMP PARAMETERS: [REF. 6] . II

DESIGN FLOW = 1500 gpm Δh = 240 ft

OFF-DESIGN POINTS, GPM/Δh: 0/263, 500/262, 1000/256, 1800/225, 2150/185

13. SCREEN WASH PUMP PARAMETERS: [REF. 5] VOL. III, Pg. 14-10, 14-13

DESIGN FLOW = 1000 GPM @ 275 ft Δh

OFF-DESIGN POINTS GPM/Δh: 0/475, 200/440, 400/410, 600/380, 800/340, 1200/190

14. SALT WATER COOLING PUMP PARAMETERS [REF. 5] VOL. III, Pg. 14-14

DESIGN FLOW = 4620 GPM @ 70 ft Δh

15. SALT WATER TEMPERATURE (DESIGN) IS 63°F [REF. 5] VOL. III, Pg. 2-5

16. ASSUMPTIONS - SEE BODY OF CALCULATION

17. COMPONENT COOLING WATER DESIGN TEMPERATURE (LIMIT) IS 200°F [REF. 1]

18. AUX. SALT WATER PUMP AND SCREEN WASH PUMP CAN BE VALVED INTO SYSTEM EASILY (DWG. 568775).

EDO RESPONSIBLE ENGINEER	DATE	REVIEW ENGINEER	DATE	EDO RESPONSIBLE GROUP LEADER	DATE
	7-15-80		7/23/80		7/24/80

DESIGN INPUT SHEET

☐ Design Requirements
☒ Design Input Change

PAGE	OF	DESIGN CALCULATION NO
3A	29	DC 814-1

SUBJECT	PROJECT
LOSS OF SALT WATER COOLING PUMPS	SONGS 1

QUALITY CLASS	SEISMIC CLASS	SPECIFICATION REFERENCE
SR	N/A	N/A

Design Input

For CASES 4a, b, and c, the spent fuel pool pump (G-5) is not operable after a LOCA due to loss of offsite power. Therefore, there is no heat exchange between the spent fuel pool and the component cooling water system. Otherwise, case 4 is the same as case 1.

FOR CASE 5a, assume main steam line break; RHR heat exchangers operating, recirc. heat exchanger not operable. Loss of salt water cooling pump occurs when reactor coolant is at 350°F.

Case 5b, same as 5a, only aux. salt water cooling pump available.

RHR HEAT EXCHANGER PARAMETERS [REF. 5]:

$\dot{m}_{ccw} = 1{,}110{,}000 \text{ lb/hr}^{(SHELL)}$, $\dot{m}_{RC} = 585{,}000 \text{ lb/hr}^{(TUBE)}$ } each heat exchanger

$U = 300 \text{ BTU/°F-ft}^2\text{-hr}$, $A = 1500 \text{ ft}^2$ }

EDO RESPONSIBLE ENGINEER	DATE	REVIEW ENGINEER	DATE	EDO RESPONSIBLE GROUP LEADER	DATE
	7/23/80		7/30/80		7/31/80

ENGINEERING DEPARTMENT

CALCULATION SHEET

SUBJECT: LOSS OF SALT WATER COOLING PUMPS DESIGN CALCULATION NO. DC 814 – 1

Rev. 1 G J Stanimay 7-30-80 — 7/30/80

J.O. NO. 6308 MADE BY G J Stanimer DATE 7-22-80 CHK. BY DATE 7/22/80

CONTENTS

RV 7/31/80 Rev 1

R Verbeck 7/24/80

RH VERBECK DATE

SHF 8/1/80 Rev 1

SH Fehrenbach 7/24/80

G H FEHRENBACH DATE

DWG. NO.

ENGINEERING DEPARTMENT

CALCULATION SHEET

SUBJECT: LOSS OF SALT WATER COOLING PUMPS
DESIGN CALCULATION NO. DC 814 - 1
Rev. 1 7-30-80
J.O. NO. ____ MADE BY DATE 7-11-80 CHK. BY 7/30/80 DATE 7/25/80

PURPOSE: TO DETERMINE, AFTER LOSS OF SALT WATER COOLING PUMPS, TIME REQUIRED FOR COMPONENT COOLING WATER SYSTEM TO REACH DESIGN TEMPERATURE, 200°F, FOR THE FOLLOWING CASES: **

I. NO SALT WATER COOLING; LOSS OF COOLING a. AT LOCA
b. 1250 sec AFTER LOCA
c. 90,000 sec AFTER LOCA

II. AUX. SALT WATER PUMP ONLY, AVAILABLE FOR CONDITIONS a., b., AND c.

III. SCREEN WASH PUMP ONLY, AVAILABLE FOR CONDITIONS a., b., c.

METHOD: 1. DETERMINE RELEVANT EQUIPMENT AND SYSTEM PARAMETERS
2. DETERMINE EXPECTED HEAT FLOWS
3. USING "NTU" METHOD, CALCULATE ACTUAL HEAT FLOWS TO AND FROM CCWS IN SHORT TIME STEPS, APPROXIMATING ACTUAL HEAT FLOWS AND INCREASES IN CCWS TEMPERATURE.

SUMMARY:

		TIME*	TEMP.
CASE	1a	17 hrs. 40 min	200°F
	1b	17 hrs 40 min	200°F
	1c	38 hrs. 39 min	200°F
	2a	@~30 hrs	~112°F max
	2b	@ 25 hrs	~112°F max
	2c	@ 33 hrs	~112°F max
	3a	@ 33 hrs.	~118°F max
	3b	@ 33 hrs.	~118°F max
	3c	@ 58 hrs	~118°F max

**

* AFTER LOCA

** CONCLUSION: AT LEAST 17 hrs IS AVAILABLE FOR OPERATOR ACTION TO REPAIR SALT WATER PUMPS & VALVE IN SCREEN WASH OR AUX. SALT WATER COOLING PUMPS.

** SEE PAGE 5A FOR CASES 4a, b, c, 5a, b

DWG. NO.

ENGINEERING DEPARTMENT

CALCULATION SHEET

SUBJECT: LOSS OF SALT WATER COOLING PUMPS DESIGN CALCULATION NO. DC 814 - 1

J.O. NO. 6308 MADE BY DATE 7/29/80 CHK. BY DATE 7/30/80

FOR CASE 4

PURPOSE: DEFINITION OF CASE 4 – SAME CONDITIONS AS CASE 1, EXCEPT SPENT FUEL PIT PUMP, G-5, IS NOT OPERABLE.

SUMMARY, CASE 4:

	Time (AFTER LOCA)	TEMP
CASE 4a	4hrs., 2min. 22sec	200°F
4b	4hrs, 2min, 23sec	200°F
4c	25 hrs, 20min., 19sec.	200°F

CONCLUSION:

FOR CASES 4a AND 4b, APPROXIMATELY 4 HRS IS AVAILABLE FOR OPERATOR ACTION. FOR CASE 4c, APPROXIMATELY 21 MINUTES IS AVAILABLE.

ASSUMPTIONS:

14. FOR CASE 4, THERE IS NO HEAT TRANSFER BETWEEN THE SPENT FUEL POOL AND THE COMPONENT COOLING WATER SYSTEM.

FOR CASE 5a & B

SUMMARY:	TIME AFTER LOSS OF SALT WATER COOLING PUMPS	TEMP	
CASE 5a	5 min 30sec	200°F	1 RHR HX
	2 min 41sec	200°F	2 RHR HX
5b	—	178.6°F	1 RHR HX
	—	227.8°F	2 RHR HX

DWG. NO.

SHEET 6 OF 29 SHEETS

ENGINEERING DEPARTMENT

CALCULATION SHEET

SUBJECT: LOSS OF SALT WATER COOLING PUMPS DESIGN CALCULATION NO. DC 814 - 1

J.O. NO. MADE BY G J Stawniczy Rev. 1 G J Stawniczy 7-30-80 DATE 7-11-80 CHK. BY 7/30/80 DATE 7/ /80

ASSUMPTIONS**:

1. VALVES AND FITTINGS HAVE THE SAME VOLUME AS AN EQUIVALENT LENGTH OF SAME DIAMETER PIPE.

2. BULK TEMPERATURE OF CCWS IS AVERAGE OF COMPONENT COOLING WATER HEAT EXCHANGER INLET AND OUTLET TEMPERATURES.

3. DISREGARD HEAT LOSS TO THE SURROUNDINGS

4. INITIAL CONDITIONS ARE AS SHOWN IN FIGURE 1.

5. ASSUME STRUCTURES IN SPENT FUEL PIT EQUAL 25% OF MAX. FUEL ASSEMBLY VOLUME. ∴ WATER VOLUME IS 75% OF PIT VOLUME.

6. C_p OF ALL WATER STREAMS IS 1.0 BTU/lb°F; NEGLECT EFFECTS OF DISSOLVED CHEMICALS.

7. ASSUME HEAT INPUT FROM SHIELD COILS (.25 $\times 10^6$ BTU/HR) IS CONSTANT UNTIL CCWS WATER TEMPERATURE REACHES 140°F, AND IS 0 THERE AFTER

8. INITIAL CONDITIONS FOR COOLING WATER ARE 73.3°F OUTLET, 115°F INLET, 94°F BULK. AFTER 1ST ITERATION, USE BULK TEMPERATURE AS INLET TO OTHER HEAT EXCHANGERS

9. DISREGARD ALL FLOWS AND HEAT LOADS EXCEPT SPENT FUEL, RECIRCULATION AND SHIELD COILS.

10. SINCE FLOW FOR SALT WATER COOLING PUMPS IS HIGHER (4620 GPM) AND SYSTEM HEAD IS LOWER (70 ft Δh) ASSUME BOTH AUX. SALT WATER COOLING PUMP AND SCREEN WASH PUMP WOULD OPERATE CLOSE TO RUN-OUT CONDITIONS:
    AUX. SWCP : ~ 2100 GPM
    SCREEN WASH PUMP : ~ 1200 GPM

11. ASSUME RECIRCULATION WATER TEMPERATURE RISES SMOOTHLY; ∴ TEMPERATURES AT INTERMEDIATE TIMES CAN BE INTERPOLATED SMOOTHLY FROM THE DATA IN REFERENCE 1.

12. NEGLECT HEAT EXCHANGER VOLUMES IN CALCULATING CCWS VOLUME

13. SINCE HEAT INPUT INTO RECIRCULATION SYSTEM IS MUCH LARGER THAN HEAT REMOVAL BY COMPONENT COOLING WATER SYSTEM, ASSUME BULK TEMPERATURE OF CONTAINMENT SUMP DEPENDS ONLY ON HEAT INPUT FROM REACTOR DECAY HEAT. THIS IS A CONSERVATIVE ASSUMPTION.

** SEE PAGE 5A FOR ADDITIONAL ASSUMPTIONS

DWG. NO.

SHEET 7 OF 29 SHEETS

ENGINEERING DEPARTMENT

CALCULATION SHEET

SUBJECT: LOSS OF SALT WATER COOLING PUMPS DESIGN CALCULATION NO. DC 814 - 1

G J S[illegible] [illegible] 7/30/80

J.O. NO. ______ MADE BY G J Stawnczy DATE 7-11-80 CHK. BY [illegible] DATE 7-?-80

REFERENCES ;

1. MEMORANDUM "FAILURE OF SALT WATER COOLING SYSTEM" W.C. MOODY TO G.H. FEHRENBACH
2. SONGS 1 FINAL SAFETY ANALYSIS REPORT
3. HOLMAN, J.P., <u>HEAT TRANSFER</u>, 2nd Ed, 1968, McGRAW-HILL
4. CRANE Co., TECHNICAL PAPER No. 410, FLOW OF FLUIDS, 1970
5. SONGS 1, STATION MANUAL
6. TELECON W/CONTROL ROOM OPERATOR @ SONGS 1, 7/12/80.
7. SCE DWGS. 568768, 568775, 568576,
8. SCE ISOMETRIC DRAWINGS:
   334488 to -493, -495 to -501, 334546, 334565, 334567-574,
   334587-89, 334591-2, 334594, 334599, 334647, 334649-52,
   334654-6, 334865, 714437, 714451-4, 714458-62
9. MEETING MINUTES, 8-4-80, TAKEN BY GJSTAWNKZY (ATTACHED)

DWG. NO.

ENGINEERING DEPARTMENT

CALCULATION SHEET

SUBJECT: Loss of Salt Water Cooling Pumps DESIGN CALCULATION NO. DC 814 - 0

J.O. NO. 6308 MADE BY GJ Strunierz DATE 7-22-80 CHK. BY DATE 7/23/80

NOMENCLATURE:

A	AREA, ft^3
C	CAPACITY RATE, $\dot{m}c_p$, Btu/hr-°F
C_p	HEAT CAPACITY, Btu/lb-°F
d	DEPTH, ft
l	LENGTH, ft
m	MASS, lb
$\dot{m}$	FLOWRATE, lb/hr
N	NUMBER OF FUEL ASSEMBLIES
m	NUMBER OF FUEL RODS
NTU	NUMBER OF TRANSFER UNITS
Q	HEAT LOAD, BTU
r	RADIUS, INCHES
T	TEMPERATURE, °F (SUBSCRIPTS REFER TO PROCESS POINTS)
t	TIME (SEC OR MIN)
U	OVERALL HEAT TRANSFER COEFFICIENT, BTU/FT^2°F-HR
V	VOLUME, ft^3
w	WIDTH, ft
Δ	CHANGE IN, e.g. ΔT, ΔP
ϵ	EFFECTIVENESS
ρ	DENSITY, lb/ft^3
#	lb's

DWG. NO.

ENGINEERING DEPARTMENT

CALCULATION SHEET

SUBJECT: LOSS OF SALT WATER COOLING PUMPS DESIGN CALCULATION NO. DC 814 – 0

J.O. NO. 6308 MADE BY DATE 7-22-80 CHK. BY DATE 7/23/80

CALCULATION

I. CALCULATE COMPONENT COOLING WATER SYSTEM VOLUME, PAGES 10 TO 11.

II CALCULATE SPENT FUEL POOL VOLUME, PAGE 12.

III. SET UP INITIAL CONDITIONS, PAGE 12

IV. CALCULATE EFFECTIVENESS FOR HEAT EXCHANGERS, PAGES 13-15

V. PLOT RECIRC HT. EXCHANGER TEMP. IN., SEE APPENDIX

VI. SET UP CALCULATOR PROGRAM FOR ITERATIVE SOLUTION OF EACH CASE, PGS. 16-17

VII. CALCULATE T_{ccws} vs TIME FOR 9 CASES, Pgs 18-26

DWG. NO.

SHEET 10 OF 29 SHEETS

ENGINEERING DEPARTMENT

CALCULATION SHEET

SUBJECT: LOSS OF SALT WATER COOLING PUMPS DESIGN CALCULATION NO. DC 814 - 0

I.O. NO. 6308 MADE BY GJ Stammey DATE 7-15-80 CHK. BY R. Evans DATE 7/[illegible]/80

CCWS VOLUME CALCULATION

THE VOLUME OF THE COMPONENT COOLING WATER SYSTEM IS FOUND BY TAKING THE CROSS SECTIONAL AREA OF EACH LINE AND MULTIPLYING IT BY THE TOTAL LENGTH. AREAS ARE OBTAINED FROM [REF.4] PG. B-16. VOLUMES OF WATER IN HEAT EXCHANGERS ARE IGNORED, EXTENT OF SYSTEM IS GIVEN IN THE APPENDIX (P&ID 568768-15). LENGTHS AND VOLUMES ARE FOUND FROM THE LISTED ISOMETRIC DRAWINGS

LINE No.	SIZE, in.	ISO No.	VOLUME FROM ISO., ft^3
3048	8, 14	334567-1	54.1775
"	10	334568-1	10.7617
3056	10, 14	334599-1	44.102
3056	14	334865	133.16
3045	6, 8	334546-1	14.55
3103	6	334546-1	1.4185
3038	4	334568-1	5.6571
3091 & 3105	2	334569-1 *	4.8842
3013	1½	334652-0	.144
3014	1	334655-0	.087
3068	3	714459-2	3.1763
3068	3	334572-1	5.4036
3080	1½	334497-2	.2044
3072	1	334491-2	.01025
3067	3	714461-2	3.177
3067	3	334574-2	8.55
3077	1½	334495-1	.208
3075	1	334493-2	.02766
3069	3	714437-2	3.1466
3069	3	334573-2	3.5469
3070	1½	334489-2	.1793
3063	1	334488-1	.0138
3094	2½	714453-1	2.315
3094	2½	334500-1	2.885
3064	8	714451-1	18.3
3064	8	334571-2	17.46
3011 & 3007	2	334647-0	1.383
3044	2	334651-0	1.15
3037	8, 14	334591-1	110.1848
		Page Total	450.26361

* ESTIMATED FROM PIPING DRAWING AND ISO

DWG. NO.

ENGINEERING DEPARTMENT

CALCULATION SHEET

SUBJECT: Loss of Salt Water Cooling Pumps DESIGN CALCULATION NO. DC 814 - 0

J.O. NO. 6308 MADE BY G J Stawniczy DATE 7-17-80 CHK. BY DATE 7/23/80

VOLUME CALCULATION, CONTINUED

LINE No.	SIZE, in.	ISO No.	VOLUME FROM ISO, ft³
3046	6, 8	334594-1	19.57
3104	6	"	8.4764
3093	4	334592-1	6.332
3017	1½	334654-0	.1698
3018	1	334656-0	.0769
3078	3	714460-2	3.2949
3078	3	334588-2	5.4637
3076	1½	334494-2	.1179
3074	1	334492-2	.028
3083	3	714462-2	3.2538
3083	3	334589-2	8.10
3083	3	334499-1	.086
3081	1	334498-2	.03713
3073	3	714458-2	3.2725
3073	3	334587-2	3.3649
3079	1½	334496-2	.1116
3071	1	334490-1	.0263
3095	2½	714454-1	2.1837
3095	2½	334501-1	2.8659
3043	2	334650-0	1.3779
3009	2	334649-0	1.4600
3033	8	714452-1	20.4100
3033	8	334565-2	18.5931
			108.67243
SHIELD COILS	1"	568576-1	127.21
		Subtotal, previous page	450.26361
			686.14604 ft³
		USE	686 ft³

NOTE: THIS NUMBER DOES NOT INCLUDE LINES 3065, 3030, 3089, 3107 AND 3108, 1½" AND ½" LINES TO SAMPLE HEAT EXCHANGERS. THESE WILL BE IGNORED TO BE CONSERVATIVE.

$686 \text{ ft}^3 \times 62.2 \text{ lb/ft}^3 = 42{,}669 \text{ lb}$, USE 42,700 lb

DWG. NO.

ENGINEERING DEPARTMENT

CALCULATION SHEET

SUBJECT: LOSS OF SALT WATER COOLING PUMPS
DESIGN CALCULATION NO. DC 814 - 1
Rev. 1 GJ Steinmetz 7-30-80
J.O. NO. 6308 MADE BY G J Steinmetz DATE 7-11-80 CHK. BY R. E. ... DATE 7/30/80 7/23/80

SPENT FUEL POOL VOLUME

SPENT FUEL POOL HOLDS 210 FUEL ASSEMBLIES AND HOLDS 210 FUEL ASSEMBLIES OF 180 FUEL RODS. EACH ROD IS 137 IN LONG, .422 IN. OD USING ASSUMPTION 5, WATER INVENTORY IN THE SFP IS CALCULATED AS:

$$V = lwd - [(1.25)n\pi r^2 l]N \div 1728\ in^3/ft^3$$

$$V = (68)(21)(40) - [(1.25)(180)(\pi)(.211)^2(137)](210) \div 1728$$

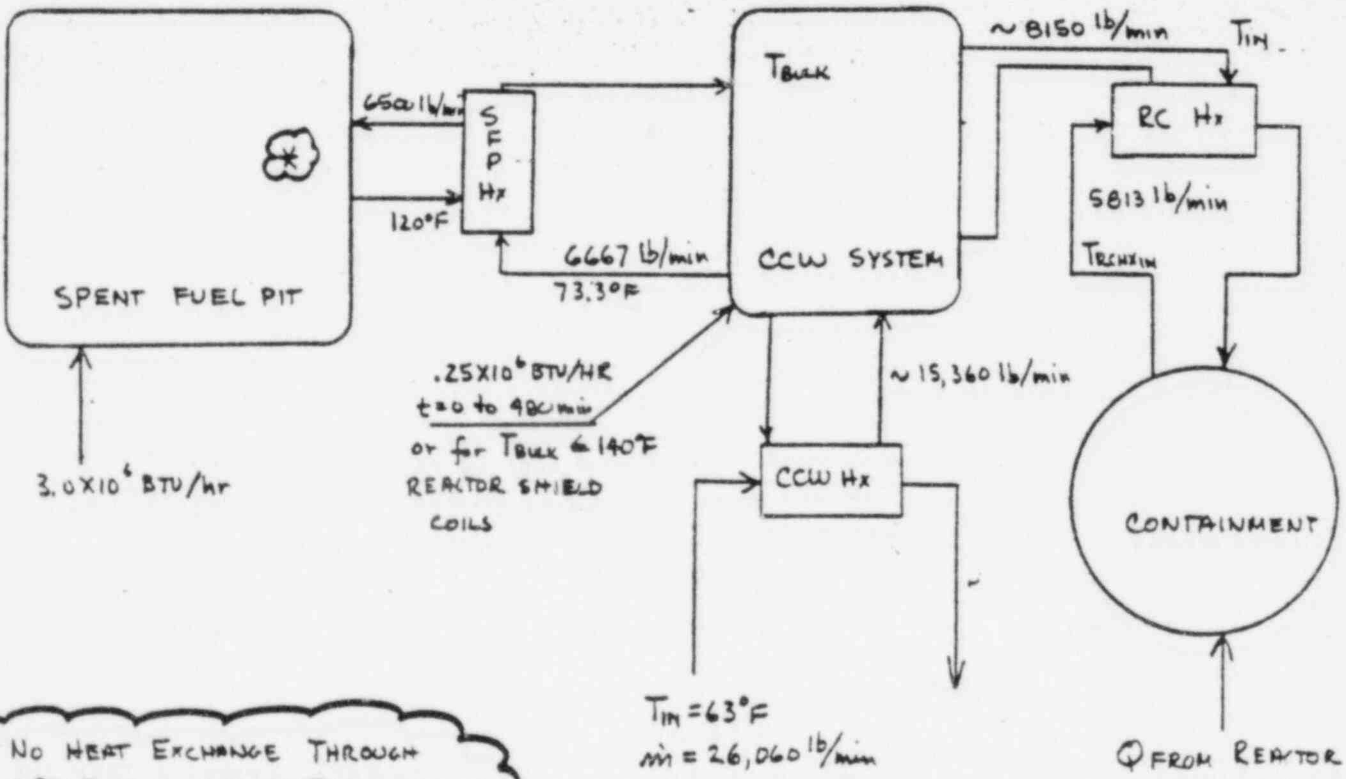
$$= 57120\ ft^3 - 524\ ft^3 = 56,596\ ft^3$$

$l = 68$ ft
$w = 21$ ft
$d = 40$ ft
$n = 180$ fuel rods
$N = 210$ assemblies
$r = .211$ in

@ 120°F, $\rho \approx 61.71$ lb/ft³ [REF. 4, Pg. A-6]

$\therefore$ INVENTORY IS (56,596)(61.17) = 3,493,000 lb of water

SET UP INITIAL CONDITIONS - BASED ON DESIGN INPUTS



* NO HEAT EXCHANGE THROUGH SPENT FUEL PIT HEAT EXCHANGER FOR CASES 4a, 4b, 4c.

ENGINEERING DEPARTMENT

CALCULATION SHEET

SUBJECT: LOSS OF SALT WATER COOLING PUMPS DESIGN CALCULATION NO. DC 814 - 0

J.O. NO. 6308 MADE BY GJ Staunierz DATE 7-12-80 CHK. BY DATE 7/23/80

INITIAL CALCULATION FOR SPENT FUEL PIT HEAT EXCHANGER
[SEE REF. 3, Pg. 311-13]

① MINIMUM FLUID IS SFP WATER; SINCE $\dot{m}_{ccws} > \dot{m}_{HX}$ and Cp's ARE EQUAL (=1.0)

$\dot{m}_{ccws} C_p > \dot{m}_{HX} C_p$

$\therefore C_{min} = \dot{m}_{SFPHX} C_p = 6500 \text{ lb/min} \times 1 \text{ Btu/lb-°F}$

② $\frac{C_{min}}{C_{max}} = \frac{6667}{6500} = 1.026$ (CONSTANT, FLOWS DO NOT CHANGE)

③ $NTU = \frac{UA}{C_{min}} = \frac{(310 \text{ BTU/ft}^2\text{-°F-hr})(948 \text{ ft}^2)}{(6500 \text{ BTU/min °F}) \times (60 \text{ min/hr})} = .754$ (CONSTANT)

④ FROM [REF. 3] Fig. 10-14, Pg. 312

@ $NTU = .754$ and $\frac{C_{mix}}{C_{unmix}} = \frac{6667}{6500} = 1.026$, $\epsilon \cong .415$

INITIAL CALCULATION FOR RECIRCULATION HEAT EXCHANGER

① $\dot{m}_{ccws} = 1000 \text{ gpm}$, $\dot{m}_{HX} = 713 \text{ gpm}$

② $\therefore \dot{m}_{HX}$ is minimum fluid and $C_{min}/C_{max} = .713$

$C_{min} = (713 \text{ gpm})(8.153 \text{ lb/gal})_{160°F} = 5813 \text{ Btu/min-°F}$

③ $NTU = \frac{UA}{C_{min}} = \frac{(335)(595)}{(5813)(60)} = .571$ (CONSTANT)

④ FROM [REF. 3] Fig. 10-14, Pg. 312

@ $NTU = .571$ and $\frac{C_{mix}}{C_{unmix}} = \frac{1000}{713} = 1.40$, $\epsilon = .375$

COMPONENT COOLING WATER HEAT EXCHANGER (SALT WATER COOLING PUMP OPERATING)

$\dot{m}_{ccws} = 1850 \text{ gpm}$, $\dot{m}_{sw} \cong 3140 \text{ gpm}$

$C_{min} = (1850)(\sim 8.3 \text{ lb/gal}) = 15,360 \text{ BTU/min-°F}$

$NTU = \frac{UA}{C_{min}} = \frac{(281.8)(2707)}{(15,360)(60)} = .828$ $\frac{C_{mix}}{C_{unmix}} = \frac{1850}{3140} = .589$, $\therefore \epsilon \cong .488$

DWG. NO.

ENGINEERING DEPARTMENT

CALCULATION SHEET

SUBJECT: LOSS OF SALT WATER COOLING PUMPS DESIGN CALCULATION NO. DC 814 - 0

J.O. NO. 6308 MADE BY DATE 7-12-80 CHK. BY DATE [illegible]

CALCULATE ϵ FOR CCW HEAT EXCHANGER WITH ASWCP AND SCREEN WASH PUMPS OPERATING

ASWCP	SCREEN WASH	BOTH PUMPS
$\dot{m}_{ccws} = 1850 \text{ gpm}$	$\dot{m}_{ccws} = 1850 \text{ gpm}$	$\dot{m}_{ccws} = 1850 \text{ gpm}$
$\dot{m}_{sw} = 2100 \text{ gpm}$	$\dot{m}_{sw} = 1200 \text{ gpm}$	$\dot{m}_{sw} = 3300 \text{ gpm}$
$C_{min} = (1850)(8.3) = 15{,}360 \frac{Btu}{°F\text{-}min}$	$C_{min} = (1200)(\sim 8.3) = 9960$	$C_{min} = 15{,}360$
$\frac{C_{min}}{C_{max}} = \frac{1850}{2100} = .881$	$\frac{C_{min}}{C_{max}} = \frac{1200}{1850} = .649$	$\frac{C_{min}}{C_{max}}\ \frac{1850}{3300} = .561$
$NTU = \frac{UA}{C_{min}} = \frac{(281.8)(2707)}{(15360)(60)} = .828$	$NTU = \frac{(281.8)(2707)}{(9960)(60)} = 1.277$	$NTU = \frac{(281.8)(2707)}{(15360)(60)} = .828$

FROM Fig 10-14 [REF. 3]

@ NTU = .828	@ NTU = 1.277	@ NTU = .828
$\frac{C_{mix}}{C_{unmix}} = \frac{1850}{2100} = .881$	$\frac{C_{mix}}{C_{unmix}} = \frac{1850}{1200} = 1.54$	$\frac{C_{mix}}{C_{unmix}} = \frac{1850}{3300} = .561$
$\epsilon = .447$	$\epsilon = .577$	$\epsilon = .491$

FOR ITERATIVE CALCULATIONS, NOTE THAT

$$\epsilon = \frac{\Delta T_{MIN\ FLUID}}{T_{HOT_{IN}} - T_{COLD_{IN}}} \qquad [REF. 3]$$

$$\therefore \quad T_{OUT_{MIN}} = T_{HOT_{IN}} - \epsilon\,(T_{HOT_{IN}} - T_{COLD_{IN}}) \quad \text{FOR HOT FLUID}$$

$$T_{OUT_{MIN}} = T_{COLD_{IN}} + \epsilon\,(T_{HOT_{IN}} - T_{COLD_{IN}}) \quad \text{FOR COLD FLUID}$$

} "MINIMUM" FLUID

DWG. NO.

SHEET 14a OF 29 SHEETS

ENGINEERING DEPARTMENT

CALCULATION SHEET

SUBJECT: LOSS OF SALT WATER COOLING PUMPS

DESIGN CALCULATION NO. DC 814 - 1

J.O. NO. 6308

MADE BY G J Stawniczy

DATE 7-30-80

CHK. BY M Evan

DATE 7-30-80

EFFECTIVENESS OF R.H. HEAT EXCHANGERS

$$\frac{C_{min}}{C_{max}} = \frac{585,000}{410,000} = .527 = unmix/mix$$

$$NTU = \frac{UA}{C_{min}} = \frac{(300)(1500)}{585,000} = .770$$

FROM Fig. 10-14 @ $NTU = .77$ $\quad \epsilon \approx .475$

$$\frac{C_{mix}}{C_{unmix}} = 1.90$$

DWG. NO.

SHEET 15 OF 29 SHEETS

ENGINEERING DEPARTMENT

CALCULATION SHEET

SUBJECT: LOSS OF SALT WATER COOLING PUMPS
DESIGN CALCULATION NO. DC 814 - 0

J.O. NO 6308
MADE BY
DATE 7-22-80
CHK. BY
DATE 7/23/80

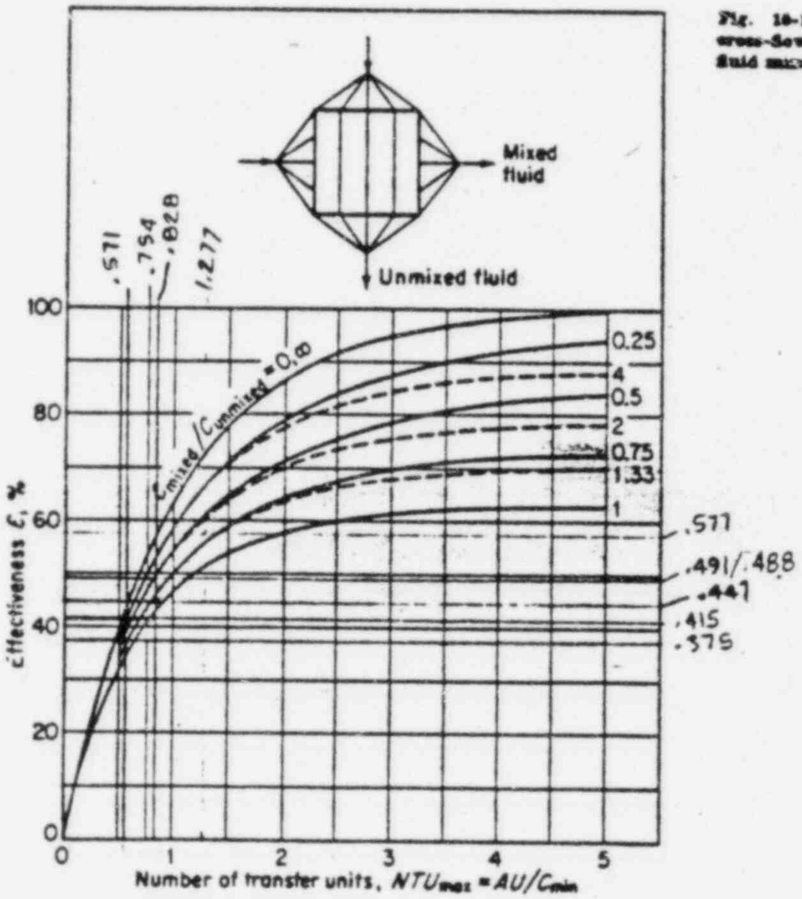


Fig. 10-14 Effectiveness for cross-flow exchanger with one fluid mixed.

DWG. NO.

SHEET 16 OF 29 SHEETS

ENGINEERING DEPARTMENT

CALCULATION SHEET

SUBJECT: LOSS OF SALT WATER COOLING PUMPS   DESIGN CALCULATION NO. DC 814 - 0

J.O. NO. 6308   MADE BY GJ Stawrizzi   DATE 7-17-80   CHK. BY R. E   DATE 7/23/80

A CALCULATOR PROGRAM WAS DEVELOPED TO SOLVE THE HEAT FLOW EQUATIONS ITERATIVELY. THE STEPS ARE OUTLINED BELOW.

1. INPUT INITIAL VALUES
2. DETERMINE CHANGE IN T_{RCHX} PER TIME UNIT. $(T_{RCHX_2} - T_{RCHX_1}) \div \Delta t = \Delta T_{RCHX}$
3. DETERMINE Q FROM SPENT FUEL POOL HX $Q_1 = .415(T_{SFP} - T_{CCWS})(6500)$
4. DETERMINE NEW SFP TEMP. $\Delta T_{SFP} = (50{,}000 - Q_1)(\Delta t) \div 3{,}493{,}000$
   $\Delta T_{SFP} + T_{SFP} = T_{SFP}$
5. DETERMINE Q FROM RECIRC. HX $Q_2 = (T_{RCHX_1} - T_{CCWS})(.375)(5813)$
6. ADD CONTRIB. Q FROM REACTOR SHIELD COILS $Q_3 = Q_1 + Q_2 + Q_{RSC}$
7. CALCULATE HEAT REMOVAL FROM CCW HX $Q_4 = \epsilon \dot{m} (T_{CCWS} - 63)$
8. DETERMINE NET HEAT INPUT TO CCW SYSTEM $\Sigma Q = Q_3 - Q_4$
9. DETERMINE NET ΔT FOR CCWS $T_{CCWS} = T_{CCWS} + (\Sigma Q \Delta t \div 42{,}700)$
10. IF ALL TIME INTERVALS USED — END, DISPLAY T_{CCWS}
11. IF ALL TIME INTERVALS NOT USED, $\# \Delta t = \# \Delta t\text{'s} - 1$

    $T_{RCHX_1} = T_{RCHX_1} + \Delta T_{RCHX_1}$

    GO TO 3

(FLOW CHART ON NEXT PAGE)

DWG. NO.

ENGINEERING DEPARTMENT

CALCULATION SHEET

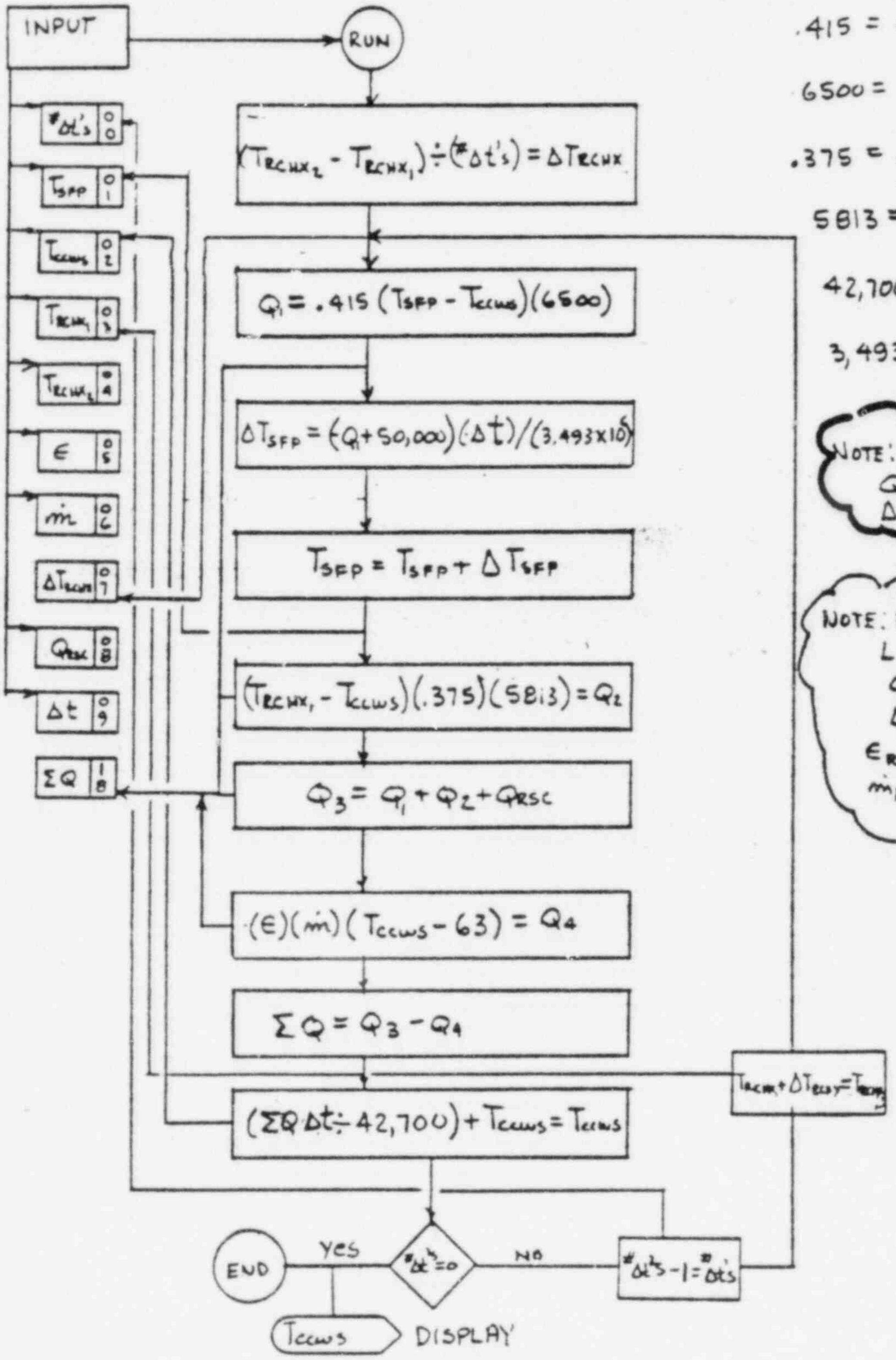
SUBJECT: LOSS OF SALT WATER COOLING PUMPS

DESIGN CALCULATION NO. DC 814 - 1

Rev. 1 G J Stauniery 7-30-80

J.O. NO. 6308 MADE BY G J Stauniery DATE 7-21-80 CHK. BY DATE 7/23/80 7/30/80

FLOW CHART FOR CALCULATOR PROGRAM (SEE APPENDIX FOR PROGRAM)



$.415 = \epsilon_{SFPHX}$

$6500 = \dot{m}_{SFPHX}$ (lb/min)

$.375 = \epsilon_{RCHX}$

$5813 = \dot{m}_{RCHX}$ (lb/min)

$42,700 = m_{CCWS}$

$3,493,000 = m_{SFP}$

NOTE: FOR CASES 4a, 4b, 4c,
$Q_1 = 0$
$\Delta T_{SFP} = 0$

NOTE: FOR CASES 5a, b
LET
$Q_1 = 0$
$\Delta T_{SFP} = 0$
$\epsilon_{RHX} = \epsilon_{RCHX} = .475$
$\dot{m}_{RHX} = \dot{m}_{RCHX} = 9750, 19,500$

DWG. NO.

SHEET 18 OF 29 SHEETS

ENGINEERING DEPARTMENT

CALCULATION SHEET

SUBJECT: LOSS OF SALT WATER COOLING PUMPS   DESIGN CALCULATION NO. DC 814 - 0

J.O. NO. 6308   MADE BY G J Sturniolo   DATE 7-17-80   CHK. BY   DATE 7/22/80

CASE No. 1a,

PUMPS LOST @ TIME 0, COOLING AVAILABLE

	t	T_{CCWS}	T_{INRHX}	T_{SPR}
Δt=2.5	0	73.3	73.3	120
	20	110.87	163	119.85
	40	139,45	168	120.26
Δt=5 1hr	60	143.59	172.3	120.88
	120	148.602	182.3	122.846
	180	154.50	193.0	124.98
	240	160.24	202,9	127.28
2hr	360	168.95	215.8	132.23
	480	175.68	224.1	137.43
	600	181.95	231.5	142.73
	720	187.26	236.6	148.09
	840	192.25	241.1	153.42
	960	196.72	244.5	158.70
	1080	200,66	246.8	163.89
	1200		248.2	
5hr Δt=10	1500		250.0	
	2000		248	
	2500		245	

t	T_{CCWS}	T_{INRHX}	T_{SPF}
2800	200.79	245	165.17

$$\frac{200-196.72}{200.66-196.72}(120)+960=1060$$

$$\frac{1060}{60}=17\tfrac{2}{3} = 17 \text{ hrs } 40 \text{ min}$$

DWG. NO.

ENGINEERING DEPARTMENT

CALCULATION SHEET

SUBJECT: LOSS OF SALT WATER COOLING PUMPS
DESIGN CALCULATION NO. DC 814 - 0
J.O. NO. 6308 MADE BY G J Stuvricas DATE 7-17-80 CHK. BY DATE 7/23/80

CASE No. 16,

PUMPS LOST @ TIME 1250 sec approx, COOLING AVAILABLE

	t min.	Tccws	TINRHX	TSPR
	20	73.3	163.	120
Δt = 2.5 min	40	136.88	168	120.48
	60	143.35	172.3	120.78
1 hr				
* Δt = 5 min	120	148.55	182.3	122.75
	180	154.45	193.0	124.88
	240	160.19	202.9	127.18
	300	165.23	210.9	129.63
	360	169.02	215.8	132.17
2hr				
	480	175.65	224.1	137.37
	600	181.92	231.5	142.68
	720	187.23	236.6	148.03
	840	192.22	241.1	153.37
	960	196.70	244.5	158.65
	1080	200.64	246.8	163.84
	1200		248.2	
5hr				
Δt=10 min	1500		250	
	2000	[illegible]	248	
	2500	19	245	

t	Tccws	TINRHX	TSPR
2800	200.84	245	165.30

* No Shield Coil Contribut

$$\frac{200-196.7}{200.64-196.70}(120)+960=1060$$

$$\frac{1060}{60}=17\tfrac{2}{3}\doteq 17\text{ hrs, }40\text{ min.}$$

DWG. NO.

SHEET 20 OF 29 SHEETS

ENGINEERING DEPARTMENT
CALCULATION SHEET

SUBJECT: LOSS OF SALT WATER COOLING PUMPS DESIGN CALCULATION NO. DC 814 - 0

J.O. NO. 6308 MADE BY G J Sturnicas DATE 7-17-80 CHK. BY DATE 7/23/80

CASE No. 1c ,

PUMPS LOST @ TIME 90,000sec, COOLING AVAILABLE NONE

$\epsilon = .488$

$\dot{m} = 15,360$

	t	T_{CCWS}	T_{INRHX}	T_{SPR}	t	T_{CCWS}	T_{INRHX}	T_{SPF}
	0	73.3	73.3	120	3000	[illegible]	244	
Δt= .5	20	78.41	163	119.63	3500		243	
	40	94.00	168	119.48	4000		242	
	60	94.76	172.3	119.37				
1hr<	120	96.49	182.3	119.13				
Δt=5	180	98.34	193.0	118.98				
	240	100.08	202.9	118.92				
2hr<	360	102.40	215.8	119.00				
*→	480	103.94	224.1	119.23				
	600	105.32	231.5	119.58				
	720	106.92	236.6	120.00				
	840	107.2185	241.1	120.473				
	960	107.59	244.5	120.94				
	1080	108.10	246.8	121.42				
5hr<	1200	108.46	248.2	121.90				
=0 Δt=5	1500	109.02	250	123.02				
	2000	193.08	248	149.09				
	2500	203.93	245	171.05				

* no shield coil controls

$$\frac{200 - 193.08}{20393 - 193.08}(500) + 2000 = 2319$$

$$\frac{2319}{60} = 38 \text{ hrs } 39 \text{ min}$$

DWG. NO.

SHEET 21 OF 29 SHEETS

ENGINEERING DEPARTMENT

CALCULATION SHEET

SUBJECT: LOSS OF SALT WATER COOLING PUMPS DESIGN CALCULATION NO. DC 814 - 0

J.O. NO 6308 MADE BY G J Sturniegs DATE 7-17-80 CHK. BY DATE 7/21/80

CASE No. 2a ,

PUMPS LOST @ TIME 0 , COOLING AVAILABLE AUX. SALT WATER PUMP

$\epsilon = .447$

$\dot{m} = 15,360$

	t	T_{CCWS}	T_{INRHX}	T_{SFP}	t	T_{CCWS}	T_{INRHX}	T_{SFP}
	0	73.3	73.3	120	3000	·	244	
Δt = 5								
	20	79.43	163	119.64				
1.5								
	40	95.66	168	119.51				
1hr	60	96.46	172.3					
	120	98.31	182.3	119.27				
	180	100.28	193.0	119.20				
	240	102.13	202.9	119.22				
2hr								
	360	104.61	215.8	119.46				
	480	106.27	224.1	119.86				
	600	107.40	231.5	120.33				
	720	108.49	236.6	120.88				
	840	109.46	241.1	121.46				
	960	110.24	244.5	122.08				
	1080	110.81	246.8	122.70				
	1200	111.22	248.2	123.30				
5hr.								
	1500	111.88	250.0	124.71				
500								
	2000	111.94	248.0	126.56				
	2500	111.66	245.0	127.77				

Max Temp is ~ 112°F @ ~ 35 hrs.

DWG. NO.

SHEET 22 OF 29 SHEETS

ENGINEERING DEPARTMENT

CALCULATION SHEET

SUBJECT: LOSS OF SALT WATER COOLING PUMPS DESIGN CALCULATION NO. DC 814 - 0

J.O. NO. 6308 MADE BY G J DATE 7-17-80 CHK. BY DATE 7/17/80

CASE No. 2b ,

PUMPS LOST @ TIME 1250sec, COOLING AVAILABLE Aux. Salt Water Pumps

$\epsilon = .447$

$\dot{m} = 15,360$

	t	T_{CCWS}	T_{INRHX}	T_{SPR}
Δt=2.5	20	73.3	163	120
	40	95.74	168	119.84
	60	96.54	172.3	119.76
1hr Δt=5	120	98.39	182.3	119.59
	180	100.35	193.0	119.51
	240	102.20	202.9	119.52
	300	103.72	210.9	119.61
	360	104.70	215.8	119.75
2hr	480	106.33	224.1	120.13
	600	107.46	231.5	120.58
	720	108.54	236.6	121.11
	840	109.51	241.1	121.68
	960	110.28	244.5	122.28
	1080	110.86	246.8	122.88
	1200	111.26	248.2	123.48
	1500	111.91	250.0	124.86
	2000	111.82	248.0	126.01
	2500	111.46	245.0	126.87

t	T_{CCWS}	T_{INRHX}	T_{SPF}
3000		244	

CCWS Peak temperature is ~112°F.

DWG. NO.

SHEET 23 OF 29 SHEETS

ENGINEERING DEPARTMENT

CALCULATION SHEET

SUBJECT LOSS OF SALT WATER COOLING PUMPS DESIGN CALCULATION NO. DC 814 - 0

J.O. NO 6308 MADE BY AJ Sturnicas DATE 7-17-80 CHK. BY DATE 7/22/80

CASE No. 2c ,

PUMPS LOST @ TIME 90,000 sec (1500 min.), COOLING AVAILABLE ASWCP

$\epsilon = .447$

$\dot{m} = 15,360$

$\Delta t = 5$

t min	T_{CCWS}	T_{INRHX}	T_{SFR}	t	T_{CCWS}	T_{INRHX}	T_{SPF}
1500	109.02	250	123.02				
2000	111,65	248	125.30				
2500	111.45	245	126.84				
3000		244					
3500		243					

Max temp reached is ~ 111.65°F @ ~ 33 hrs.

DWG. NO.

SHEET 24 OF 29 SHEETS

ENGINEERING DEPARTMENT

CALCULATION SHEET

SUBJECT: LOSS OF SALT WATER COOLING PUMPS DESIGN CALCULATION NO. DC 814 - 0

J.O. NO. 6308 MADE BY G J Sturniolo DATE 7-17-80 CHK. BY [illegible] DATE 9/22/80

CASE No. 3a, ______

PUMPS LOST @ TIME 0, COOLING AVAILABLE Screen Wash

$\epsilon = .577$

$\dot{m} = 9960$

t	T_{CCWS}	T_{INRHX}	T_{SFR}	t	T_{CCWS}	T_{INRHX}	T_{SPF}
0	73.3		120				
20	81.62	163	119.64				
40	99.06	168	119.55				
60	99.99	172.3	199.53				
120	102.08	182.3	119.53				
180	104.29	193.0	119.62				
240	106.38	202.9	119.81				
360	109.22	215.8	120.39				
480	111.14	224.1	121.13				
600	112.48	231.5	121.93				
720	113.76	236.6	122.79				
840	114.98	241.1	123.68				
960	115.85	244.5	124.59				
1080	116.55	246.8	125.49				
1200	117.07	248.2	126.36				
1500	117.95	250	128.37				
2000	118.23	248	131.03				
2500	118.08	245	132.85				

DWG. NO.

ENGINEERING DEPARTMENT

CALCULATION SHEET

SUBJECT: LOSS OF SALT WATER COOLING PUMPS DESIGN CALCULATION NO. DC 814 - 0

J.O. NO. 6308 MADE BY A J St. Laurent DATE 7-17-80 CHK. BY DATE 7/22/80

CASE No. 3b ,

PUMPS LOST @ TIME 1250 , COOLING AVAILABLE Screen Wash Pump

$\epsilon = .577$
$\dot{m} = 9960$

	t	T_{ccws}	T_{INHX}	T_{SFP}	t	T_{ccws}	T_{INHX}	T_{SPF}
Δt=2.5	20	73.3	163	120				
	40	99.16	168	119.88				
	60	100.08	172.3	119.86				
1hr <								
Δt=5	120	102.16	182.3	119.84				
	180	104.37	193.0	119.93				
	240	106.46	202.9	120.11				
2hr <								
	360	109.29	215.8	120.66				
*	480	111.21	224.1	121.38				
	600	112.54	231.5	122.16				
	720	113.81	236.6	123.01				
	840	114.96	241.1	123.89				
	960	115.89	244.5	124.78				
	1080	116.60	246.8	125.67				
	1200	117.11	248.2	126.53				
5hr <								
	1500	117.99	250	128.51				
500 min <								
	2000	118.26	248	131.14				
	2500	118.10	245	132.93				

DWG. NO.

SHEET 26 OF 29 SHEETS

ENGINEERING DEPARTMENT

CALCULATION SHEET

SUBJECT: LOSS OF SALT WATER COOLING PUMPS   DESIGN CALCULATION NO. DC 814 - 0

J.O. NO. 6308   MADE BY G J Sturnicz   DATE 7-17-80   CHK. BY   DATE 7/23/80

CASE No. 3c ,

PUMPS LOST @ TIME 90,000 sec, COOLING AVAILABLE Screen Wash $\epsilon = .577$

$\dot{m} = 9960$

Δt=5

t min	T_{CCWS}	T_{INRHX}	T_{SPR}	t	T_{CCWS}	T_{INRHX}	T_{SPF}
1500	109.02	250	123.02				
2000	117.20	248	127.00				
2500	117.31	245	129.83				
3000	117.61	244	131.81				
3500	117.63	243					
4000		242					

CCWS Stabilizes @ ~ 118°F

DWG. NO.

ENGINEERING DEPARTMENT

CALCULATION SHEET

SUBJECT: Loss of Salt Water Cooling Pumps DESIGN CALCULATION NO. DC 814 - 1

J.O. NO. 6308 MADE BY GJ Stawniczy DATE 7-30-80 CHK. BY DATE 7/30/80

	CASE 4a			CASE 4b		
Δt=2.5	t	T_{ccws}	T_{cchx}	t	T_{ccws}	T_{cchx}
	0	73.3	73.3	0	—	—
	20	75.5	163	20	73.3	163
	40	136.66	168	40	135.93	168
	60	158.99	172.3	60	160.01	172.3
Δt=5	120	178.74	182.3	120	178.77	182.3
	180	189.50	193.0	180	189.51	193.0
	240	199.66	202.9	240	199.66	202.9
	300	208.27	210.9	300	208.23	210.9
	360		215.8	360		215.8

$$\frac{200-199.66}{208.27-199.66}(60) = 2.369 \text{ min}$$

200°F @ 4 hrs, 2 min, 22 sec after LOCA.

$$\frac{200-199.66}{208.23-199.66}(60) = 2.380 \text{ min}$$

200°F @ 4 hrs, 2 min, 23 sec after LOCA

DWG. NO.

ENGINEERING DEPARTMENT

CALCULATION SHEET

SUBJECT: LOSS OF SALT WATER COOLING PUMPS DESIGN CALCULATION NO. DC 814 - 1

J.O. NO. 6308 MADE BY G J [illegible] DATE 7-30-80 CHK. BY K. [illegible] DATE 7/30/80

CASE 4c

	t	T_{ccws}	T_{ccHx}
$\Delta t = 2.5$	0	73.3	—
	20	73.3	163
	40	86.39	168
	60	86.66	172.3
	120	89.64	182.3
	180	92.54	193.0
$\Delta t = 5.0$	240	94.79	202.9
	360	97.32	215.8
	480	99.23	224.1
	600	100.90	231.5
	720	102.07	236.6
	840	103.09	241.1
	960	103.86	244.5
	1080	104.39	246.8
	1200	104.71	248.2
$\Delta t = 1$	1500	105.12	250
	1510	164.21	250
	1520	199.20	250
	1521	201.79	250

$$\frac{200-199.2}{201.79-199.2}(60) + 25\text{ hrs}, 20\text{ min} =$$

25 hrs, 20min, 19sec

DWG. NO.

ENGINEERING DEPARTMENT

CALCULATION SHEET

SUBJECT: LOSS OF SALT WATER COOLING PUMPS DESIGN CALCULATION NO. DC 814 - 1

J.O. NO. 6308 MADE BY gJ Staurney DATE 7-30-80 CHK. BY DATE 8/6/80

CASE 5a (1 RHR HT EXCHANGER)

ΔT = ½ min.

	T_{CCWS}	$T_{RHR\ IN}$
t=0	73.3	350
1	102.5	↓
2	128.6	
3	152.0	
4	172.9	
5	191.6	
6	208.3	

200°F @ 5min 30 sec

(2 RHR HT EXCHANGERS)

Δt = ½ min

	T_{CCWS}	$T_{RHR\ IN}$
t=0	73.3	350
1	130.1	↓
2	175.2	
3	211.1	
4		
5		

200°F @ 2 min 41 sec

CASE 5b (1 RHR HX) (2 RHR HX)

AUX SALT WTR PP OPERATING

Δt = 2.0 min.

	T_{CCWS}	$T_{RHR\ IN}$
t=0	200.0	350
20	178.6	
40	178.6	
60	↓	
80		
100		
120		

178.6°F

FINAL TEMP

Δt = 2.0min

	T_{CCWS}	$T_{RHR\ IN}$
t= 0	200	350
20	227.8	
40	227.8	
60		
80		
100		
120		

227.8°F

FINAL TEMP.

DWG. NO.

TITLE Heat Exchanger Program PAGE 1 OF 2
PROGRAMMER GJS DATE 7/23/80

SR-52 Coding Form

LOC	CODE	KEY	COMMENTS	LOC	CODE	KEY	COMMENTS	LOC	CODE	KEY	COMMENTS
0 112		*LBL	T_{SFP}			STO				1	
		A				0				−	
		STO		040 152		6				RCL	
		0				HALT				0	
		1				*LBL		080 192		2	
005 117		HALT				*C				)	
		*LBL	T_{CCWS}			STO				X	
		B		045 157		0				6	
		STO				7				5	
		0				HALT		085 197		0	
010 122		2				*LBL				0	
		HALT				*E				=	
		*LBL	T_{RCHX_1}	050 162		RCL				STO	
		C				0				1	
		STO				4		090 202		8	
015 127		0				−				+/−	
		3				RCL				+	
		HALT		055 167		0				5	
		*LBL				3				0	
		D				)		095 207		0	
020 132		STO				÷				0	
		0				RCL				0	
		4		060 172		0				)	
		HALT				0				X	
		*LBL	# Δt's			=		100 212		RCL	
025 137		E				STO				0	
		STO				0				9	
		0		065 177		8				)	
		0				*LBL				÷	
		HALT				*1		105 217		3	
030 142		*LBL	ϵ			.				4	
		*A				4				9	
		STO		070 182		1				3	
		0				5				0	
		5				X		110 222		0	
0		HALT				(				0	
		*LBL				RCL					
		*B		075 187		0					

LABELS	
A	
B	
C	
D	
E	
A'	
B'	
C'	
D'	
E'	

REGISTERS	
00	# Δt's
01	T_{SFP}
02	T_{CCWS}
03	T_{RCHX_1}
04	T_{RCHX_2}
05	ϵ
06	$\dot{m}$
07	$\dot{Q}_{RSC}$
08	ΔT_{RCHX}
09	Δt
10	
11	
12	
13	
14	
15	
16	
17	
18	ΣQ
19	

FLAGS	
0	
1	
2	
3	
4	

TEXAS INSTRUMENTS
INCORPORATED

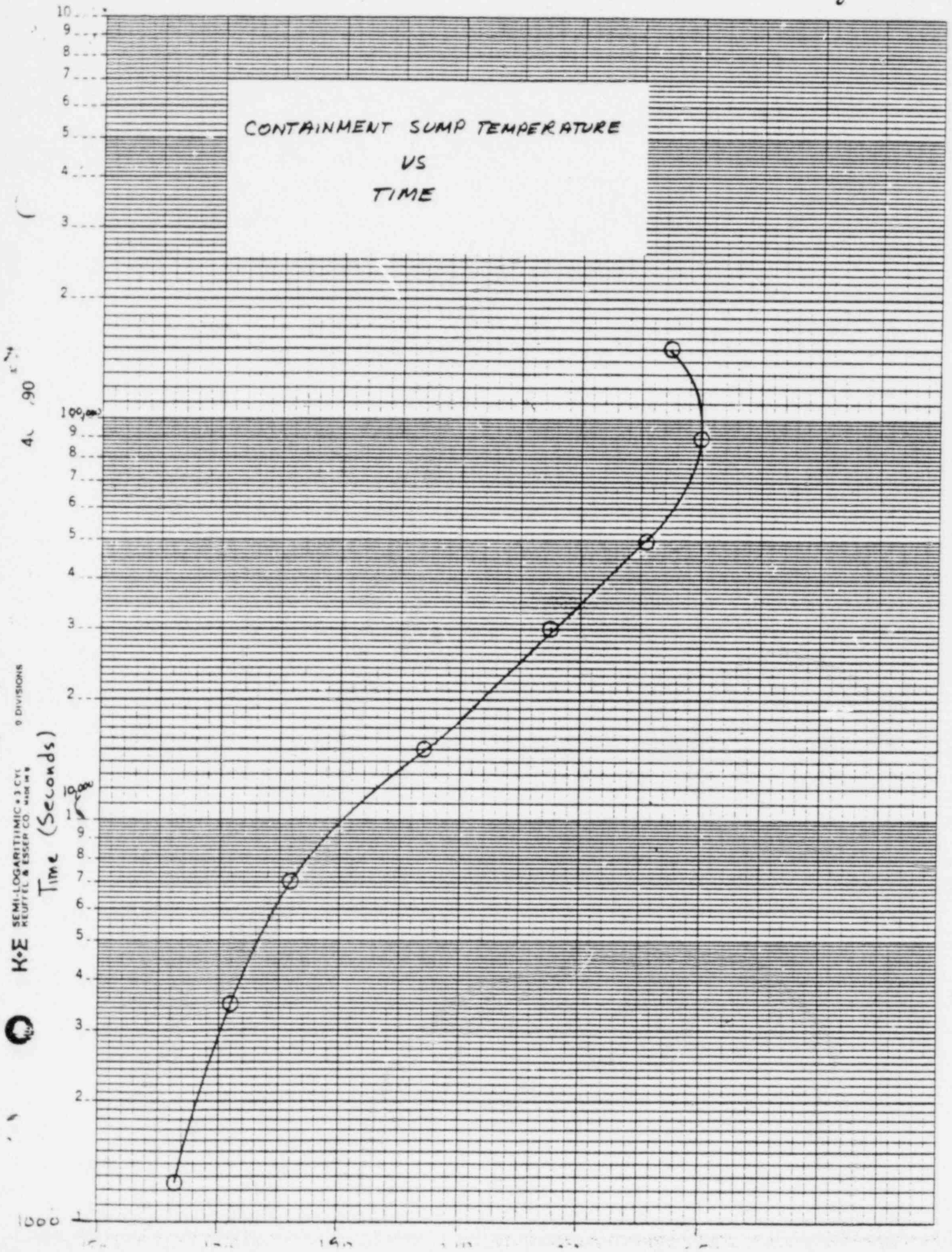
Pg 28 of 29

TITLE ____ PAGE 2 OF 2
PROGRAMMER ____ DATE ____

SR-52 Coding Form

LOC	CODE	KEY	COMMENTS	LOC	CODE	KEY	COMMENTS	LOC	CODE	KEY	COMMENTS	LABELS
.2		+				5				+		A
		RCL				+/-				RCL		B
		0		040 152		X				0		C
		1				(				2		D
		=				RCL		080 192		=		E
005 117		STO				0				STO		A'
		0				2				0		B'
		1		045 157		−				2		C'
		RCL				6				*DSZ		D'
		0				3		085 197		*1		E'
0 122		3				)				HALT		REGISTERS
		−				X				*LBL		00
		RCL		050 162		RCL				*D		01
		0				0				STO		02
		2				6		090 202		0		03
015 127		)				=				9		04
		X				SUM				HALT		05
		•		055 167		1						06
		3				8						07
		7				RCL		095 207				08
020 132		5				0						09
		X				7						10
		5		060 172		SUM						11
		8				1						12
		1				8		100 212				13
025 137		3				RCL						14
		=				1						15
		SUM		065 177		8						16
		1				X						17
		8				RCL		105 217				18
030 142		RCL				0						19
		0				9						FLAGS
		8		070 182		÷						0
		SUM				4						1
		0				2		110 222				2
035 147		3				7						3
		RCL				0						4
		0		075 187		0						

TEXAS INSTRUMENTS
INCORPORATED



CONTAINMENT SUMP TEMPERATURE
VS
TIME

Pg 29 A of 29

MEMO TO All Attendees

August 6, 1980
DATE PREPARED

Meeting Minutes (August 4, 1980)
Subject: NRC Response on Loss of Salt Water Cooling Pumps

Attendees:

G.H. Fehrenbach		R. Krieger	
R.H. Verbeck	Mech.	R. Ornelas	Nuclear
G.J. Stauniozs		R. Limstrom	

Major Points:

1. The worst case for temperature rise in the component cooling water system may be a main steam line break, as opposed to a LOCA.
2. This possibility should be investigated.

Action Items:

1. Mechanical (GJS) to investigate "Case 5":
    1. Loss of Salt Water Cooling, for Main Steam Line Break, when RCS temperature is 350°F, RH heat exchangers in operation (one in operation / two in operation).
    2. Calculate equilibrium temperature when Aux Salt Water cooling pump is available.

cc's
all attendees

From G J Staumezs

80-1-1 NEW 10/73 (PREV. ED 80-1)

Enclosure 2

AIR OPERATED SAFETY RELATED EQUIPMENT

SAFETY RELATED VALVES

Reactor Coolant System

PCV 430C

PCV 430 H

CV 530

CV 531

CV 532*

CV 533

CV 534

CV 538

CV 542

CV 543

CV 544*

CV 545

CV 546

CV 566

Chemical and Volume Control System

FCV 1102A

FCV 1102B

FCV 1112

FCV 1115A

FCV 1115B

Chemical and Volume Control System (Continued)

FCV 1115C

FCV 1115D

FCV 1115E

FCV 1115F

HCV 1117

LCV 1100A

LCV 1112

PCV 1105

PCV 1115A*

PCV 1115B

PCV 1115C

TCV 1105

CV 202

CV 203

CV 204

CV 276

CV 287

CV 288

CV 291

CV 304

CV 305

CV 333

CV 334

CV 406A

CV 406B

Chemical and Control Volume System (Continued)

- CV 410
- CV 411
- CV 412
- CV 413
- CV 414

Safety Injection System

- CV 875A
- CV 875B

Containment Spray

- CV 28
- CV 82
- CV 92
- CV 114
- CF 115

Component Cooling Water

- CV 722A*
- CV 722B
- CV 722C
- HCV 602
- RCV 605*
- TCV 601A
- TCV 601B

Main Steam System

- CV 3
- CV 4
- CV 76
- CV 77
- CV 78
- CV 79
- CV 128
- CV 129
- CV 130
- CV 131

Condensate and Feedwater System

- CV 19
- CV 20
- CV 21
- CV 36
- CV 37
- CV 142
- CV 143
- CV 144
- FCV 456
- FCV 457
- FCV 458

Salt Water Cooling System

POV 5*

POV 6*

POV 11

Miscellaneous Water System

CV 150*

CV 537*

Air Conditioning

POV 9

POV 10

CV 10

CV 40

CV 116

CV 146

CV 147

Reactor Cycle Sampling System

CV 948

CV 949

CV 951

CV 953

CV 955

CV 956

CV 957

CV 962

CV 992

Radioactive Waste Disposal System

- CV 45
- CV 101
- CV 104
- CV 105
- CV 106
- CV 107
- CV 138
- CV 535
- CV 536
- CV 102
- CV 103

Turbine Cycle Sampling System

- CV 117
- CV 118
- CV 119
- CV 120
- CV 121
- CV 122

* Indicates a component in which desiccant contamination has been identified

Enclosure 3

SAFETY RELATED PNEUMATIC EQUIPMENT

Safety Injection Pump Discharge	PT-910A PI-910A	PT-910B PI-910B
Boric Acid Tank Level	LT-1108 LR-1108 (Alarm, low level LC-1108)	
Refueling Water Storage Tank Level	LT-950 LI-950 (Low level & high level alarms)	
Charging Pump Discharge Pressure	PT-1119A PI-1119A	PT-1119B PI-1119B
Refueling Water Pump Discharge Pressure	PI-165	
R.C.P. Seal Water Flow Meters	FI-1114A; FI-1114B; FI-1114C (to be replaced January, 1981)	