N-4080-003 Rev 5: Containment Spray and Emergency Cooling Unit Actuation Times (including CCN1)

CALCULATION TITLE PAGE

ICCN NO./ PRELIM. CCN NO. ______ PAGE ___ OF ___

CCN CONVERSION: CCN NO. CCN-

Calc. No. N-4080-003 DCP/MMP/FIDCN/FCN No. & Rev. N/A

Subject Containment Spray (CS) and Emergency Cooling Unit (ECU) Actuation Times Sheet 1

System Number/Primary Station System Designator 1206, 1500/ BKA, GNF SONGS Unit 2/3 Q-Class II

Tech. Spec. Affecting? X NO ☐ YES, Section No. N/A Equipment Tag No. N/A

CONTROLLED COMPUTER PROGRAM/ DATABASE	☐ PROGRAM ☐ DATABASE IN ACCORDANCE WITH NES&L 41-5-1	PROGRAM/DATABASE NAME(S) ☐ ALSO, LISTED BELOW N/A	VERSION/RELEASE NO.(S) N/A

RECORDS OF ISSUES

REV. / DISC.	DESCRIPTION	TOTAL SHTS. / LAST SHT.	PREPARED (Print name/initial)	APPROVED (Signature)	
0	ORIGINAL ISSUE	SEE	ORIG. BECHTEL CALC	GS COVER SHEET	Other
BECH			IRE	DM	DATE
~~1~~ ~~4~~	REVISIONS 1 THROUGH 4	SEE	ORIG. BECHTEL CALC	GS COVER SHEET	Other
BECH			IRE	DM	DATE
5	Complete revision - All sheets from Revs 0-4 replaced; includes 5 psig	38 / 37	ORIG. Paul Barbour PB	GS [signature] for [signature]	Other
NSA	analysis setpt for contmt hi-pres & revised spray piping fill analysis		IRE Allen Evinay AE	DM [signature]	DATE 12/23/93
			ORIG.	GS	Other
			IRE	DM	DATE

Space for RPE Stamp, identify use of an alternate calc., and notes as applicable.

PB 12/23/93

REVISION 5 SUPERSEDES CALCULATION M-0014-003, REV. 0

This calculation was typed using "Word perfect 5.1" software as an electric typewriter. The WP5.1 software was not used for any computational portions of this calculation.

This calc. was prepared for the identified DCP/MMP. DCP completion and turnover acceptance to be verified by receipt of a memorandum directing DCN Conversion. Upon receipt, this calc. represents the as-built condition. Memo date ________ by ______________.

SCE 26-121-1 REV. 9/91

CALCULATION TITLE SHEET

BECHTEL

SHEET 1A 1 OF 38 55 △5

PROJECT San Onofre Nuclear Generating Station 2&3 JOB NO. 10079 DISCIPLINE Nuclear

SUBJECT Containment Spray (CS) & Emergency Fan (EF) Actuation Times. FILE NO. 712-A

CALC. NO. N-4080-3

① ORIGINATOR SIG. Ray S. Dawaguchi DATE Oct. 15, 1976 QUALITY CLASSIF. II

② CHECKER SIG. David M. Wilbur DATE Nov. 8, 1976 NO. LAST PAGE 55 37

LEVEL OF REVIEW ① ② ③ ④ ⑤ ⑥ CHECK AS REQUIRED

P.E. STAMP IF REQ'D

ORIGINAL ISSUE

	NAME	DATE	SIGNATURE
③ GROUP LEADER	S.G. McConnell	11/28/76	S.G. McConnell
④ EGS	J. B Hosmer	11/28/76	J B Hosmer
⑤ SPECIALIST			
⑥ CHIEF	L. Lepisto	12-2-76	L.L. Lepisto
OTHER			

RECORD OF REVISIONS

NO.	REVISION	DATE	ENG.	CKR	EGL	EGS	SPEC.	CHIEF
△1	Add p.21 - 31 Reflect new data	4/29/77	[illegible]	TER		JH		LLL
△2	Add p 32 - 42, Reflect new data	5/23/77	[illegible]	TER		JH		LL
△3	Add P 43-51, Evaluated CCW Valve time	3/19/82	[illegible]	JPW		[illegible]		[illegible]
△4	Add P 52-55, REFLECT NEW DATA	1/17/83	J P Watson	SEW	[illegible]	[illegible]		*
△								
△								

Assumption #3 on page 6 (emergency fan acceleration time of ≤ 15.6 seconds) was verified in American Air Filter to Bechtel letter XB-11294 dated 10/7/76. This letter is filed in 5023-410-1.

Ray S. Dawaguchi 1/25/77

*Staff Group Leader signature is equivalent to chief sign.

Reference calc - 4080-2.

~~NOTE: Revisions are noted by Sub Dash Numbers~~ [initials] 1-31-83

PF-254(1304) 6/

MICROFILMED

CALCULATION CROSS INDEX

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Sheet No. 2

Calc. rev. number and responsible supervisor initials and date	INPUTS These interfacing calculations and/or documents provide input to the subject calculation, and if revised may require revision of the subject calculation.		OUTPUTS Results and conclusions of the subject calculation are used in these interfacing calculations and/or documents.		Does the output interface calc/document require revision? YES/NO	Identify output interface calc/document CCN, DCN TCN/Rev. or FIDCN
	Calc/Document No.	Rev. No.	Calc/Document No.	Rev. No.		
AJB 12/23/93	Calculations: M-0014-009 N-4080-002 N-4080-007 E4C-016 SO23-944-C50 (CE-NPSD-570-P, Rev. 03-P)	0 1 2 5 0	UFSAR, SONGS Units 2&3, Section 6.2.2 Tables 6.2-30 & 6.2-31 Calculation M-0014-003 Calculation N-4080-004	9 0 1	Yes Yes/supersede Yes	SAR23-270 AJB-93-141* 9030001/1 thru 9030004/1**
5	Drawings: 40383 40397 40421, sheet 1 40494 40114B 90004	10 8 16 6 12 55	Calculation N-1140-020 Calculation N-4080-026 Calculation N-4080-027	0 0 0	No No No	N/A N/A N/A
5	Isometric Drawings: S2-1206-ML-047, sheet 1 S2-1206-ML-047, sheet 2 S2-1206-ML-048, sheet 1 S2-1206-ML-049, sheet 1 S2-1206-ML-050, sheet 1 S2-1206-ML-051, sheet 1 S2-1206-ML-052, sheet 1	9 8 4 3 4 3 4				* NEDOTRAK Log Item **NEDOTRAK Action Items
5	Vendor Prints: SO23-405-9-70 SO23-410-1-158	1 3				

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Calculation No. N-4080-003

Sheet No. 3

Calc. rev. number and responsible supervisor initials and date	INPUTS These interfacing calculations and/or documents provide input to the subject calculation, and if revised may require revision of the subject calculation.		OUTPUTS Results and conclusions of the subject calculation are used in these interfacing calculations and/or documents.		Does the output interface calc/document require revision? YES/NO	Identify output interface calc/document CCN, DCN TCN/Rev. or FIDCN
	Calc/Document No.	Rev. No.	Calc/Document No.	Rev. No.		
5 12/23/93	Specification SO23-403-12	2				
5	SONGS Unit 2 Technical Specifications	Amdt 108				
5	Procedures: SO23-XV-6 SO23-V-3.4.6 SO23-V-3.5 SO23-3-3.30 SO23-3-3.11.2 SO23-3-3.12	 TCN 0-2 TCN10-12 TCN 7-32 TCN 7-26 TCN 0-3 TCN 11-1				
5	NCR 93030001 NCR 93030002 NCR 93030003 NCR 93030004	1 1 1 1				

NES&L DEPARTMENT

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Project or DCP/MMP N/A Calc. No. N-4080-003

Subject Containment Spray (CS) & Emergency Cooling Unit (ECU) Actuation Times Sheet No. 4

REV	ORIGINATOR	DATE	IRE	DATE	REV	ORIGINATOR	DATE	IRE	DATE
5	Paul Barbour	12/23/93	Allen Evinay	12/23/93					

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1.0 PURPOSE

The purpose of this calculation is to determine a conservative time interval between the occurrence of the design basis loss of coolant accident (LOCA) or main steam line break (MSLB) in containment and the time at which a single train of the containment spray (CS) system or a post accident emergency cooling unit (ECU) is fully functional for containment heat removal. The containment spray and emergency cooling unit delay times are determined with and without a loss of off-site power (LOOP).

This revision of the calculation specifically includes engineered safety features (ESF) analysis set points of 5 psig for safety injection and containment emergency cooling unit actuation and 20 psig for containment spray system actuation. This revision also specifically calculates a spray piping fill time consistent with the performance of a 7.5% degraded containment spray pump identified in calculation M-0014-009 [Ref. 6.1].

The results of this calculation are included in UFSAR Chapter 6, tables 6.2-30 and 6.2-31, which present design basis delay times for containment heat removal system operation following a design basis LOCA or MSLB in containment. For conservatism, the delay times developed in this calculation are based on the containment pressure response to the design basis MSLB (main steam line break at 102% reactor power) since this accident provides a slower rate of containment pressure rise than does the design basis LOCA.

The delay times determined in this calculation provide a basis for modeling the start of containment heat removal systems in analyses to determine the containment pressure and temperature response to the design basis LOCA and MSLB events. These delay times are applicable only to large break events with containment pressure ramps that reach the containment high and high-high pressure analysis setpoints within the times used in this calculation. In-containment high energy line break events which provide slower rates of containment pressurization should be individually evaluated for the timing of heat removal system operation using the methodology of this calculation, but based on a calculated break-specific time to reach the high and high-high containment pressure analysis setpoints.

This calculation revision is required to support closure of disposition step 2 of NCRs 93030001, 2, 3, and 4 [Ref. 6.7] by providing minimum CS and ECU start time data for use in revising the design basis LOCA and MSLB analyses of record.

2.0 RESULTS, CONCLUSIONS, AND RECOMMENDATIONS

2.1 Results

The results of this calculation show that, following a design basis loss of coolant accident (DB LOCA) or a design basis main steam line break (DB MSLB), the containment emergency cooling units and containment spray system will be fully functional after the time intervals identified below. Delay times reflecting loss of offsite power (LOOP) and no loss of offsite power (no LOOP) are provided. For the LOOP case, the loss of power is assumed to occur at a point in time following the LOCA or MSLB such that the loss of voltage signal (LOVS) which starts the emergency diesel generator, occurs coincident with the generation of the safety injection actuation signal (SIAS) occurring on containment high pressure (SIAS/LOVS event). The values in brackets {} are the values of record from the previous revisions of this calculation.

SUMMARY OF RESULTS
Emergency Cooling Unit and Containment Spray Actuation Times

	No Loss of Power	With Loss of Power
Emergency Cooling Unit Delay Time (seconds)	**15** {13}	**34** {33}
Containment Spray Delay Time (seconds)	**49** {46.6}	**59** {55}

These delay times are specifically applicable to the DB LOCA (double-ended RCS suction leg slot break) or DB MSLB (steam line break at 102% power). Containment high energy line break events which provide slower rates of containment pressurization than the DBA events cited should be individually evaluated for the timing of heat removal system operation using the methodology of this calculation, but based on break-specific times to reach the high and high-high containment pressure setpoints.

Timelines describing the sequence of events and individual delay times associated with each component of the overall actuation time are provided in Section 8 (Calculations) as Figures 1 and 2 on pages 24 and 28 for the emergency cooling units and the containment spray, respectively.

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The change in analysis setpoint for containment high pressure from 4 psig to the currently used 5 psig [Ref. 6.2] had no effect on the delay time calculation. The 2 seconds previously allowed for the containment pressure to reach the high pressure setpoint envelopes the higher setpoint.

The 2-second increase in the delay time for emergency cooling unit operation with no LOOP is due to not crediting full operability until the component cooling water block valves to the fan cooler units are completely open versus 83% open at 13 seconds in the prior analysis.

The 1-second increase in the delay time for emergency cooling unit operation with LOOP is due to increasing the tolerance on the sequencing time delay relays for component cooling water pump start from 0.5 seconds to 1.5 seconds (±10% of the 15-second delay setting).

The change in containment spray system flow rate to allow for up to 7.5% spray pump degradation [Ref. 6.1] increased the spray piping/header fill time by about 3.5 seconds which is the major contributor to the changes in spray start time. Minor changes in other components of the overall delay time for the spray system actuation, including a ±10% uncertainty in the repeatability of sequencing the containment spray pump, also contributed to the differences in the results.

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2.2 Conclusions & Recommendations

The overall delay times employ constituent response times which are consistent or conservative with respect to Station response time and operability testing success criteria. Therefore, this calculation revision does not impact Station procedures.

The overall delay times from the prior revisions of this calculation are included in UFSAR table 6.2-30 and 6.2-31. Therefore, a UFSAR change request has been initiated to conform these tables to the current analysis of record.

The analyses of record for containment pressure and temperature response to the design basis LOCA and MSLB events [N-4080-026 and N-4080-027,Refs. 6.9 and 6.8, respectively] use emergency cooling unit and containment spray start times which conservatively envelope the values generated in this calculation. Therefore, these P/T calculations are not impacted by this revision.

The analysis of record for the containment P/T response to the design basis MSLB event for equipment qualification [N-4080-004, Ref. 6.23] used emergency cooling unit and spray start times which do not envelope the values in this calculation. Calculation N-4080-004 is scheduled for revision as a disposition step of NCRs 93030001, 2, 3, and 4 [Ref. 6.7]. The future revision of the MSLB P/T equipment qualification calculation will include emergency cooling unit and containment spray start times consistent with the current revision of this start time calculation.

Calculation M-0014-003 [Ref. 6.24] is an early analysis of the fill time for containment spray piping inside containment. The current piping fill analysis contained in this revision of the emergency cooling unit and containment spray system startup delay times supersedes the analysis in Reference 6.24, and that calculation will be obsoleted.

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3.0 ASSUMPTIONS

3.1 Instrument response and ESF signal generation time is assumed to be 1 second. This value is consistent and conservative with respect to the ESF response times calculated and used in the Plant Protection System Setpoint Calculation, CE-NPSD-570-P [Ref. 6.2]. According to sections 4.9 and 4.10 of Reference 6.2, the total ESFAS response time for either containment high pressure or high-high pressure is estimated to be 0.551 seconds, which is below the 1 second analysis response time assumed in this calculation. The 1-second response time also coincides with the combined "sensor and ESF logic" and "subgroup relay" delay times identified in General Engineering Procedure SO23-XV-6, "Technical Specification Response Time Surveillance Implementing Procedure Master List" [Ref. 6.3]. The 1-second ESF response time used in this calculation and in Reference 6.2 is split in to the "sensor and ESF logic" and "subgroup relay" delay times to facilitate response time testing by the Reference 6.3 procedure.

3.2 Closing times for the electrical power breakers supplying the motors for the containment spray pumps, the component cooling water pumps and the emergency cooling unit fans are assumed to be included in the motor acceleration times identified in Design Input items 4.7, 4.8, and 4.9. The breaker closing time is normally a very short interval, and a typical value from vendor equipment catalog data [Ref. 6.4] shows closure times of about 4.5 cycles (0.075 seconds) for the 5Kv breakers used to supply the 4160 volt power to the component cooling water and containment spray pumps. Since the minimum motor acceleration times used in this calculation are at least 4 seconds and typically include margin above the expected acceleration times, the assumption that the motor acceleration times include a breaker closure time allowance of the order of 0.1 second is reasonable.

3.3 For the loss of offsite power case, the LOOP is assumed to occur at a finite time following the LOCA or MSLB such that the diesel start in response to the loss of voltage signal (LOVS) occurs coincident with the generation of the safety injection actuation signal (SIAS), a SIAS/LOVS event. Since, as identified in Design Input 4.5, the bounding time for the containment pressure to reach the high pressure analysis setpoint of 5 psig is taken to be 2 seconds following either the design basis LOCA or MSLB event and the ESF delay time to generate the SIAS is assumed to be 1 second (Assumption 3.1, above), the diesel generators will be starting 3 seconds following the design basis pipe break event.

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3.4 Consistent with vendor specifications for sequencing time delay relay repeatability of ±10% of the Agastat relay setting as provided in Reference 6.25, conservative sequencing delays of 11 seconds (10±1 sec) and 16.5 seconds (15±1.5 sec) will be assumed for the containment spray pumps and component cooling water pumps, respectively. These delay times are conservative with respect to the acceptance criteria for sequence loading accuracy of ±10% of the load block time interval (±0.5 sec for load groups 2 through 4) as provided in the Reference 6.3 procedure.

3.5 The bounding time for the containment pressure to rise to the high pressure analysis setpoint of 5 psig following the design basis LOCA or MSLB pipe break event will be assumed to be 2 seconds. This time delay is based on the containment pressure response to the design basis steam line break event (MSLB at 102% power). For this break, the containment pressure has increased by 6.5 psi at 2 seconds following the break [Ref. 6.8]. For the design basis LOCA event, the containment pressure has increased by 11.7 psi at 2 seconds following the break [Ref. 6.9].

3.6 The bounding time for the containment pressure to rise to the high-high pressure analysis setpoint of 20 psig following the design basis LOCA or MSLB pipe break event will be assumed to be 9 seconds. This time delay is based on the containment pressure response to the design basis MSLB at 102% power. For this break, the containment pressure has increased by 20 psi at 8 seconds and by 21.8 psi at 9 seconds following the break [Ref. 6.8]. For the design basis LOCA event, the containment pressure has increased by 20 psi at about 4.1 seconds, and by 34 psi at 9 seconds following the break [Ref. 6.9].

3.7 The containment spray piping riser is assumed to be filled with water to within 10 feet of the lower (first) ring header as required by Technical Specification Surveillance Requirement 4.6.2.1.b.4 [Ref. 6.15]. The water level in the spray riser piping is established using Station Procedure SO23-3-3.11.2 [Ref. 6.16]

3.8 The containment spray headers are assumed to fill one at a time from the bottom ring to the top ring. As each spray ring is being filled, it is further assumed that the flow rate of water into the ring available to fill the ring is reduced by having each nozzle in the ring immediately begin leaking water at a flow rate set by an assumed water pressure in the ring of 5 psi above the containment pressure. This is a conservative assumption since the nozzles can only begin to leak water after the water reaches them, and the pressure driving the leakage would only be the static head at each nozzle location which, on average, would be expected to be

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less than the assumed 5 psi for the ring being filled. As the riser between the rings is filled, the full spray rings leak water at a flow rate consistent with the 5 psi assumed for the higher ring being filled plus the static pressure between the ring being filled and the full ring below. The nozzle spray flow rate as a function of nozzle pressure drop is defined in Design Input 4.11.

3.9 The filling of the spray headers will be assumed to start at the time the spray pump reaches full speed. The filling flow rate will be assumed to be 1900 gpm. This value is conservatively chosen to be less than that calculated in Case 7 of Reference 6.1 (1933 gpm; see Design Input 4.10). This flow rate is representative of the minimum value during injection mode operation with the RWST full, the containment at the design pressure of 60 psig, the spray block valves full open, but without the full nozzle pressure drop as would be the case while the headers are filling. For the case of containment spray actuation with <u>no</u> LOOP, the spray block valves are only 67% open at the time the spray pump reaches full speed, and about 4 seconds remain before the block valves are full open (see section 8.2.1). Based on Case 5 of Reference 6.1, the filling flow rate with the valves half open would be greater than 1650 gpm, or 87% of the valves full open flow rate (1679 gpm is shown in Ref. 6.1). Using linear interpolation, the filling flow with the block valves 67% open would be about 91% of the maximum filling flow rate. The assumption of the maximum filling flow rate from the time the block valves are 67% open, with the spray pump at full speed, is justified since no credit is taken for the substantial amount of water which will enter the assumed empty portion of the riser during the 4 seconds that the pump is accelerating to full speed while the block valves are moving from about 33% open to 67% open. It is estimated that over 50 gallons of water would enter the assumed empty portion of the spray riser system, which is enough to fill about 25 feet of the initial 8" and 6" diameter riser piping before the calculation assumes any water enters the dry part of the piping system.

3.10 The spray piping filling time will be calculated for the "A" spray train (header number 1) since the total length of all 3 ring headers for this train is about 19 feet longer than that for the "B" train.

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4.0 DESIGN INPUT

4.1 The analysis setpoint for containment high pressure is 5 psig [Ref. 6.2]. This value is consistent with the actual containment high pressure setpoint of 3.4 psig established in Reference 6.2 and incorporated into the Station Technical Specifications [Ref. 6.15, Unit 2 as an example]. The high pressure setpoint initiates the safety injection actuation signal (SIAS) and containment cooling actuation signal (CCAS). The SIAS signal initiates startup of the high and low pressure safety injection pumps and the containment spray pumps (P-012 and P-013) through the ESF sequencer. The CCAS signal will start the emergency cooling units (E-399, E-400, E-401 and E-402) and cause the component cooling water block valves to the emergency cooling units to open (2(3)HV-6366 through 2(3)HV-6373).

4.2 The analysis setpoint for containment high-high pressure is 20 psig [Ref 6.2]. This value is consistent with the actual containment high-high pressure setpoint of 14.0 psig established in Reference 6.2 and incorporated into the Station Technical Specifications [Ref. 6.15, Unit 2 as an example]. The high-high pressure setpoint initiates the containment spray actuation signal (CSAS) which causes the containment spray block valves, 2(3)HV-9367 and 2(3)HV-9368, to open.

4.3 The diesel generator delay for the LOOP case is 10 seconds [Section 4.8.5.D of Ref. 6.5]. This time interval includes generator start, attainment of rated voltage and frequency, and breaker closure energizing the 4160 volt ESF bus. This value is the same as the surveillance test acceptance value of 10 seconds cited in Section 7.1.16.2.2 of Reference 6.17.

4.4 The nominal delays for sequencing the first 4 ESF load groups are [Ref. 6.6]:

Group 1	0 seconds
Group 2	5 seconds
Group 3	10 seconds
Group 4	15 seconds

The emergency fan cooler motors are in Group 1 [Ref. 6.6].
The containment spray pump motors are in Group 3 [Ref. 6.6].
The component cooling water pump motors are in Group 4 [Ref. 6.6].

As identified in Assumption 3.4, supported by Reference 6.25, the repeat accuracy of the load group delay times is ±10% of the Agastat time delay relay setting.

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4.5 The maximum stroke time for opening the containment spray block valves, 2(3)HV-9367 and 2(3)HV-9368, is 12 seconds [Refs. 6.10 and 6.11].

4.6 The maximum stroke time for opening CCW isolation valves 2(3)HV-6366 through 2(3)HV-6373, which permit cooling water to flow through the containment emergency cooling units, is 12 seconds [Refs. 6.10 and 6.11].

4.7 The maximum time required to accelerate a containment spray pump to full speed, following closure of the pump power supply breaker is 4 seconds. This value is slightly more conservative than the maximum acceptable surveillance test value of 3.9 seconds identified in Reference 6.12.

4.8 The maximum time required to accelerate a CCW pump to full speed following closure of the pump power supply breaker is 4.5 seconds [Ref. 6.3]. This value is conservative with respect to a vendor-supplied acceleration time of 2 seconds at 75% voltage shown in Reference 6.13.

4.9 The maximum time required to accelerate an emergency cooling unit fan motor to full speed following closure of the fan motor power supply breaker is 10 seconds [Ref. 6.3]. This value is conservative with respect to a vendor-supplied acceleration time of 7.8 seconds at 80% voltage shown in Reference 6.14.

4.10 The spray pump flow rate delivered to the containment riser while filling of the spray ring headers is in progress (prior to establishment of full containment spray flow at design nozzle pressure drop) will be taken to be 1650 gpm with the spray isolation valve 2(3)HV-9367 or 2(3)HV-9368 one-half open and 1900 gpm with the spray block valves full open. These values have been conservatively selected to be less than the minimum flow rates calculated for cases 5 and 7, respectively, of Reference 6.1 for a 7.5% degraded spray pump drawing water from a full RWST and pumping into a 60 psig containment building during the time that the spray piping is filling, before the full nozzle pressure drop is developed.

4.11 The Sprayco 1713A hollow cone bottom ramp spray nozzles have a design flow rate of 15.2 gpm at a 40 psid nozzle pressure drop [Appendix 2 of Ref. 6.1]. With turbulent flow conditions, the flow rate will vary as the square root of the nozzle pressure drop.

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5.0 METHODOLOGY

The start times for the containment sprays and emergency cooling units are determined by combining in series (and in parallel, if appropriate) the time intervals for each action which must occur to establish a functioning heat removal system. The constituents of the total delay times are identified below.

A. Emergency Cooling Unit Operation

1) Time to reach containment high pressure analysis setpoint following the design basis LOCA or MSLB

2) Sensor and instrumentation delays to generate the containment cooling actuation signal (CCAS)

3) Assuming LOOP, time to start the diesel generator, reach design voltage and frequency, and energize the 4160 volt ESF bus (with no LOOP, the diesel generator delay is not applicable)

4) Time to open the component cooling water (CCW) block valves to the emergency cooling units

5) Time for the emergency cooling unit fan motors, which are in the 1st ESF load group, to be energized and accelerate to full speed

6) Also, assuming LOOP, ESF sequencing delay in restarting the CCW pumps which start in the 4th load group (with no LOOP, CCW pumps remain running and this delay does not apply)

7) Time to accelerate the CCW pumps to full speed, restoring CCW flow, assuming a LOOP had occurred (not applicable for a no LOOP case)

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Subject Containment Spray (CS) & Emergency Cooling Unit (ECU) Actuation Times Sheet No. 15

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5	Paul Barbour	12/23/93	Allen Evinay	12/23/93					

B. Containment Spray System Operation

1) Time to reach containment high pressure analysis setpoint following the design basis LOCA or MSLB

2) Sensor and instrumentation delays to generate the safety injection actuation signal (SIAS) which initiates automatic sequencing of ESF equipment and starts the containment spray pump in the 3rd load group (with LOOP, sequencing is delayed until the ESF bus is energized by the emergency diesel generator)

3) Assuming LOOP, time to start the diesel generator, reach design voltage and frequency, and energize the 4160 ESF bus (with no LOOP, the diesel generator delay is not applicable)

4) Time for the spray pump motors to be energized and accelerate to full speed

5) Time to reach containment high-high-pressure analysis setpoint following design basis LOCA or MSLB

6) Sensor and instrumentation delays to generate the containment spray actuation signal (CSAS) which initiates opening of the containment spray isolation valves and allow spray water to begin filling the spray piping in containment

7) Time to open the containment spray isolation valves

8) Time to fill the spray rings and establish full containment spray flow

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6.0 REFERENCES

6.1 Mechanical Calculation M-0014-009, Rev. 0, "Containment Spray Pumps Inservice Testing Minimum Requirements", March 3, 1993

6.2 ABB-CE Calculation CE-NPSD-570-P, Rev. 03-P, "Plant Protection System Setpoint Calculation", October, 1991, SCE Document No. SO23-944-C50-0

6.3 General Engineering Procedure SO23-XV-6, Rev. 0, thru TCN 0-2, "Technical Specification Response Time Surveillance Implementing Procedure Master List", April 27, 1989

6.4 Gould-Brown Bovari Switchgear Division Bulletin 8.2-1E, "ITE Type HK Stored Energy Metal-Clad Switchgear", Table 9, page 43 (copy of page 43 provided in Appendix A)

6.5 Specification SO23-403-12, Rev. 2, "Diesel Driven Electrical Generating Sets for SONGS Units 2 and 3", October 3, 1975

6.6 Electrical Calculation E4C-016, Rev. 5, "ESF Sequencing", May 4, 1984

6.7 NCRs 93030001, 2, 3, and 4; Containment Spray Pumps 1 & 2 for SONGS Units 2 & 3

6.8 Nuclear Calculation N-4080-027, Rev. 0, "Containment P/T Analysis for Design Basis MSLB"

6.9 Nuclear Calculation N-4080-026, Rev. 0, "Containment P/T Analysis for Design Basis LOCA"

6.10 Engineering Procedure, SO23-V-3.5, TCN 7-32, "Inservice Testing of Valves Program", December 9, 1993

6.11 Surveillance Operating Instruction, SO23-3-3.30, TCN 7-26, "In-service Valve Testing, Quarterly", September 10, 1993

6.12 Engineering Procedure SO23-V-3.4.6, TCN 10-12, "Containment Spray Inservice Pump Test", November 6, 1993

6.13 Vendor Drawing, SO23-405-9-70-1, "Motor Acceleration Time Curves"

6.14 Vendor Document, SO23-410-1-158-3, "Electric Motor Data, 460-Volt Motors and Below"

6.15 SONGS Unit 2 Technical Specifications, Through Amendment 108

6.16 Operator Surveillance Test, SO23-3-3.11.2, TCN 0-3, "Containment Spray System Refueling Test", September 20, 1993

6.17 Surveillance Operating Instruction, SO23-3-3.12, TCN 11-1, "Integrated ESF System Refueling Test", November 23, 1993

6.18 Spray Piping Plan Drawings (Unit 2)

a. 40494-6 c. 40397-8
b. 40421-16 (sheet 1) d. 40383-10

6.19 Spray Piping Isometric Drawings (Unit 2)

A-Train (Header No. 1)	B-Train (Header No. 2)
a. S2-1206-ML-047, Sh. 1, Rev. 9	h. S2-1206-ML-041, Sh. 1, Rev. 9
b. S2-1206-ML-047, Sh. 2, Rev. 8	i. S2-1206-ML-041, Sh. 2, Rev. 9
c. S2-1206-ML-048, Sh. 1, Rev. 4	j. S2-1206-ML-042, Sh. 1, Rev. 5
d. S2-1206-ML-049, Sh. 1, Rev. 3	k. S2-1206-ML-043, Sh. 1, Rev. 5
e. S2-1206-ML-050, Sh. 1, Rev. 4	l. S2-1206-ML-044, Sh. 1, Rev. 5
f. S2-1206-ML-051, Sh. 1, Rev. 3	m. S2-1206-ML-045, Sh. 1, Rev. 4
g. S2-1206-ML-052, Sh. 1, Rev. 4	n. S2-1206-ML-046, Sh. 1, Rev. 6

6.20 Piping and Instrumentation Drawing 40114B-12

6.21 Piping Material Classifications, Drawing 90004-55

6.22 Crane, Technical Paper 410, "Flow of Fluids", 1976

6.23 Nuclear Calculation N-4080-004, Rev. 1, "Equipment Qualification Thermal Analysis (MSLB)", November 6, 1978

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5	Paul Barbour	12/23/93	Allen Evinay	12/23/93					

6.24 Mechanical Calculation M-0014-003, Rev. 0, "Containment Spray Flow History", May 28, 1975

6.25 Amerace Corporation, Industrial Electrical Products Division, Bulletin E70-1, "Agastat Nuclear Qualified Time Delay Relays", E7000 Series Operating Characteristics from Specifications on Page 4 (copy of the table provided in Appendix B)

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7.0 NOMENCLATURE

7.1 Mathematical Symbols

A pipe flow area (ft^2)

L pipe length (feet)

Q volumetric flow rate (gal/min)

q_n individual spray nozzle flow rate (gal/min-nozzle)

t time (seconds)

V piping volume (ft^3)

7.2 Abbreviations & Acronyms

CCAS Containment Cooling Actuation Signal

CCW Component Cooling Water

COPATTA Containment Pressure and Temperature Transient Analysis computer program

CS Containment Spray

CSAS Containment Spray Actuation Signal

CSP Containment Spray Pump

DB Design Basis

DBA Design Basis Accident

ECU Emergency Cooling Unit (in containment)

EDG Emergency Diesel Generator

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5	Paul Barbour	12/23/93	Allen Evinay	12/23/93					

ESF Engineered Safety Feature

ESFAS Engineered Safety Feature Actuation System

gpm gallons per minute (flow rate)

LOCA Loss Of Coolant Accident

LOOP Loss of Offsite Power

LOVS Loss Of Voltage Signal

MSLB Main Steam Line Break

NCR Non-Conformance Report

psid pounds per square inch differential

RWST Refueling Water Storage Tank

SIAS Safety Injection Actuation Signal

UFSAR Updated Final Safety Analysis Report

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8.0 CALCULATIONS

8.1 Emergency Cooling Units

The timing of the automatic startup of the emergency cooling units following a design basis LOCA or MSLB, with and without loss of offsite power, is developed in the following two sub-sections. The total delay time is developed using a chronology of events approach. Timelines describing the sequence of events for emergency cooling unit startup, with and without loss of offsite power, are provided in Figure 1. The delay times associated with each component of the overall delay time, which are provided in the chronologies below, have been included on the timelines in parentheses.

8.1.1 ECU Actuation With No Loss of Offsite Power (see Figure 1.A)

	Event	Time
(A)	DB LOCA or MSLB occurs	zero seconds
(B)	Containment pressure reaches the analysis setpoint for containment high pressure (5 psig, Des. Input 4.1)	2 seconds (Assump. 3.5)
(C)	SIAS generated Sequencing of ESF equipment begins (CCW pumps already running) CCAS generated CCW block valves to ECUs begin to open Emergency cooling unit fan motors start (ECUs are in the first ESF load group per Design Input 4.4)	1 second after reaching hi pressure setpoint (Assump. 3.1)
(D)	Emergency cooling unit motor and fan at rated speed	10 seconds after ESF start signal (Des. Input 4.9 and Assump. 3.2)
(E)	CCW isolation valves to ECUs are fully open	12 seconds from time valves begin to open (Des. Input 4.6)

Elapsed time following DB LOCA or MSLB for emergency cooling unit fan to reach full speed = A + B + C + D
= 0 + 2 + 1 + 10 = 13 seconds

Elapsed time following DB LOCA or MSLB for emergency cooling unit fan to be at full speed with CCW block valves full open
= A + B + C + E
= 0 + 2 + 1 + 12 = **15 seconds**

The limiting action for establishing emergency cooling unit full operability with no loss of offsite power, following a design basis LOCA or MSLB, is opening the CCW valves which provide cooling water flow through the ECUs. Although the CCW block valves will be about 83% open at the time the emergency cooling unit fans reach full speed, and should be capable of passing essentially full cooling water flow, full EF cooler operability will conservatively assumed to be available only after the block valves are full open at 15 seconds post accident.

8.1.2 ECU Actuation With Loss of Offsite Power (see Figure 1.B)

(A)	DB LOCA or MSLB occurs	zero seconds
(B)	Containment pressure reaches the analysis setpoint for containment high pressure (5 psig, Des. Input 4.1)	2 seconds (Assump. 3.5)
(C)	SIAS generated CCAS generated LOVS is present and EDG starts due to LOOP	1 second after reaching hi pressure setpoint (Assump. 3.1)
(D)	EDG @ full speed and frequency and ESF bus energized Sequencing of ESF equipment begins CCW block valves to ECUs begin to open ECU fan cooler motors start (ECUs are in first ESF load group per Design Input 4.4)	10 seconds after EDG start (Des. Input 4.3)
(E)	ECU motor and fan at rated speed	10 seconds after ESF start signal (Des. Input 4.9 and Assump 3.2)

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(F) CCW isolation valves to ECUs are fully open — 12 seconds from time valves begin to open (Des. Input 4.6)

(G) CCW pump motor starts (CCW pump motors are in the fourth ESF load group per Des. Input 4.4) — 16.5 seconds after start of ESF sequencing (Assumps. 3.2 and 3.4)

(H) CCW pump at full speed — 4.5 seconds after ESF start signal (Des. Input 4.8)

Elapsed time following DB LOCA or MSLB for emergency cooling unit fan to reach full speed = A + B + C + D + E
= 0 + 2 + 1 + 10 + 10 = 23 seconds

Elapsed time following DB LOCA or MSLB for emergency cooling unit fan to be at full speed with CCW block valves full open
= A + B + C + D + F
= 0 + 2 + 1 + 10 + 12 = 25 seconds

Elapsed time following DB LOCA or MSLB for emergency cooling unit fan to be a full speed, CCW block valves fully open and restarted CCW pump
= A + B + C + D + G + H
= 0 + 2 + 1 + 10 + 16.5 + 4.5 = **34 seconds**

The limiting action for establishing emergency cooling unit full operability with loss of offsite power and the loss of voltage signal simultaneous with the safety injection actuation signal (SIAS/LOVS event), following a design basis LOCA or MSLB, is restarting the CCW pumps through the ESF sequencing time delay relays. The total delay time for emergency cooling unit operability in this case is 34 seconds.

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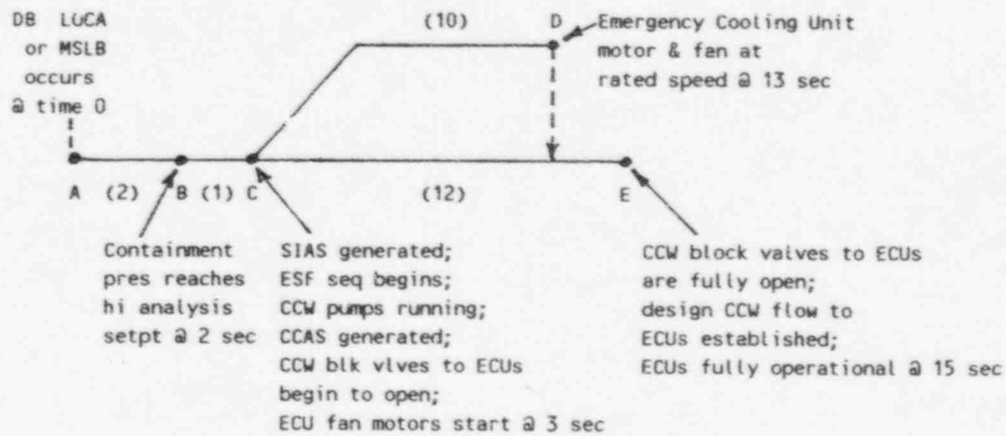
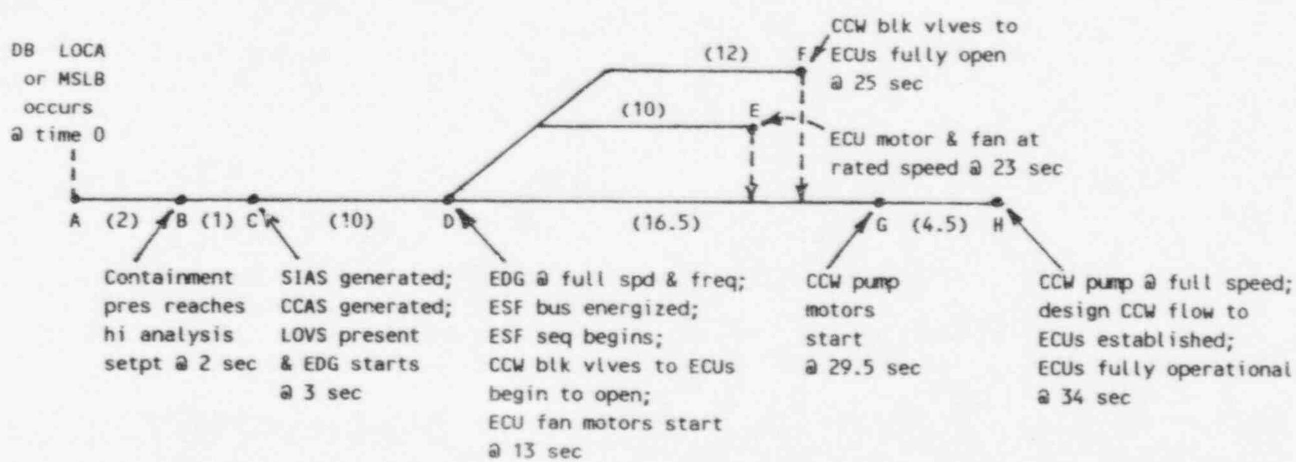
5	Paul Barbour	12/23/93	Allen Evinay	12/23/93					

FIGURE 1 - Emergency Cooling Unit Actuation Timelines

A. ECU ACTUATION WITH NO LOSS OF OFFSITE POWER



B. ECU ACTUATION WITH LOSS OF OFFSITE POWER



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8.2 Containment Spray System

The timing of the automatic startup of the containment spray system following a design basis LOCA or MSLB, with and without loss of offsite power, is developed in a manner similar to that used for the emergency air coolers. The time to fill the empty spray piping and ring headers inside containment is calculated separately in sub-section 8.2.3. Timelines describing the sequence of events for containment spray startup, with and without loss of power, are provided in Figure 2. The delay times associated with each component of the overall delay time, which are provided in the chronologies below, have been included on the timelines in parentheses.

8.2.1 CS Actuation With No Loss of Offsite Power (see Figure 2.A)

(A)	DB LOCA or MSLB occurs	zero seconds
(B)	Containment pressure reaches the analysis setpoint for containment high pressure (5 psig, Des. Input 4.1)	2 seconds (Assump. 3.5)
(C)	SIAS generated Sequencing of ESF equipment initiated	1 second after reaching hi pressure setpoint (Assump. 3.1)
(D)	Containment pressure reaches the analysis setpoint for containment high-high pressure (20 psig, Des Input 4.2)	9 seconds (Assump. 3.6)
(E)	CSAS generated Containment spray block valves begin to open	1 second after reaching hi-hi pressure setpoint (Assump. 3.1)
(F)	Containment spray pump motor starts (Spray pump motors are in the third ESF load group per Des. Input 4.4)	11 seconds after start of ESF sequencing (Assumps. 3.2 and 3.4)
(G)	Containment spray pump at full speed Spray block valves are about 67% open (8 seconds of the 12 second valve stroke time have elapsed)	4 seconds after ESF start signal (Des. Input 4.7)

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(H) Containment spray block valves full open — 12 seconds after CSAS generated (Des. Input 4.5)

(I) Spray piping and ring headers filled and full containment spray flow established from the spray system — 31.1 seconds after CSP at full speed (see 8.2.3)

Elapsed time following DB LOCA or MSLB for containment spray pumps to reach full speed = A + B + C + F + G
= 0 + 2 + 1 + 11 + 4 = 18 seconds

Elapsed time following DB LOCA or MSLB for containment spray block valves to be full open = D + E + H
= 9 + 1 + 12 = 22 seconds

Elapsed time following DB LOCA or MSLB for containment spray system to be fully functional assuming full header filling flow rate credited at time CSP reaches full speed (Assump 3.9) = A + B + C + F + G + I
= 0 + 2 + 1 + 11 + 4 + 31.1 = 49.1 seconds
= **49 seconds, rounded**

8.2.2 CS Actuation With Loss of Offsite Power (see Figure 2.B)

(A) DB LOCA or MSLB occurs — zero seconds

(B) Containment pressure reaches the analysis setpoint for containment high pressure (5 psig, Des. Input 4.1) — 2 seconds (Assump. 3.5)

(C) SIAS generated
LOVS is present and EDG starts due to LOOP — 1 second after reaching hi pressure setpoint (Assump. 3.1)

(D) Containment pressure reaches the analysis setpoint for containment high-high pressure (20 psig, Des. Input 4.2) — 9 seconds (Assump. 3.6)

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(E) CSAS generated — 1 second after reaching hi-hi pressure setpoint (Assump. 3.1)

(F) EDG at full speed and frequency and ESF bus energized
Sequencing of ESF equipment begins
Containment spray block valves begin to open with CSAS already present — 10 seconds after EDG start (Des. Input 4.3)

(G) Containment spray pump motor starts (Spray pump motors are in the third ESF load group per Des. Input 4.4) — 11 seconds after start of ESF sequencing (Assumps. 3.2 and 3.4)

(H) Containment spray block valves full open — 12 seconds after ESF bus is loaded with CSAS present (Des. Input 4.5)

(I) Containment spray pump at full speed — 4 seconds after ESF start signal (Des. Input 4.7)

(J) Spray piping and ring headers filled and full containment spray flow established from the spray train — 31.1 seconds after CSP at full speed (see 8.2.3)

Elapsed time following DB LOCA or MSLB for containment spray block valves to be full open
= A + B + C + F + H
= 0 + 2 + 1 + 10 + 12 = 25 seconds

Elapsed time following DB LOCA or MSLB for containment spray pump to be at full speed
= A + B + C + F + G + I
= 0 + 2 + 1 + 10 + 11 + 4 = 28 seconds

Elapsed time following DB LOCA or MSLB for containment spray system to be fully functional assuming full header filling flow rate credited at time CSP reaches full speed (with all valves wide open at that time)
= A + B + C + F + G + I + J
= 0 + 2 + 1 + 10 + 11 + 4 + 31.1 = 59.1 seconds
= **59 seconds, rounded**

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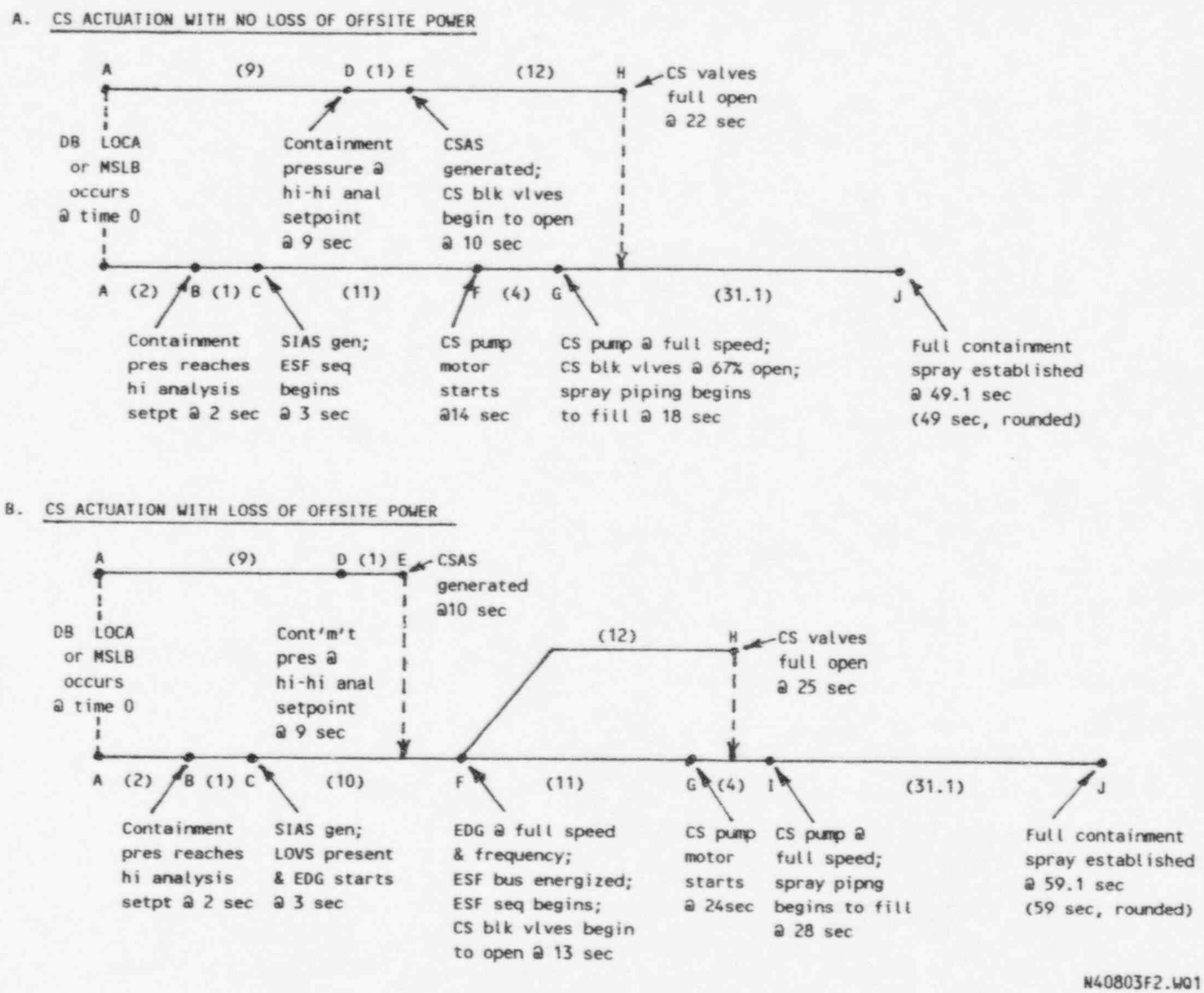
5	Paul Barbour	12/23/93	Allen Evinay	12/23/93					

FIGURE 2 - Containment Spray Actuation Timelines



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8.2.3 Spray Piping/Header Filling

Filling of the spray riser piping and ring headers in containment is modeled as occurring in 8 discrete steps. The separate times calculated for each step are individually combined in series although a number of the steps will actually occur in parallel. The resultant fill time is, therefore, conservative. With reference to Figure 3 on page 30, the 8 steps are:

1) Filling the 8" riser from 10 feet below the first ring header up to the elevation of the first ring header (length AB)

2) Filling the horizontal 6" riser at the elevation of the first ring header (length BC)

3) Filling the first ring header (4" piping), from points B and C to the capped ends of the ring header

4) Filling the 6" riser from the first to the second ring headers (length CD)

5) Filling the horizontal 6" riser at the elevation of the second ring header (length DE)

6) Filling the second ring header (4" piping) from points D and E to the capped ends of the ring header

7) Filling the 4" riser between the second and third ring headers (length EF)

8) Filling the third ring header (2 1/2" piping) from point F to the capped ends of the ring header

The A-train spray piping will be used as a basis for the fill time calculation per Assumption 3.9. The A-train piping to be filled consists of the following specific lines:

10 feet of 047-8"-C-KEO	049-4"-C-KEO
047-6"-C-KEO	050-4"-C-KEO
047-4"-C-KEO	051-4"-C-KEO
048-4"-C-KEO	052-2 1/2"-C-KEO

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5	Paul Barbour	12/23/93	Allen Evinay	12/23/93						

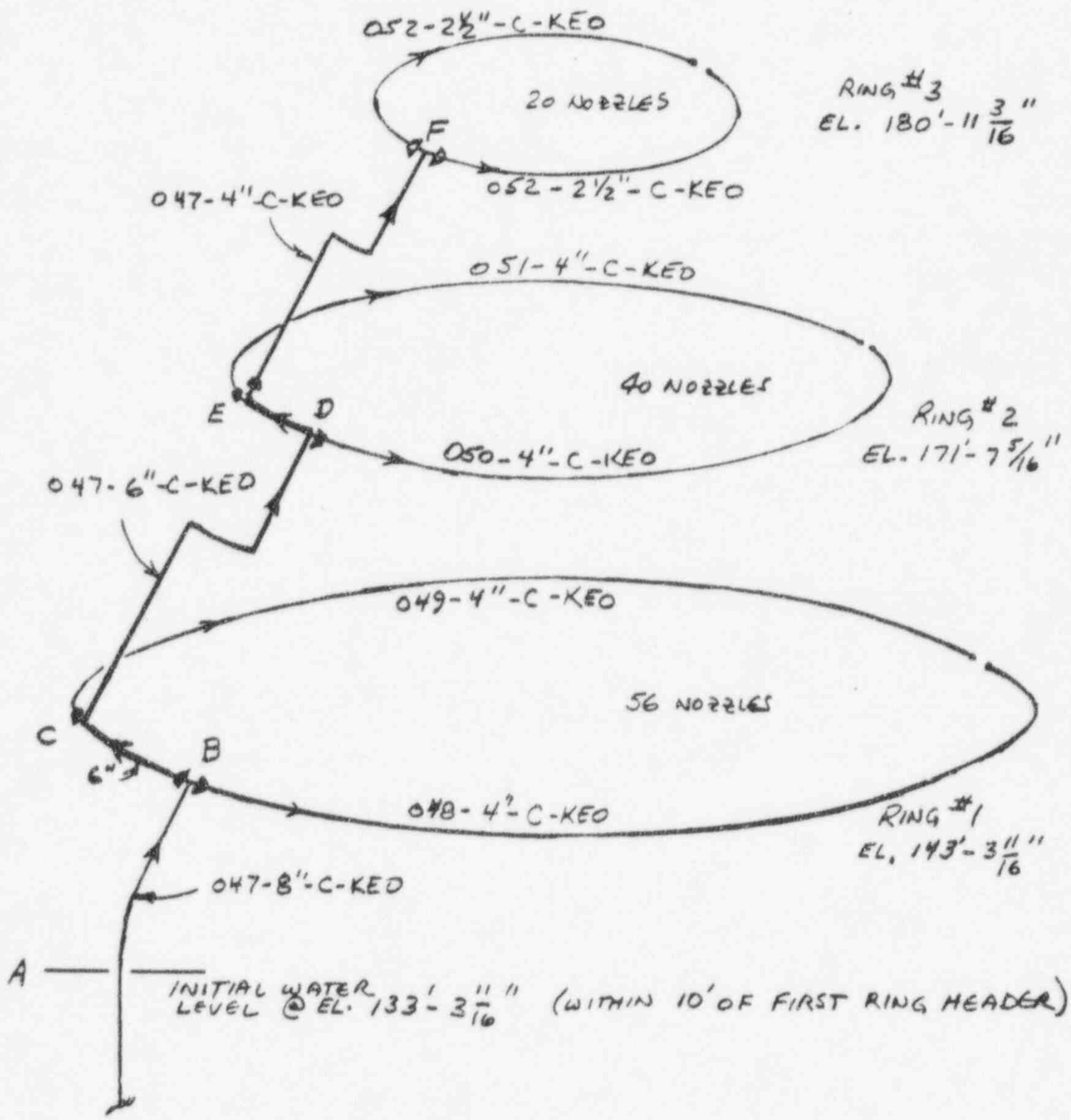

FIGURE 3

Containment Spray Header Schematic - Train A

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The spray piping is all class KEO per P&ID 40114B [Ref. 6.20]. The schedule [Ref. 6.21], inside diameter and cross-sectional flow area [Ref. 6.22] of each of the 4 pipe sizes being filled are tabulated below.

8"	Schedule 20	8.125" ID	0.3601 ft^2 area
6"	Schedule 10S	6.357" ID	0.2204 ft^2 area
4"	Schedule 10S	4.260" ID	0.09899 ft^2 area
2 1/2"	Schedule 40S	2.469" ID	0.03325 ft^2 area

The time to fill each of the 8 piping sections identified on the previous page, and shown in Figure 3, is calculated as follows:

1) The 10-foot length of empty riser below the 1st spray ring header (length AB):

   Length, L_1 = 10 feet [Assumption 3.7]

   Volume, $V_1 = L_1 \times A_1 = 10 \times 0.3601 \times 7.48$ gal/ft^3 = 26.9 gallons

   Filling flow rate, Q_1 = 1900 gpm [Des. Input 4.10]

   Fill time, $t_1 = V_1/Q_1 = (26.9/1900) \times 60$ sec/min = <u>0.85 seconds</u>

2) The 6" horizontal pipe connecting the lower 8" riser to the 6" riser between the 1st and 2nd ring headers (length BC):

   Length, L_2 = 17 feet [Ref. 6.19.a]

   Volume, $V_2 = L_2 \times A_2 = 17 \times 0.2204 \times 7.48$ gal/ft^3 = 28.0 gallons
   Filling flow rate, Q_2 = 1900 gpm [Des. Input 4.10]

   Fill time, $t_2 = V_2/Q_2 = (28.0/1900) \times 60$ sec/min = <u>0.88 sec</u>

3) The first ring header, 4" lines 048 and 049, points B and C to the capped ends of the ring header:

   Ring header radius = 66' - 6" [Ref. 6.19.a]
   Circumference (maximum for a complete circle) = $2 \times \pi \times 66.5$ = 418 feet
   Ring header length, L_3 (less length BC) = 418 - 17 = 401 feet

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Volume, $V_3 = L_3 \times A_3 = 401 \times 0.09899 \times 7.48 \text{ gal/ft}^3 = 296.9$ gallons

While filling the 1st ring header, the filling flow rate (1900 gpmu) will be reduced by an assumed leakage flow from each of the 56 nozzles in the 1st header with the leakage flow rate based on a 5 psig head [Assumption 3.8].

Based on Design Input 4.11, the expected flow per nozzle with a 5 psig pressure drop is

$$q_n = 15.2\ (5/40)^{0.5} = 5.37 \text{ gpm per nozzle}$$

total nozzle leakage = 56 x 5.37 = 301 gpm

Net filling flow rate, Q_3 = 1900 - 301 = 1599 gpm

Fill time, $t_3 = V_3/Q_3$ = (296.9/1599) x 60 sec/min = <u>11.14 seconds</u>

4) The 6" riser from the 1st ring header to the 2nd ring header (length CD):

Length, L_4 = 44 feet [Refs. 6.19.a and 6.19.b]

Volume, $V_4 = L_4 \times A_4 = 44 \times 0.2204 \times 7.48 \text{ gal/ft}^3 = 72.5$ gallons

While filling the 6" riser, the static head on the first ring header increases by the elevation gain from the 1st ring header to the 2nd ring header. The elevation of the 1st ring is 143'-3 11/16" [Ref. 6.19.a] and the elevation of the 2nd ring is 171'-7 5/16" [Ref. 6.19.b]. The elevation difference is 28'-3 5/8", or 28.3 feet. At ambient temperature, the conversion factor for feet of water to psi is 0.433. Thus, the elevation gain will increase the pressure on the 1st ring header by 28.3 x 0.433 = 12.3 psi. The effective pressure acting to drive leakage out through the nozzles in the first ring header while the 6" riser is being filled is conservatively taken to be the 5 psig applicable during the filling of the ring plus the 12.3 psig due to the elevation difference between the 1st and 2nd rings, or a total of 17.3 psig [Assumption 3.8].

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Based on Design Input 4.11, the expected flow per nozzle with a 17.3 psig pressure drop is

$q_n = 15.2\ (17.3/40)^{0.5} = 10.0$ gpm per nozzle

total 1st ring nozzle leakage = 56 x 10.0 = 560 gpm

Net filling flow rate, Q_4 = 1900 - 560 = 1340 gpm

Fill time, $t_4 = V_4/Q_4$ = (72.5/1340) x 60 sec/min = <u>3.25 sec</u>

5) The 6" horizontal pipe connecting the riser feeding the 2nd ring header with the 4" riser that feeds the 3rd ring header (length DE):

Length, L_5 = 15 feet [Ref. 6.19.b]

Volume, $V_5 = L_5 \times A_5$ = 15 x 0.2204 x 7.48 gal/ft^3 = 24.7 gallons

Filling rate, Q_5 = 1340 gpm (same as Q_4)

Fill time, $t_5 = V_5/Q_5$ = (24.7/1340) x 60 sec/min = <u>1.11 sec</u>

6) The second ring header, 4" lines 050 and 051, points D and E to the capped ends of the ring header:

Ring header radius = 43'-0" [Ref. 6.19.e]
Circumference (maximum for a complete circle) = 2 x π x 43.0 = 270 feet
Ring header length, L_6 (less length DE) = 270 - 15 = 255 feet

Volume, $V_6 = L_6 \times A_6$ = 255 x 0.09899 x 7.48 gal/ft^3 = 188.8 gallons

While filling the 2nd ring header, the maximum filling flow rate (1900 gpm) will be reduced by leakage out of the 40 nozzles in the 2nd ring header at a pressure drop of 5 psig plus leakage out of the nozzles in the 1st ring header at a pressure drop of 5 psig plus the static head of water between the two ring headers [Assumption 3.8].

Net filling rate, $Q_6 = Q_5$ - (40 x 5.37) = 1340 - 215 = 1125 gpm

Fill time, $t_6 = V_6/Q_6$ = (188.8/1125) x 60 sec/min = <u>10.07 sec</u>

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7) The 4" riser from the 2nd ring header to the 3rd ring header (length EF):

Length, L_7 = 25 feet [Ref. 6.19.b]

Volume, $V_7 = L_7 \times A_7 = 25 \times 0.09899 \times 7.48 \text{ gal/ft}^3 = 18.5$ gallons

While filling the riser, the pressure on the 1st and 2nd ring header nozzles will be increased by the static head equivalent to the elevation difference between the 2nd and the 3rd ring headers. Per References 6.19.e and 6.19.g, the elevation of the 3rd ring header is 180'-11 3/16" and that of the 2nd ring header is 171'-7 5/16". The elevation difference is 9'-3 7/8", or 9.33 feet. At 0.433 psi/ft, the static head is worth 4.0 psi pressure. Thus, the nozzles in the first ring header will see 5 psig plus 12.3 psig plus 4.0 psig, or 21.3 psig and the nozzles in the 2nd ring header will see 5 psig plus 4 psig, or 9 psig.

Based on Design Input 4.11, the expected flow per nozzle with a 21.3 psig pressure drop is

$$q_n = 15.2\ (21.3/40)^{0.5} = 11.1 \text{ gpm per nozzle}$$

1st ring header leakage = 56 x 11.1 = 622 gpm

and the flow per nozzle with a 9 psig pressure drop is

$$q_n = 15.2\ (9/40)^{0.5} = 7.21 \text{ gpm per nozzle}$$

2nd ring header leakage = 40 x 7.21 = 288 gpm

Net filling flow rate, Q_7 = 1900 - 622 - 288 = 990 gpm

Fill time, $t_7 = V_7/Q_7$ = (18.5/990) x 60 sec/min = 1.12 sec

REV	ORIGINATOR	DATE	IRE	DATE	REV	ORIGINATOR	DATE	IRE	DATE	REV
5	Paul Barbour	12/23/93	Allen Evinay	12/23/93						

8) The third ring header, 2 1/2" line 052, from point F in two half-circles to the capped ends of the ring header:

Ring header radius = 25'-6" [Ref. 6.19.g]
Ring header length, L_8 = circumference = $2 \times \pi \times 25.5 = 160$ feet

Volume, $V_8 = L_8 \times A_8 = 160 \times 0.03325 \times 7.48\ \text{gal/ft}^3 = 39.8$ gallons

While filling the 3rd ring header, the net flow rate will be the value used to fill the riser EF less leakage flow from the 20 nozzles in the top ring header leaking at a pressure drop of 5 psig, as used for the filling of the other two ring headers.

Net filling rate, $Q_8 = Q_7 - (20 \times 5.37) = 990 - 107 = 883$ gpm

Fill time, $t_8 = V_8/Q_8 = (39.8/883) \times 60$ sec/min = <u>2.70 sec</u>

The total time to fill the spray piping from the time flow is assumed to begin is the sum of t_1 through t_8. Thus,

$t_{spr\ hdr\ fill} = 0.85 + 0.88 + 11.14 + 3.25 + 1.11 + 10.07 + 1.12 + 2.70$

$t_{spr\ hdr\ fill} = 31.12$ sec, or <u>**31.1 seconds, rounded**</u>

APPENDIX A

Table 7—Operating Voltage Range

Nominal Control Voltage	Spring Charging Motor	Close Coil	Trip Coil	Under Voltage	
				Pick-Up Maximum	Drop-Out
* 24 V DC	—	—	14- 30	21	7- 14
⊥ 48 V DC	† 35- 50	35- 50	28- 60	41	15- 29
125 V DC	90-130	90-130	70-140	106	38- 75
250 V DC	180-260	180-260	140-280	212	75-150
115 V AC	95-125	95-125	‡ 95-125	98	35- 96
230 V AC	190-250	190-250	‡190-250	198	69-140

NOTES:
* Unless the circuit breaker is located close to the battery and protective relay and adequate electrical connections are provided between the battery and trip coil, 24 volt DC tripping is not recommended.
† 48VDC spring charging is not recommended.
‡ AC tripping is not recommended (see page 39).

Table 8—Current Values — Voltage shown in Table 7.§

Spring Charging Motor	Close Coil	Trip Coil	Lockout Coil	Under Voltage	N.E.C. Fuse
—		22.0		0.9	30
†20.0	10.7	10.7	0.15	0.5	30
10.0	5.0	5.0	0.06	0.2	30
5.0	2.2	2.2	0.03	0.1	30
10.0	4.5	4.5	0.04	0.2	30
5.0	2.3	2.3	0.20	0.1	30

§ **Current values are average steady state values—momentary inrush currents for all charging motors and AC coils are approximately 6-8 times these values, an important consideration when sizing the battery.**
⊥ 48 volt tripping or closing functions are not recommended, except when the device is located near the battery or where special effort is made to insure the adequacy of conductors between battery and control terminals.

Table 9—HK Breaker Time Characteristics

Breaker	Av. Closing	Av. Tripping	Av. Spring Charging	Interrupting Time 0-100% of Rating
5 HK	4.5 Cycles	1.5 Cycles	2 Seconds	5 Cycles
7.5 & 15 HK	7.5 Cycles			
15 HK 1000	8 Cycles	2.0 Cycles	2 Seconds	5 Cycles

Closing Time—Between energizing closing coil and making of arcing contacts.
Tripping Time—Between energizing of trip coil and parting of arcing contacts.
Interrupting Time—Between energizing trip coil and complete interruption.

Table 10—Current Transformers MC-5, MC-15A1

Ratio*	Relay† Accuracy	Metering Accuracy†				
		PO.1	BO.2	BO.5	B1	B2
75/5	C10	1.2	1.2	—	—	—
100/5	C10	0.6	1.2	—	—	—
150/5	C20	0.3	0.6	1.2	—	—
200/5	C20	0.3	0.6	1.2	—	—
300/5	C50	0.3	0.3	0.3	1.2	2.4
400/5	C50	0.3	0.3	0.3	0.6	1.2
600/5	C100	0.3	0.3	0.3	0.3	0.6
800/5	C100	0.3	0.3	0.3	0.3	0.3
1200/5	C200	0.3	0.3	0.3	0.3	0.3
1500/5	C200	0.3	0.3	0.3	0.3	0.3
2000/5	C200	0.3	0.3	0.3	0.3	0.3
2500/5	C200	0.3	0.3	0.3	0.3	0.3
3000/5	C200	0.3	0.3	0.3	0.3	0.3
4000/5	C200	0.3	0.3	0.3	0.3	0.3

* Front mounted Current Transformers are available only up to 2000/5A.
† For higher accuracies refer to nearest district sales office.

Table 11—Space Heaters for Outdoor Equipment*

Type Unit	No. of Heaters Per Frame	Total Watts Per Frame
5 HK	2	300
7.5 & 15 HK	3	450

* Space heaters on indoor equipment are an optional addition.

Table 12 **Standard Single Phase Control Power Transformers**

KVA	Voltage
5	2400—240/120
	4160—240/120
10	4800—240/120
	7200—240/120
15	8400—240/120
	13200—240/120
25	13800—240/120

Table 13 **Standard Potential Transformers**

Voltage Rating
2400/4160y—120
2400—120
4200—120
4800—120
7200—120
8400—120
12000—120
14400—120

NES&L DEPARTMENT

CALCULATION SHEET

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	CCN CONVERSION: CCN NO. CCN --

Project or DCP/MMP N/A Calc. No. N-4080-003

Subject Containment Spray (CS) & Emergency Cooling Unit (ECU) Actuation Times Sheet No. 37

REV	ORIGINATOR	DATE	IRE	DATE	REV	ORIGINATOR	DATE	IRE	DATE
5	Paul Barbour	12/23/93	Allen Evinay	12/23/93					

APPENDIX B

OPERATING CHARACTERISTICS

Environmental Conditions. (Qualified Life)

PARAMETER	MIN.	NORMAL	MAX.
Temperature (°F)	40	70-104	156
Humidity (R.H. %)	10	40-60	95
Pressure	—	Atmospheric	—
Radiation (rads)	—	—	2.0 X 10^6 (Gamma)

Operating Conditions. (Normal Environment)

NORMAL OPERATING SPECIFICATIONS	WITH DC COILS	WITH AC COILS
Coil Operating Voltage, Nominal (Rated)	As Spec	As Spec
Pull-in (% of rated value)	80% Min.	85% Min.
Drop-out (% of rated value)	10% Approx.	50% Approx.
Power (Watts at rated value)	8 Approx.	8 Approx.
Relay Operate Time		
Model E7012	N/A	N/A
Model E7022	50 ms Max.	50 ms Max
Relay Release (Recycle) Time		
Model E7012	50 ms Max.	50 ms Max.
Model E7022	N/A	N/A
Contact Ratings, Continuous		
(Resistive at 125 vdc)	1.0 amp	1.0 amp
(Resistive at 120 vac, 60 Hz)	10.0 amp	10.0 amp
Insulation Resistance (In megohms at 500 vdc)	500 Min.	500 Min.
Dielectric (vrms, 60 Hz)		
Between Terminals and Ground	1,500	1,500
Between Non-connected Terminals	1,000	1,000
Repeat Accuracy **	± 10%	± 10%

Operating Conditions. (Abnormal Environment)

ADVERSE OPERATING SPECIFICATIONS	NORMAL	DBE "A"	DBE "B"	DBE "C"	DBE "D"
Temperature (°F)	70-104	40	120	145	156
Humidity (R.H. %)	40-60	10-95	10-95	10-95	10-95
Coil Operating Voltage * (% of Rated)					
Model E7012 (AC)	85-110	85-110	85-110	85-110	85-110
(DC)	80-110	80-110	80-110	90-110	90-110
Model E7022 (AC)	85-110	85-110	85-110	85-110	85-110
(DC)	80-110	80-110	80-110	80-110	80-110

* All coils may be operated on intermittent duty cycles at voltages 10% above listed maximums (Intermittent Duty = Maximum 50% duty cycle and 30 minutes "ON" time.)

** Repeat accuracy at any fixed temperature is ± 10% of setting.

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INDUSTRIAL ELECTRICAL PRODUCTS
530 W. MT. PLEASANT AVENUE
LIVINGSTON, NJ 07039-1790
(201) 992-8400
TELEX 13-8403 • FAX (201) 992-9416

E70-1
November 1989
Supersedes 6/82

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CALC. NO. N 4080-3

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PROJECT SONGS 2 & 3 JOB NO. 10079-006

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References

(1). Containment Pressure & Temperature Analysis, Calc# 4080-2-0 by Subin Banharnsupavat (preliminary)

(2). Specification 5023-403-12 (41-0486) QC II Diesel Driven Electrical Generating Sets, San Onofre Nuclear Generating Station, Units 2 & 3 Including Revisions 1 and 2.

(3) CE MOV valve spec. 1370-PE-705

(4) CE to Bechtel letter S-CE-3055 dated July 6, 1976 Subj: Containment Spray System Actuation Time

(5) Electrical Calc. E4C-016, ESF Sequencing by D. A. Monus dated 1-5-76

(6) Mechanical Calc. M-14.3 Containment Spray Flow History by J.R. Bliss dated 5-14-75.

(7) CSR Valve Data sheet dated 9-26-76, 507-58, pg. ~~14~~ 14

(8) Dwg S-023-705-9-30-0

(9) Interoffice memo J. Hosna to S. Freck dated Oct. 7, 1976 Containment Accident Analysis (Attachment 1)

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Problem Statement

The purpose of this calculation is to establish:

1. Maximum delay times to establish containment spray flow following a LOCA and MSLB. Consideration is given to conditions when offsite power is available, and when off site power is not available and the diesel generator provides electrical power.

   Time 0 seconds for the delay time is when the LOCA or MSLB accidents initiate. The end of the delay time is when full flow is established through the spray nozzles in containment.

2. Maximum delay times to establish containment emergency fan cooling. Consideration is given to conditions when offsite power is available, and when off site power is not available and the diesel generator provides electrical power.

   Time 0 seconds for the delay time is when the LOCA or MSLB accidents initiate. The end of the delay time is when the containment emergency fan is operating, and component cooling water flow established through the emergency coolers.

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Results:

1. Maximum delay times with loss of off site power
   a. Containment spray - 60 seconds
   b. Containment emergency fan - 33 seconds

2. Maximum delay time with off site power available.
   a. Containment spray - 56 seconds
   b. Containment emergency fan - 19 seconds.

Recommendations

1. The prospect of quicker opening spray isolation valves should be investigated. For example, if 10 second opening time was used (vice the 20 seconds currently used), 5.6 seconds could be saved in the case of loss of off site power and 10 seconds could be saved in case with off site power available.

2. The assumptions (2 & 3) listed on page 5 6 should be verified by the appropriate vendors.

3. Pending the completion of calculation # 4080-2-0 (Reference 1), the following items need to be verified.

   THESE VALUES WERE CONFIRMED →

   a. high containment pressure (4.0 psig) is reached in ≤ 2.0 seconds.
   b. high-high containment pressure (12.0 psig) is reached in ≤ 8.0 seconds.

   Numbers not consistent with 3a and 3b above will invalidate the results shown above.

4. A design change is required to insure that the spray header is kept full to just below the lowest spray ring.

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Assumptions

1. Breaker closing time is ≤ 0.4 seconds

2. Instrument response and signal generation time is 1 second. (this was used for SIAS, CSAS, and CCAS signal generation). CE provides this equipment and will need to document the actual time.

3. Emergency fan acceleration time ≤ 15.6 seconds.

4. The spray header downstream ~~of the~~ of the isolation valves (SI-671 & 672) are filled to the lowest spray ring.

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Method of Solution

To establish the maximum delay times for containment spray flow and containment cooling, conservative time estimates for each event required to occur are summed.

For example, consider the delay time to establish containment spray flow following a LOCA with off site power not available. The events required to occur are

1. At time 0 seconds, the LOCA occurs.
2. At a time X seconds (after LOCA), the setpoint for high containment pressure is reached.
3. The instrumentation and logic circuitry function to initiate a SIAS signal . The instrument response time is considered.
4. The SIAS signal starts the diesel. The time for starting the diesel is factored in.
5. When the diesel is at operating speed, the automatic loading sequence incorporates time delays.
6. Valve opening time and pump acceleration times are considered.
7. Time to fill dry headers are established till full flow issues from the containment spray nozzles.

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Calculation

1. Maximum Delay Time for Containment Spray Flow with loss of offsite power. (Refer to Figure 1)

   a. The design basis LOCA or MSLB occurs at time 0 seconds. In the time interval 0 → A, the pressure inside containment increases from 0 psig to the high containment pressure setpoint (4 psig).

   From Reference 1, at 1 second after LOCA containment pressure is 6.6 psig and for the MSLB, containment pressure is 4.3 psig at 2 seconds.

   The high containment pressure setpoint is reached in < 1 second for the LOCA, and in slightly less than 2 seconds for the MSLB. Since longer times are more conservative it is approximated that:

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   <u>0 sec. → A = 2 seconds max.</u>

   b. The next event to occur is the instrument response and circuitry time to convert the high containment pressure condition to an SIAS signal (A → B), delivered to the diesel starting circuit. Combustion Engineering provides pressure detector and logic to generate the SIAS signal on high containment pressure.

   The time interval A → B is estimated as ≤ 1 seconds which is consistent with numbers used in the ANO-2 FSAR.

   <u>A → B = 1 second max.</u>

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c. During the time interval B → C, the diesel generator starts on the SIAS signal delivered at B and comes upto rated speed and voltage. This time interval is 10 seconds from reference 2.

B → C = 10 seconds max.

d. At time C seconds (O→A + A→B + B→C) sequencing of ESF loads initiate. During this sequencing, two conditions have to be present in order for the containment spray isolation valves to open and for the containment spray pumps to start. They are SIAS and CSAS.
The SIAS signal has already been established earlier by the high containment pressure.
In the time interval O → K, containment pressure increases to the high-high containment pressure setpoint (12.0 psig). This pressure was selected in order to have the high-high containment pressure signal (and CSAS) available prior to having the containment spray loads being sequenced.

At 6 seconds after LOCA, containment pressure is ~~25~~ 26.3 psig ✓ (Ref. 1)
At 8 seconds after the MSLB, containment pressure is 14.6 psig (Ref. 2). 7-7-[illegible]
In the limiting case (MSLB), the high-high containment pressure setpoint is reached in < 8 seconds. The time interval is established as:

O → K = 8 seconds.

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The time interval K → L is estimated as 1 second (instrument response)
At L, the CSAS signal is generated.

Thus, the CSAS signal is generated in 9 seconds (O→K + K→L = 8 + 1 second = 9 second) and is available prior to the diesel supplied loads being sequenced at 13 seconds (O→A + A→B + B→C = 2 + 1 + 10 = 13 seconds).

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At C, since the CSAS signal and power is available, the containment spray isolation valves (SI-671 and SI-672) begin to open. During the time interval C→G, the valves go from the shut to the fully open position. The time interval C→G is 20 seconds (References 3 & 4)

C→G = 20 seconds

Concurrent with the opening of the spray isolation valves (C→G), the containment spray pump sequence according to the load sequencing schedule (Reference 5). The containment spray pumps are 3rd on the load sequencing, and the breakers begin to close at 10 seconds after load sequencing begin.

The containment spray pumps sequence is C→D = 10 seconds

The interval D→E is when the CS pump breaker close, and the pump begins to come up to speed. The pump is at full speed in the interval E→F, which is equal to 4 seconds from reference 4.

D→E = .4 seconds (assumed)

E→F = 4 seconds

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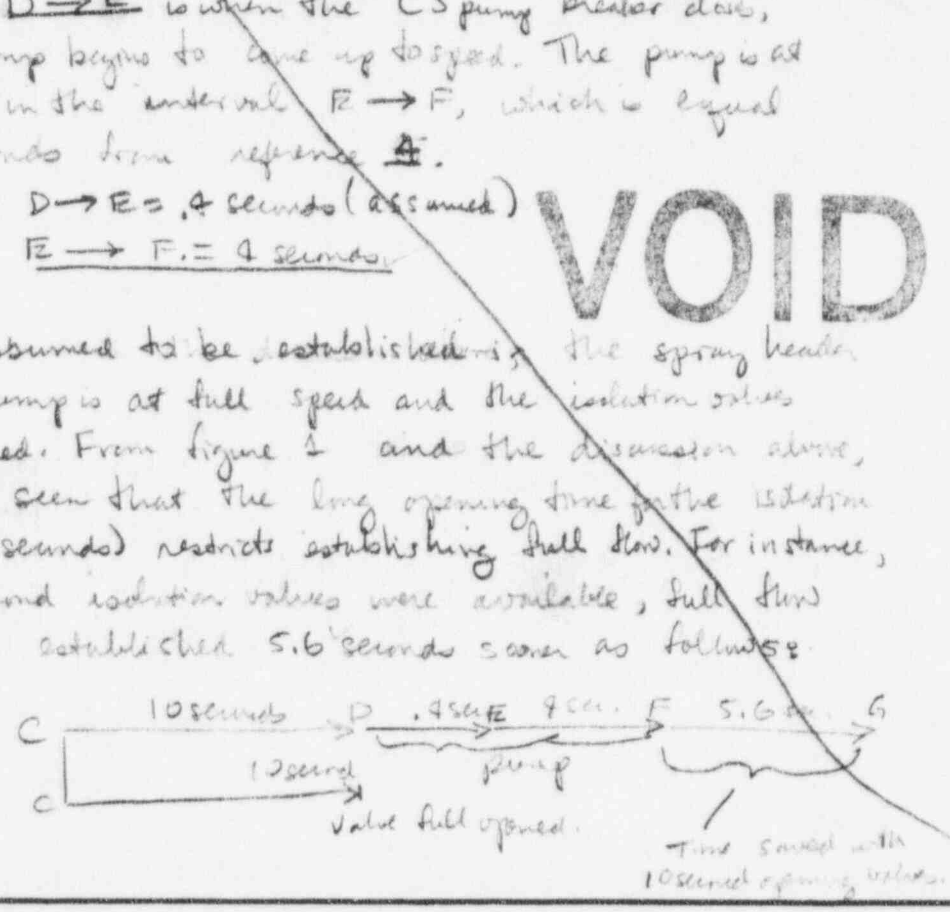
Flow is assumed to be established in the spray header when the pump is at full speed and the isolation valves fully opened. From figure 1 and the discussion above, it can be seen that the long opening time for the isolation valves (20 seconds) restricts establishing full flow. For instance, if 10 second isolation valves were available, full flow would be established 5.6 seconds sooner as follows:



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e. Once full flow is established, there are two sequences that could occur:

1. G → H → I. Interval G → H assumes that the header downstream of the isolation valves is dry. In the interval G → H, the spray header is filled to the lowest spray ring. From Reference 6, this time is 19.2 seconds.

G → H = 19.2 seconds ✓

In the interval H → I, the spray rings are filled. This interval is equal to ~~27~~ 27.6 seconds (reference 6).

H → I = ~~27~~ 27.6 seconds.

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2. The second sequence G → J is similar to the sequence G → H → I with the exception that the sequence G → H is eliminated by requiring that the spray header downstream of the isolation valve is assumed filled to the lowest spray ring. This eliminates the 19.2 second header filling time.

G → J = ~~27~~ 27.6 seconds (reference 6)

G → J = time to fill spray rings.

For the SONGS 2 and 3 design, it is assumed that sequence 1.e.2 will be used, and that the spray header will will be full to the lowest spray ring.

f. The total maximum delay time following LOCA/MSLB with loss of offsite power till full containment spray flow is established is:

O → A → B → S → G → J

LOCA 2 sec + 1 sec + 10 sec + 20 sec + 27 sec = <u>60 seconds</u>

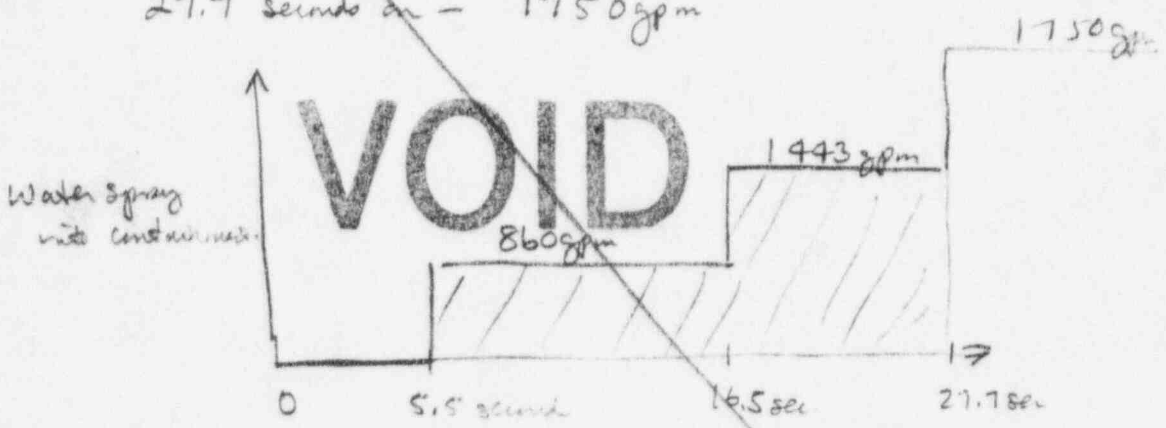
From Reference 6, page 10 of 17, after the spray header is filled to the lowest ring, a spray history in containment is as follows:

0 - 5.5 seconds - 0 gpm

5.5 - 16.5 seconds - 860 gpm sprayed into containment

16.5 - 27.7 seconds - 1443 gpm sprayed into containment

27.7 seconds on - 1750 gpm



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The mass of water sprayed into containment between 0 - 27.7 seconds is equal to the shaded area under the curve

$$Mass_{0-27.7 sec} = [(860 gpm)(11 sec) + 1443 gpm (11.2 sec)] \times \frac{1 min}{60 sec}$$

This is equivalent to full flow being established $\frac{Mass_{0-27.7 sec}}{1750 gpm} \times \frac{60 sec}{1 min}$

$$\text{seconds earlier} = \frac{[(860 gpm)(11 sec) + 1443 gpm (11.2 sec)]}{1750 gpm} \times \frac{1 min}{60 sec} \cdot \frac{60 sec}{1 min}$$

$$= 14.6 \text{ seconds}$$

This means that the equivalent of full spray flow starts $27.7 - 14.6 = 13.1$ seconds after the spray header is filled

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to the lowest spray ring. Of this 14.6 seconds reduction in time when the equivalent of full spray flow starts into containment, credit for ~~0.7~~ 0.6 seconds is used to reduce overall maximum delay time. The difference of 14.6 − ~~0.7~~ 0.6 = ~~13.9~~ 14.0 is maintained as a conservative margin. Only ~~0.7~~ 0.6 seconds credit is taken because 60 seconds was used in the containment pressure and temperature calculation (Reference 1) per direction in Reference (9). This calculation is meant to show that 60 seconds is an acceptable number.

O ⟶ A ⟶ B ⟶ C ⟶ G ⟶ J = 60.7 − 0.7 = 60 seconds

Assumption that lower rate of flow is equivalent to higher rate for less time may not be accurate, but is good basis for taking off 0.6 sec.

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2. Maximum Delay Time for Containment Spray Flow with offsite power available (refer to Figure 2)

a. See 1.a, 1.b, and 1d

O → B = 2 seconds.
A → B = 1 second
O → K = 8 seconds K → L = 1 second

At 3 seconds after LOCA or MSLB, the load sequencing begins when the SFAS signal is generated. The containment spray isolation valves should begin to open. However, at 3 seconds after LOCA, the CSAS signal has not been generated, consequently the containment spray pump and breaker cannot sequence.

At 9 seconds post LOCA/MSLB, the CSAS signal is generated and the containment spray isolation valves (SI671 and 672) begin to open. The valves are fully opened in 20 seconds.

L → F = 20 seconds (see 1.d above interval C → G).

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Concurrent with the valves opening (L → F), the containment spray pump sequences at B → C = 10 seconds after load sequencing (Reference 5) starts. The breaker is assumed to be shut in .9 seconds (C → D = .9 seconds). The containment spray pumps is at full speed in 4 seconds (Reference 4)

D → E = 4 seconds.

b. Since the spray header is filled to the lowest spray header (See 1.e above), the spray ring is filled in 27.6 seconds (Reference 6)

F → I = 27.7 seconds (27.6)

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2.c. The maximum total delay time to establish spray flow with offsite power available is:

O ⟶ K ⟶ L ⟶ F ⟶ I

8 sec + 1 sec. + 20 sec + 27.7 (27.6) = 56.7 (56.6) seconds.

Again subtracting 0.7 (0.6) seconds as in page 12, the maximum total delay becomes O → K → L → F → I = 56.7 − 0.7 = 56 seconds

3. Maximum delay time for containment emergency fan operation with a concurrent loss of offsite power. (Refer to Figure 1)

The sequence of events include the following

a. At time O, the LOCA or MSLB accident occurs.

b. Between O → A, containment pressure increases to the high containment pressure setpoint (4.0 psig).

O → A = 2 seconds (see 1.a above)

c. A → M. In this time interval, an SIAS signal is generated which causes a CCAS (containment cooling actuation signal) to be generated

A → M = 1 second (assumed)

d. In the interval M → C, the diesel is started and brought to rated speed and voltage.

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M → C = B → C = 10 seconds (see 1.C above)

e. In the next significant interval (C → S), the CCW isolation valves have to open, the emergency fans have to operate, and the CCW pumps must start & be brought up to speed.

55.6
43.7

CCW valve opening (C → P) = 10 seconds (Reference 1)

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BECHTEL

CALCULATION SHEET

CALC. NO. N 4080-3

SIGNATURE R.S. Kawaguchi DATE 10/18/76 CHECKED [illegible] DATE 11/8/76

PROJECT SONGS 2&3 JOB NO. 10079.006

SUBJECT CS & RF Actuation Times SHEET 16 OF 20 SHEETS

Q → R
C → N (time for emergency fan and CCW pump breaker to shut) = .4 seconds (assumed)

N → O (time for emergency fan to come to speed) ≤ 15.6 seconds (assumed)

C → Q (time for CCW pump to sequence) = 15 seconds (Reference 5)

R → S (time for CCW pump to get up to rated speed) = 4 seconds* (Ref. 8)

* No specified time. Calculated time was approximately 2 seconds. 4 seconds (conservative direction) used.

f. The total time delay for full emergency fan operation is:

O → A → M → C → Q → R → S

2 sec + 1 sec + 10 sec + 15 sec + .4 sec + 4 sec = 32.4 sec. ≈ **33 seconds**

4. Maximum total delay time to establish containment emergency fan operation with offsite power available (Refer to figure 2)

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The sequence of events include the following:

a. At time 0, the LOCA or MSLB occurs.
b. O → A = 2 seconds (see 3.b above)
c. A → M = 1 second (see 3.b above)
d. M → O = 10 seconds (time for CCW isolation valve to open - Reference 7)
e. M → N = 0.4 seconds (assumed breaker closing time).
f. N → P = 15.6 seconds - time for emergency fan to get up to rated speed (assumed).
h. total delay time is:

O → A → M → N → P

2 sec + 1 sec + .4 sec + 15.6 sec = **19 seconds.**

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CALCULATION SHEET

CALC. NO. N4080-3

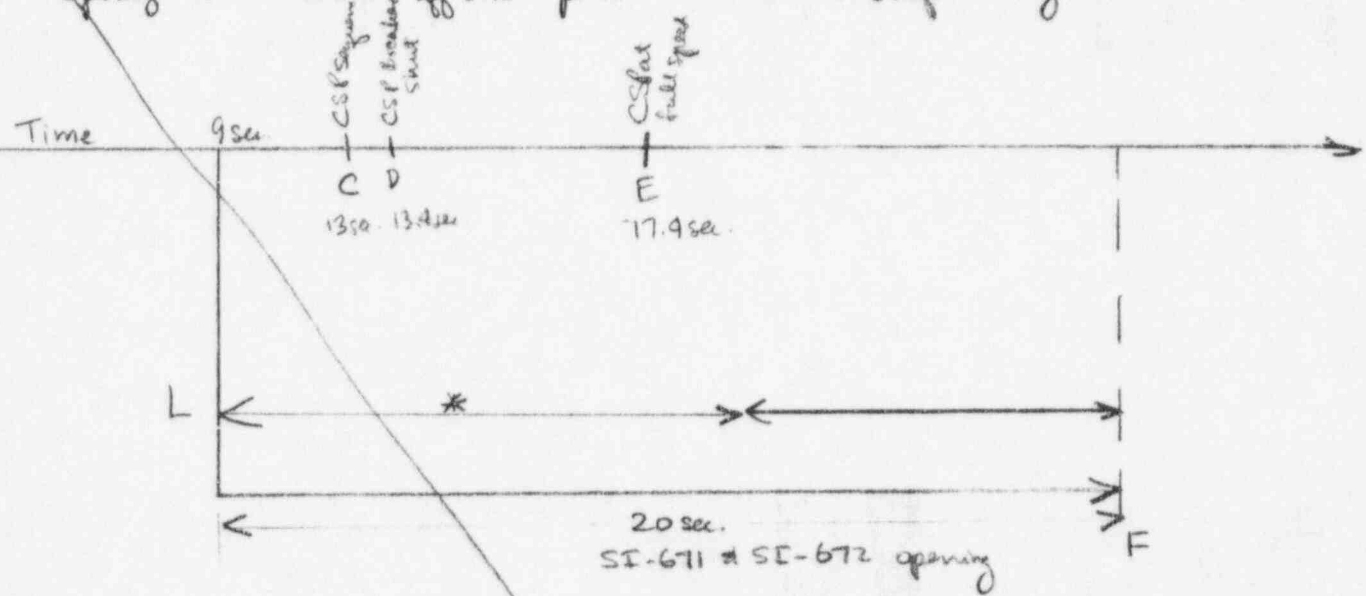
SIGNATURE [illegible] DATE 10/15/76 CHECKED [illegible] DATE [illegible]

PROJECT SONGS 2&3 JOB NO. 10079-006

SUBJECT CS & EF Actuation Time SHEET 17 OF 20 SHEETS

5. Time savings from 10 second opening valves (offsite power available)

If SI-671 and SI-672 opened in 10 seconds vice 20 seconds, 10 seconds could be saved from the time sequence for establishing spray flow with offsite power available. (Refer to Fig 2)



* If SI-671 & 672 were 10 seconds opening valves, then valves would be full opened by 19 seconds (L + 10 = 9 + 10 = 19 seconds). Since the CSP is at full speed by 17.4 seconds, 10 seconds would be saved.

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CALCULATION SHEET

12400 E. IMPERIAL HWY.
NORWALK, CALIFORNIA 90650

CALCULATION NO. N 4080-3

SIGNATURE P S Gavrazzuchi DATE 10/15/76

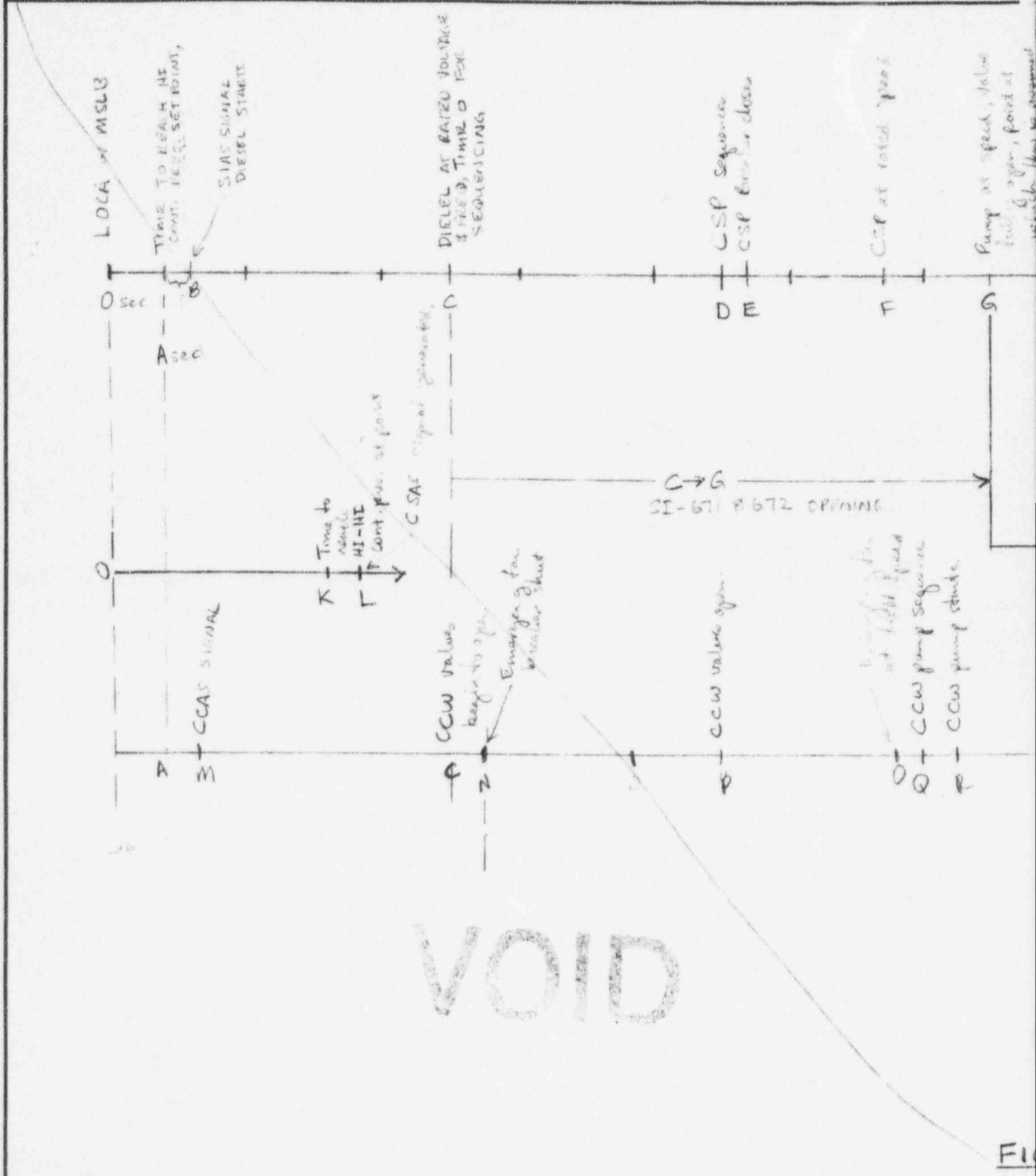
CHECKED [illegible] DATE [illegible]

PROJECT SONGS 2 & 3

JOB NO. 10079-006

SUBJECT CS & EF Actuation Time

SHEET 18 OF 20 SHEETS



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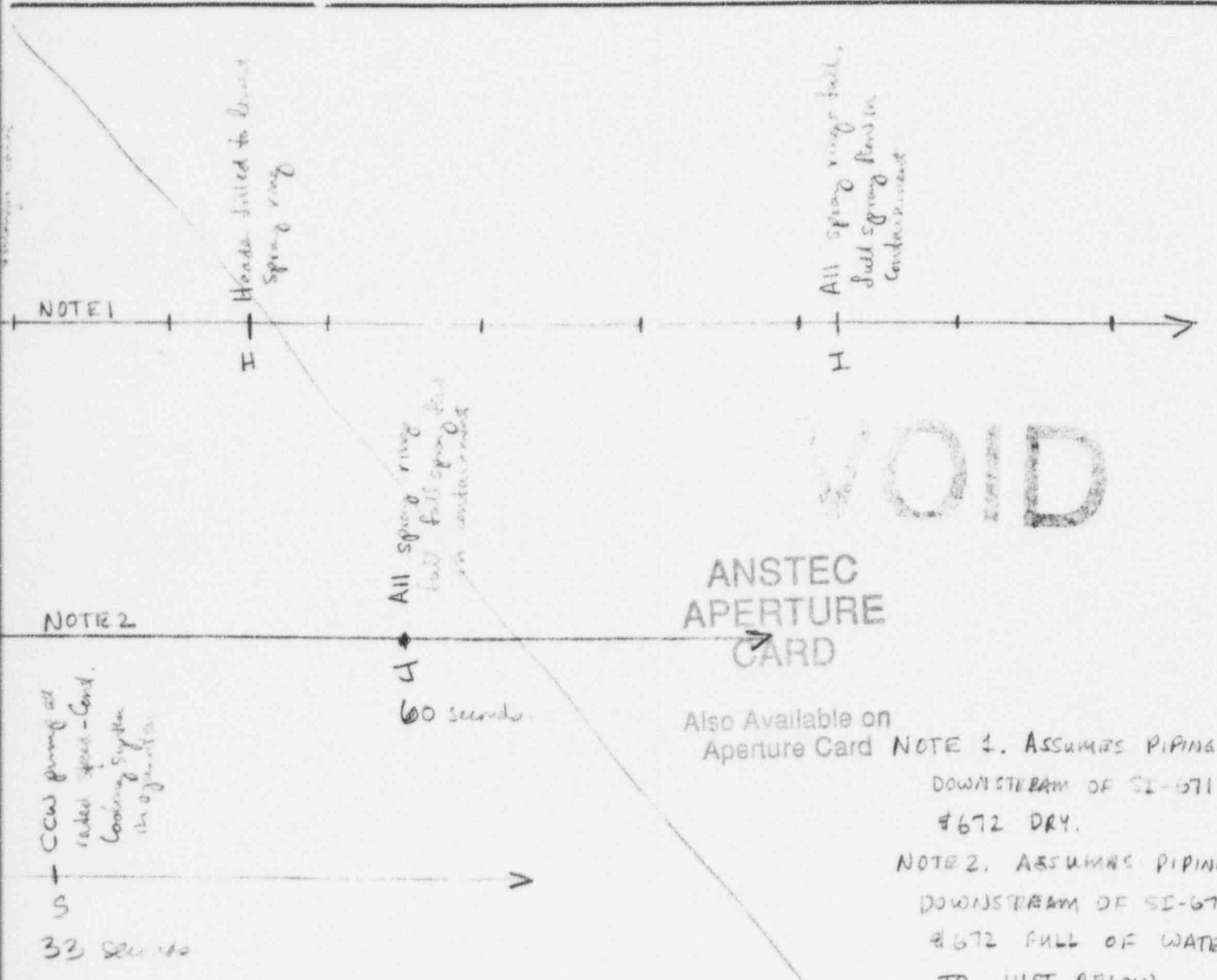


NOTE 1. ASSUMES PIPING DOWNSTREAM OF SI-671 & 672 DRY.

NOTE 2. ASSUMES PIPING DOWNSTREAM OF SI-671 & 672 FULL OF WATER TO JUST BELOW LOWEST SPRAY RING.

9606040035-01

URE 1 SEQUENCE OF EVENTS FOR CONTAINMENT SPRAY FLOW & EMERGENCY FAN OPERATION (WITH LOSS OF OFFSITE POWER)

LAO 0514 4-7

CALCULATION SHEET

12400 E. IMPERIAL HWY.
NORWALK, CALIFORNIA 90650

CALCULATION NO. N4080-2

SIGNATURE [illegible] DATE 10/15/76

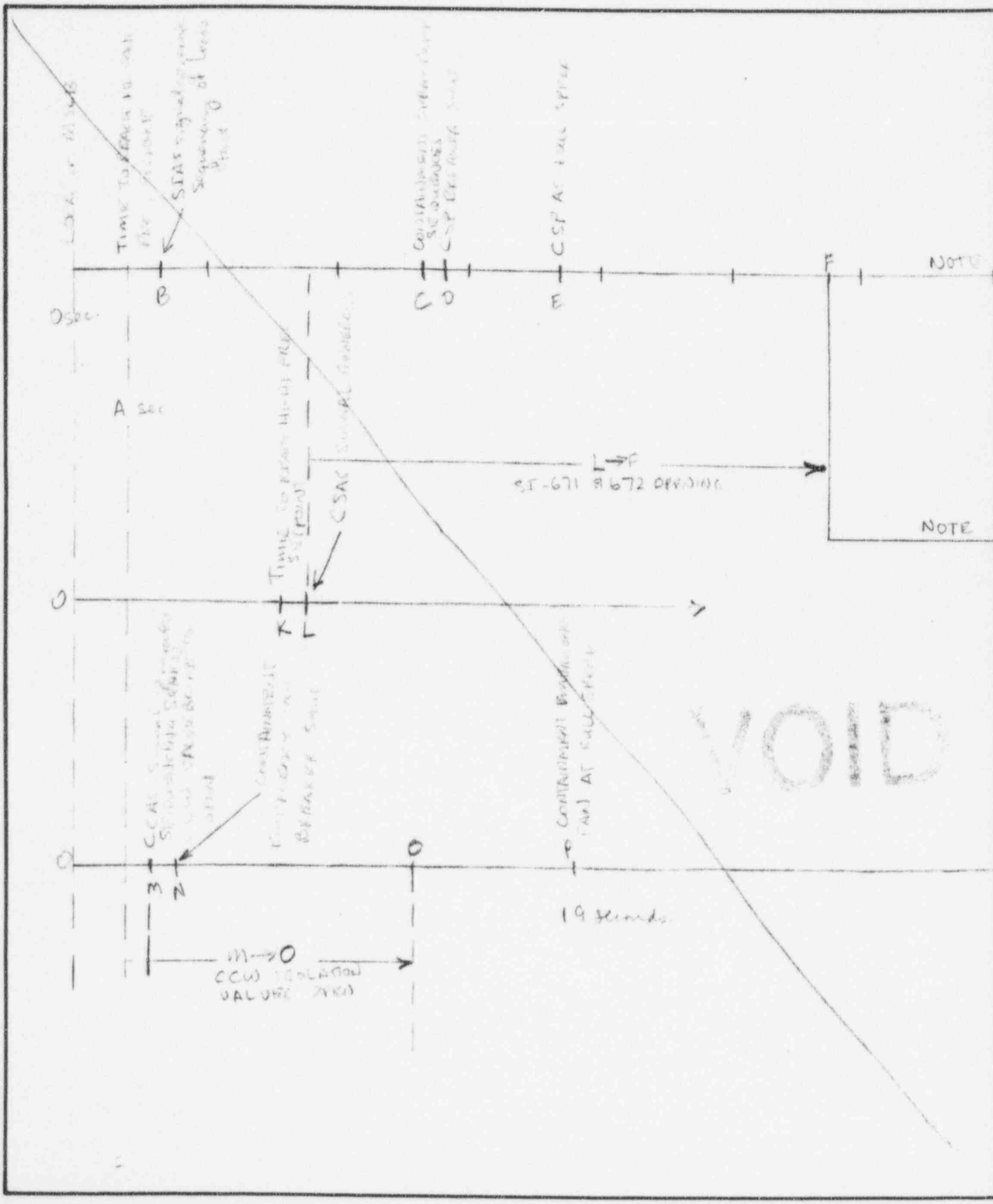
CHECKED [illegible] DATE [illegible]

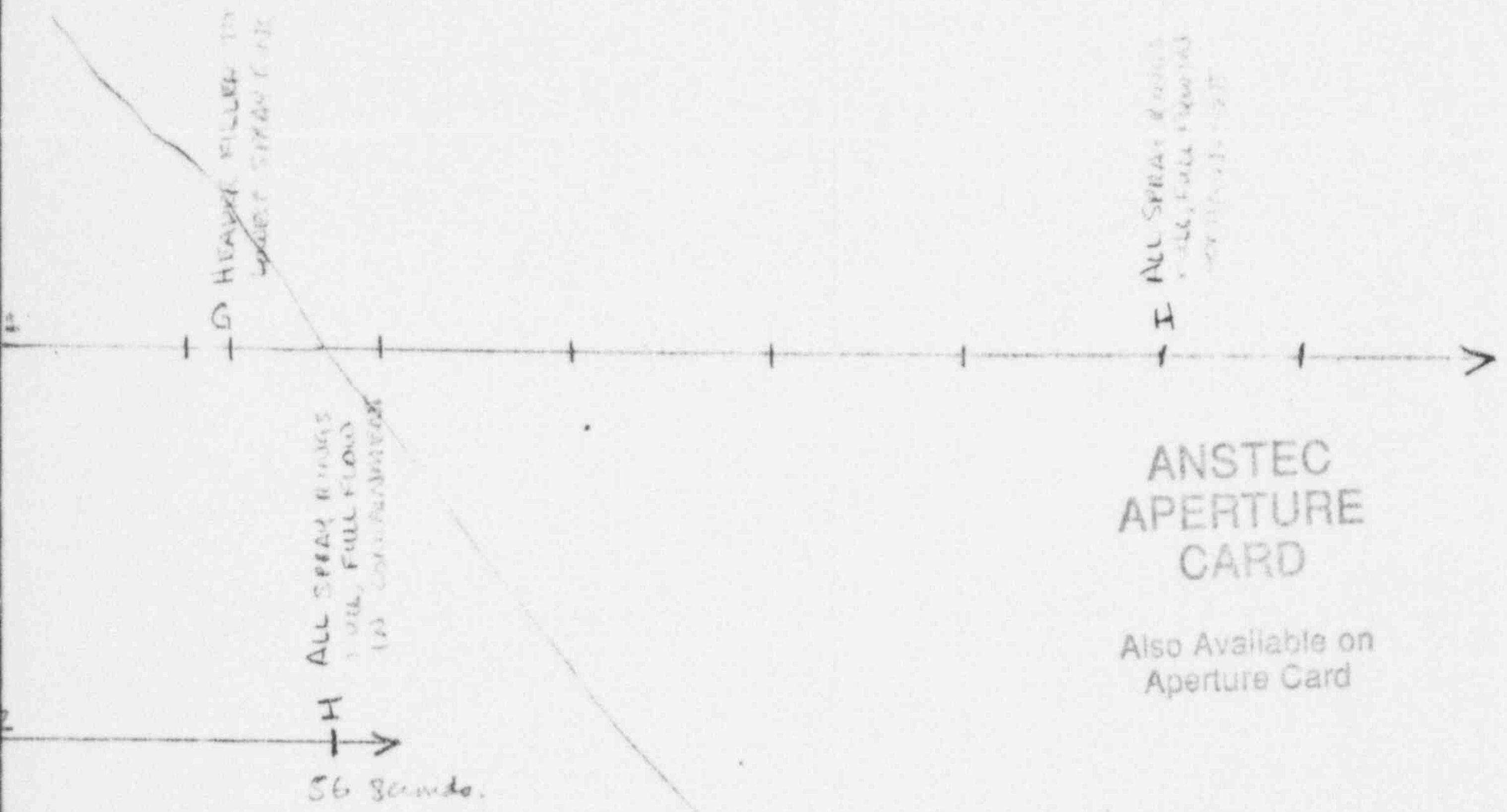
PROJECT SONGS 2&3

JOB NO. 10079-006

SUBJECT CS & EF Actuation Times

SHEET 19 OF 20 SHEETS





NOTE 1. ASSUMING PIPING DOWNSTREAM OF SI-671 & -672 DRY

NOTE 2. ASSUMING PIPING DOWNSTREAM OF SI-671 & -672 FULL OF WATER TO JUST BELOW LOWEST SPRAY RING

FIGURE 2. SEQUENCE OF EVENTS FOR CONTAINMENT SPRAY FLOW & EMERGENCY FAN OPERATION (OFFSITE POWER AVAILABLE)

Signature R. Kawaguchi 10/15/76
Project: SONGS 2&3
Subj: CS & ECF Actuation Times
Checked D.M. Wilbur Date [illegible]
Job. No. 10079-006

D.M. Wilbur 11/8/76
Calc N4080-3

Bechtel Power Corporation

Interoffice Memorandum N-4080-3
Sheet 20 of 20

Date	October 7, 1976	File No.	S023-650-A Log IOM-1634
To	S. Freid	From	J. Hosmer
Subject	San Onofre Units 2 & 3 Bechtel Job 10079 Containment Accident Analysis	Of	Nuclear Engineering
		At	Los Angeles Power Division Building 45
Copies to		Ext.	

R. Kawaguchi
D. Wilbur

Utilize the following delay times for your containment accident analysis calculations:

(1) Loss of offsite power

Sprays 60 seconds
Coolers 33 seconds

(2) Offsite power available

Sprays 56 seconds
Coolers 19 seconds

J. B. Hosmer

JBH:gg

VOID

LAO 0513 8-73

BECHTEL

CALCULATION SHEET

CALC. NO. N4080-3

SIGNATURE [signature] DATE 4-12-77 CHECKED [signature] DATE 5/26/77

PROJECT SONGS 2+3 JOB NO. 10079-006

SUBJECT CS + EFS ACTUATION TIMES SHEET 21 OF 31 SHEETS

Revision 1

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NOTE FROM PG 26. CSS PUMP SEQUENCE ASSUMES PUMP IS SEQUENCED ON BY AN SIAS SIGNAL. DCN BEING WRITTEN AND FSAR TO BE CHANGED TO REFLECT THIS ASSUMPTION.

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CALCULATION SHEET

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CALC. NO. N4080-3

SIGNATURE [signature] DATE 4-12-77 CHECKED [signature] DATE 5/20/77

PROJECT SONGS 2&3 JOB NO. 10079-006

SUBJECT CS & EF Actuation Times SHEET 22 OF 31 SHEETS

1. Objective

Revise containment spray and emergency cooler actuation times to reflect a 10 second containment spray isolation valve opening, and a fan acceleration time of 7.8 seconds.

2. Basic Criteria

Provide analytical support for the CS and EF actuation times used in the containment pressure and temperature transient analysis. The analysis should provide adequate conservatism for dead time, instrumentation response time and other uncertainties.

3. Applicable Codes and Standards

N/A

4. General Method

Reference p. 7 (4080-3)

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CALCULATION SHEET

1 CALC. NO. N4080-3

SIGNATURE [signature] DATE 4-12-77 CHECKED [signature] DATE 5/26/77

PROJECT SONGS 2+3 JOB NO. 10079-006

SUBJECT CS + EF ACTUATION TIMES SHEET 23 OF 31 SHEETS

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5. Calculational Assumptions

Same as revision 0, except as amended below:

1) CS isolation valves open in 10 seconds (Reference 1)

2) Fan motor acceleration time is 7.8 seconds (Reference 2)

3) CS isolation valve passes rated flow at 1/2 open (Reference 3)

6. References

1) CE to Bechtel letter log CB-3 93, dated 12/17/76, subject: Containment Spray System Motor Operated Valves (SI671 + SI 672)

2) AAF to Bechtel letter log XB-11294, dated 10/7/76, subject AAF project no. 25-1392.

3) TN-5275 dated 5/5/77 Steve Lelewer to T Young

7. Summary

Start times are as follows

	Loss of Offsite Power	Offsite Power Available
Containment Spray	55 seconds (p 26R1)	45 seconds (p 29R1)
Emergency Fans	33 seconds (p 31R1)	13 seconds (p 31R1)

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CALCULATION SHEET

CALC. NO. N 4080-3

SIGNATURE [signature] DATE 4-14-77 CHECKED [signature] DATE 5/26/77

PROJECT SONGS 2+3 JOB NO. 10079-006

SUBJECT CS & EF Activation Times SHEET 24 OF 31 SHEETS

8. Calculations and Results

1. Maximum Delay time for Containment Spray Flow with loss of offsite power.

a) Time interval for pressure to build from 0 psig to 4 psig (high pressure setpoint)

0 → A = 2 seconds (max) (Ref. p. 8)

b) Instrument response and circuitry time i.e. time required to convert high containment pressure signal to an SIAS signal. (A ⇒ B)

A → B = 1 second (Ref p. 8)

c) Time required to start diesel and come up to rated voltage

B ⇒ C = 10 seconds

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At time C ESF loads are starting to sequence.

d) Containment spray isolation valves require the signals SIAS and CSAS. SIAS has already occurred. CSAS

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CALCULATION SHEET

CALC. NO. N 4080-3

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SUBJECT CS + EF Actuation Times

is initated at containment pressure of 12.0 psig.

O → K = 8 seconds (Ref. p. 9)

Add 1 second for instrument response (Ref. p 5)

K ⇒ L = 1 second

Therefore at time L the CSAS is generated.

Note: O ⟶ C = 13 seconds (diesel available)

O ⟶ L = 9 seconds (SIAS + CSAS generated)

The containment spray valves (SI-671 + SI-672) begin to open at 13 seconds (time C). The spray valves are fully open at 10 seconds (Ref. 1) but are designed to pass rated flow at half open or 5 seconds (Ref. 3). Conservatively, no flow is assumed to occur until the valve is half open. *

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C ⇒ G = 5 seconds (Ref. 3)

The containment spray pumps sequence at 10 seconds

C ⇒ D = 10 seconds (Ref p. 10)

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CALCULATION SHEET

△1

CALC. NO. N 4080-3

SIGNATURE [signature] DATE 4-28-77 CHECKED [signature] DATE 5/2/77

PROJECT SONGS 2+3 JOB NO. 10079-006

SUBJECT CS & EF Actuation Times SHEET 26 OF 31 SHEETS

The pump breaker closes in .4 seconds and the pump is at rated flow in 4 seconds

D⇒E = .4 seconds (Ref P10)
E⇒F = 4 seconds (Ref p 10)

Note: Comparison of valve opening to pump flow available

$$C \xrightarrow{10sec.} D \xrightarrow{.4sec} E \xrightarrow{4sec} F = 14.4 \text{ seconds}$$

$$C \xrightarrow{5sec} G = 5 \text{ seconds}$$

therefore, containment spray header piping doesn't start to fill until time F = 14.4 seconds + 13 seconds = 27.4 seconds.

e) Assuming the spray header riser is full, the time required to establish full spray flow is 27.6 seconds

F → J = 27.6 seconds (ref p. 11)

VOID

f) The total maximum delay time following LOCA/MSLB with loss of offsite power till full containment spray flow is established is:

$$0 \rightarrow A \rightarrow B \rightarrow C \rightarrow F \rightarrow J$$
2 sec + 1 sec. + 10 sec. + 14.4 sec + 27.6 sec = 55 seconds

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CALCULATION SHEET

CALC. NO. N4080-3

SIGNATURE [signature] DATE 4-28-77 CHECKED [signature] DATE 5/26/77

PROJECT SONGS 2&3 JOB NO. 10079.006

SUBJECT CS & EF ACTUATION TIMES SHEET 27 OF 31 SHEETS

This takes no credit for partial flow as the spray rings fill.

2. Maximum Delay Time for Containment Spray Flow with Offsite Power Available

See 1a., 1b., and 1d.

O → A = 2 seconds
A → B = 1 second
SIAS is generated <u>3 seconds</u> after the LOCA/MSLB.

O → K = 8 seconds

K → L = 1 second

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CSAS is generated <u>9 seconds</u> after the LOCA/MSLB

At 9 seconds, the containment spray valves (SI-671 & SI 672) start to open. The valves are open enough to pass rated flow in 5 seconds (Ref p. 25R1).

L → F = 5 seconds

The containment spray pumps are sequenced 10 seconds after the load sequencing starts.

B → C = 10 seconds (Ref. p. 14)

The breaker is assumed to shut in .4 seconds (Ref. p 14). Note: The CSAS signal is generated 9 seconds after LOCA/MSLB and 6 seconds after SIAS. Therefore, since the sequencing for the spray pumps is 10 seconds both ~~the~~ signals and power will be available.

C → D = .4 seconds

The spray pumps are at rated speed in 4 seconds (Ref. p 14)

D → E = 4 seconds

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<u>Valve</u>

O —(2 seconds)→ A —(1 second)→ B (SIAS generated)

O —(8 seconds)→ K —(1 second)→ L —(5 seconds)→ F ∴ Valve open at time <u>F = 14 seconds</u>

<u>Pump</u>

O —(2 seconds)→ A —(1 second)→ B (SIAS generated, load sequencing starts)

B —(10 seconds)→ C

O —(8 seconds)→ K —(1 second)→ L —(4 seconds)→ C —(.4 seconds)→ D —(4 seconds)→ E

L: CSAS generated

C: spray pump sequencing

∴ pump @ rated speed at time <u>E = 17.4 seconds</u>

Note: See page 21

Note: SHOULD BE SIAS INSTEAD OF CSAS. SIAS IS LESS LIMITING. [initials]

System is <u>pump</u> limited.

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CALCULATION SHEET

CALC. NO. N 4080-3

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PROJECT SONGS 2&3 JOB NO. 10079-006

SUBJECT CS + EF ACTUATION TIMES SHEET 29 OF 31 SHEETS

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b. Spray header riser is assumed to be full. Spray rings are filled in 27.6 seconds (Ref. p 14)

E → I = 27.6 seconds

c. The maximum total delay time to establish spray flow with offsite power available is

O →(2 seconds) A →(1 second) B →(10 second) C →(.4 second) D →(4 second) E →(27.6 second) I

∴ full spray flow is available @ Time I = <u>45 seconds</u>

No credit is taken for partial flow during filling of the spray rings

3. Maximum delay time for containment emergency fan operation with a concurrent loss of offsite power.

a) LOCA/MSLB occurs at time 0

b) Containment pressure increases to 4.0 psig, containment high pressure setpoint O → A = 2 seconds (Ref. p 15)

VOID

c) Signal generation time for CCAS is

A → M = 1 second (Ref. p15)

d) Diesel started and up to voltage

M → C = 10 seconds (Ref. p15)

e) Time interval for CCW isolation valves to open, emergency fans to operate, and CCW pumps to start and come up to rated speed.

CCW valve opening C → P = 10 seconds (Ref p 15)

breaker closing time for emergency fan and CCW pump Q → R = .4 seconds (Ref p 16)
C → N = .4 seconds (Ref p 16)

time for fan to come up to speed N → O = 7.8 seconds (Ref. 2)
(see note on page 31)

time for CCW pump to sequence C → Q = 15 seconds (Ref p16)

time for CCW to come up to speed R → S = 4 seconds (Ref. p16)

f) Total time delay for full emergency fan operation is:

0 → A → M → C → Q → R → S
2 seconds 1 second 10 seconds 15 seconds .4 seconds 4 seconds

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CALCULATION SHEET

△1 CALC. NO. N4080-3

SIGNATURE [signature] DATE 4-29-77 CHECKED [signature] DATE 5/26/77

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SUBJECT CS + EF ACTUATION TIMES SHEET 31 OF 31 SHEETS

33 seconds

4. Maximum total delay time to establish containment emergency fan operation with offsite power available.

The sequence of events including the following:

	CCW Flow		Emergency fan operation
Time to reach 4.0 psig	0 → A = 2 seconds (Ref. p. 16)		0 → A = 2 seconds (same)
signal generation time	A → B = 1 second (Ref p. 16)		A → B = 1 second (same)
	valve	pump	fan
	opening time: 10 seconds (Ref p16)	breaker closing time: .4 seconds (Ref p16)	breaker closing time: .4 seconds (Ref p16)
		pump at rated speed: 4 seconds (Ref. p16)	fan up to rated speed: 7.8 seconds (see note at bottom of page) (Ref. 2)
Total	13 seconds	7.4 seconds	11.2 seconds

VOID

The limiting component is the valve. Therefore, the total delay time is 13 seconds.

Note: Ref 2 provides fan start times at 80% of rated voltage. Normally 75% of rated voltage is assumed. If an additional 1.5 seconds is added to account for the voltage, no effect is made on the delay times since the fans are not limiting.

LAO 0513 8-73

BECHTEL

CALCULATION SHEET

CALC. NO. N4080-3 (2)

SIGNATURE [signature] DATE 5/23/77 CHECKED [signature] DATE 5/26/77

PROJECT SONGS 2&3 JOB NO. 10079-006

SUBJECT CS & EF Actuation Times

Revision 2

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LAO 0513 8-73

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CALCULATION SHEET

CALC. NO. N 4080-3 (Rev. 2)

SIGNATURE [signature] DATE 5/23/77 CHECKED [signature] DATE 5/24/77

PROJECT SONGS 2+3 JOB NO. 10079-006

SUBJECT CS + EF Actuation Times SHEET 33 OF 42 SHEETS

1. Objective

Revise containment spray actuation times to reflect a pump flowrate of 2100 gpm (Ref. 1) and a more realistic filling of the spray ring headers than used in the calculation M-14.3, reference 6 of the original calculation.

VOID

2. Basic Criteria

Same as Revision 1

3. Applicable Codes and Standards

N/A

4. General Method

Same as Revision 1

5. Calculation Assumptions

Same as Revision 1, except as amended below:

1) CS pump flowrate is 2100 gpm (Ref. 1)

2) As a spray ring fills all the nozzles spray at the flowrate specified for the nozzles at 5 psi. As the riser between rings fills the nozzles in the full rings spray at the specified flowrate for the nozzles at 5 psi plus the static pressure between the full rings and the ring to be filled.

6. References

1) CE to Bechtel ltr. CB 3455 of May 19, 1977
2) Dwg. 40494-3 dated 11/16/76
3) Sprayco Catalog 73 p. 15
4) Dwg 90004 Rev. 12 dated 12/17/76 (Piping Material)
5) Crane Tech Paper 410

VOID

7. Summary

The results of this calculation show that the spray actuation times for the revised flow of 2100 gpm and the new header fill model doesn't change the results of the calculation provided in revision 1.

	Offsite power available	No Offsite Power
CS start time	45 seconds	55 seconds

The filling of the spray ring headers is calculated to be 27.6 seconds. (p 42R2).

Calculations and Results

Preliminary Data require for the calculation

The spray headers are pipe class KEO

For KEO pipe the follow schedules are used (Ref. 4)

	schedule	inside diameter (Ref. 5)
8"	20	8.125"
6"	10S	6.357"
4"	10S	4.26"
2½"	40S	2.469"

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CALCULATION SHEET

2

CALC. NO. N4080-3

SIGNATURE [signature] DATE 5/23/77 CHECKED [signature] DATE 5-27-77

PROJECT SONGS 2&3 JOB NO. 10079-006

SUBJECT CS + EF Actuation Times SHEET 36 OF 42 SHEETS

In both the original calc. and Revision 1 the spray ring filling time has been based on 1750 gpm from the CS pumps and calc M-14.3 (Ref. 1 of Calc. 4080-0). For this calc. the spray fill times will be modified to reflect 2100 gpm, a more realistic fill model and a revised piping drawing. The riser to the spray rings is assumed to be full to within 10 feet of the first spray ring. For conservativism, the elevation of the higher of the two rings at each level will be used, and the larger diameter of the two rings at each level will be used.

a) Fill time from 10 feet below first ring to first ring.

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10 feet of KEO 8" pipe

$$\frac{10' \times \dfrac{\left(\frac{8.125}{2}\right)^2 \pi}{144 \text{ in}^2/\text{sq ft}}}{2100 \text{ gpm} \times \dfrac{1}{449 \text{ gpm}} \text{ cuft/sec}} = .77 \text{ seconds}$$

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BECHTEL

CALCULATION SHEET

CALC. NO. N4080-3 (2)

SIGNATURE [signature] DATE 5/23/77 CHECKED [signature] DATE 5-27-77

PROJECT SONGS 2+3 JOB NO. 10079-006

SUBJECT CS+EF Actuation Times SHEET 37 OF 42 SHEETS

b) Add the fill of 6" KEO pipe that connects the lower riser with the next riser up. Approx 15' (Ref. 2)

$$\frac{15' ft \times \frac{(6.357/2)^2 \pi}{144\ in^2/ft^2}}{2100\ gpm \times \frac{1}{449}\ cuft/sec/gpm} = .71 \text{ seconds}$$

VOID

c) Add the filling of the 1st ring. Radius of ring equals 66'-6" (Ref. 2) Length of ring equals 66'-6 × 2 × π = 418 ft − 15 ft (b above) = 403 ft of 4" KEO pipe. The flowrate will be decreased by the flow out the nozzles. The first ring has 56 nozzles. The pressure is assumed to be 5 psi (Assump. 2 p.). The flowrate of each 1713 spray nozzle is 5.4 gpm (Ref. 3)

The flow available for filling the first ring is 2100 − 5.4×56 = 1797.6 gpm

$$\frac{403 ft \times \frac{(4.26/2)^2 \pi}{144\ in^2/ft^2}}{1797.6 \times \frac{1}{449}\ cuft/sec/gpm} = 9.96 \text{ seconds}$$

d) Add the riser between the first ring and the second ring. Elevation change is 143'-3 11/16" to 171'-7 5/16" or a change of 28.33 ft and an additional lateral stress loop of 20 ft for a total length of 48.33 ft of 6" KEO pipe. The flowrate available will be decreased by the flow out the nozzles. The pressure is assumed to be 5 psi (assump. 2 p.) plus the additional 28.33 ft of elevation head for a total of approx. 15 psi. The flowrate out of each of the 56 1713 type spray nozzles is 9.5 gpm (Ref 3) The flow available for filling the riser is 2100 gpm − 9.5×56 = 1568 gpm.

$$\frac{48.33\,\text{ft}\,\dfrac{\left(\frac{6.357\,\text{in}}{2}\right)^2\pi}{144\,\text{in}^2/\text{ft}^2}}{1568\,\text{gpm} \times \frac{1}{449}\,\frac{\text{cuft/sec}}{\text{gpm}}} = 3.05 \text{ seconds.}$$

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LAO 0513 8-73

BECHTEL

CALCULATION SHEET

CALC. NO. N4080-3

SIGNATURE [signature] DATE 5/23/77 CHECKED [signature] DATE 5-27-77

PROJECT SONGS 2+3 JOB NO. 10079-006

SUBJECT CS + EF Actuation Times SHEET 39 OF 42 SHEETS

VOID

e) Add the fill of 6" KEO pipe that connects the 2nd riser with the 3rd riser. Approx. 15' (Ref. 2)

$$\frac{15\,ft \times \frac{(6.357/12)^2\pi}{144\ in^2/ft^2}}{1568\ gpm \times \frac{1}{449}\ \frac{cuft/sec}{gpm}} = .95\ seconds$$

f) Add the filling of the 2nd ring. Radius of ring equals 46'-0" (Ref 2) Length of ring equals 46' × 2 × π = 289 ft − 15 ft = 274 ft of 4" KEO pipe. The flowrate will be decrease by the loss from the first ring, 9.5 × 56 = 532 gpm plus the loss from the second ring which is at 5 psi and 38 nozzles. Again the nozzle flowrate at 5 psi is 5.4 gpm (Ref. 3). This results in an additional reduction of 5.4 × 38 = 205.2 gpm for a total available flowrate of 2100 − 532 − 205.2 = 1362.8 gpm

$$\frac{274\,ft \times \frac{(4.26/12)^2\pi}{144\ in^2/ft^2}}{1362.8\ gpm \times \frac{1}{449}\ \frac{cuft/sec}{gpm}} = 8.94\ sec.$$

g) Add the filling of the next riser between the second ring and the third ring. Elevation change is 169'5" to 181'-11 11/16" or a change of 12.6 ft and an additional lateral stress loop of 20 ft for a total length of 32.6 ft of 4" KEO pipe. The flowrate available will be decreased by the flow out the nozzles. The first ring pressure is 5 psi (assump. 2) + 28.33 ft of head to the second ring + 12.6 ft of head to the third ring or approx. 20 psi. The flowrate out each of the 56 nozzles will be 11.0 gpm (Ref. 3). The second ring pressure is 5 psi (assump. 2) + 12.6 ft of head to the third ring or approx. 10 psi. The flowrate rate out of each of the 38 nozzles in the second ring is 7.7 gpm. (Ref. 3) The flow available for filling the riser is

$$2100\ gpm - 11 \times 56 - 7.7 \times 38 = 1191.4\ gpm$$

$$\frac{32.6\,ft \; \frac{(4.26/2)^2 \pi}{144\ in^2/ft^2}}{1191.4 \times \frac{1}{449}\ \frac{ft^3/sec}{gpm}} = 1.22\ seconds$$

VOID

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CALCULATION SHEET

△2 CALC. NO. N4080-3

SIGNATURE [signature] DATE 5/23/77 CHECKED T.E. Richardson DATE 5-27-77

PROJECT SONGS 2&3 JOB NO. 10079-006

SUBJECT CS & EF Actuation Times SHEET 41 OF 42 SHEETS

h) Add the filling of the third spray ring.

The third spray ring radius is 25'-6" (Ref. 2)

Length of the spray ring piping is $25.5' \times 2 \times \pi = 160$ ft of 2½" K40 pipe. The flowrate available for filling the spray ring will be same as that for the riser in (g) or 1191.4 gpm less that which sprays out of the 20 nozzles in the 3rd ring. The pressure is at 5 psi (Assump. 2) 3rd ring and the flow out each nozzle is 5.4 gpm (Ref. 3). Therefore the flow available for filling the third spray ring is $1191.4 - 5.4 \times 20 =$ 1083.4 gpm.

$$\frac{160\,ft \dfrac{(2.469/2)^2 \pi}{144\ in^2/ft^2}}{1083.4 \times \dfrac{1}{449} \dfrac{cuft/sec}{gpm}} = 2.20 \text{ seconds}$$

VOID

CALCULATION SHEET

BECHTEL

LAO 0513 8-73

CALC. NO. ⚠1 N4080-3

SIGNATURE [signature] DATE 5/23/77 CHECKED [signature] DATE 5-27-77

PROJECT SONGS 2/3 JOB NO. 10079-006

SUBJECT CS & EF Actuation Times SHEET 42 OF 42 SHEETS

i) The total delay time for filling the spray rings is a+b+c+d+e+f+g+h = 27.8 seconds

VOID

The 27.8 seconds calculated here updates the 27.6 seconds calculated M14.3. The new number reflects new line sizes, flow rates and fill models. In order to prevent a re work of other calculations affected by this number, .2 seconds of conservatism will be removed and the fill time of the spray rings will be assumed as 27.6 seconds. The justification for this is based on the highly conservative calculational assumption ~~that~~ all the nozzles spray at the start of the filling of that ring when in fact nozzles cannot spray until the water reaches ~~them~~.

Table of Contents

VOID

CALCULATION SHEET

BECHTEL

3

LAO 0513 8-73

CALC. NO. 4080-3

SIGNATURE G. Thurston DATE March 19 '82 CHECKED JF Watson DATE 3/25/82

PROJECT SONGS 2 & 3 JOB NO. 10079-006

SUBJECT Evaluate CCW Isolation Valve Stroke Time SHEET 44 OF 51 SHEETS

I Task - Evaluate the affect of a 12 sec stroke time in place of the 10 sec time orginally used for the CCW isolation valves. (HV-6366 - 6373)

II References

(1) Data sheet 507-5B page 14 (attached sht 49)

(2) WKM valve division letter of 8/27/75
Main steam Isolation Valve Cv Vs stroke (attached sht 50-51)

(3) Telephone Conversation with WKM Valves - 2/11/82
(see sht 45)

III Results - The increased stroke time, 12 sec, will not affect achieving essentially full flow in the required time of 10 secs.

IV Criteria - None

V Applicable Codes & Standards - None

VOID

VI Assumptions – The pressure loss thru the valve in the partially open position is similar to that of sudden contraction and a sudden expansion. The contraction loss is equal to .5 velocity heads and the expansion loss is equal to 1 velocity head; this is based on the velocity thru the restricted area. This should be conservative as there is probably some pressure recovery.

VII General Method – Determine pressure drop thru a partially open valve and compare to allowable value on valve data sheet.

VOID

VIII Calculation –

Flow = 2000 GPM H_2O @ 105°F } Ref 1
Allowable ΔP = 3 PSI

Valve Data – ref (3)

% Stem Travel	% Area
75	68
80	74
85	80
90	87
95	93
100	100

Wide open Cv = 9848 wide open area = 8" dia

CALCULATION SHEET

BECHTEL

(3)

LAO 0513 8-73

CALC. NO. N4080-3

SIGNATURE G. Thurston DATE March 19, 1982 CHECKED JF Watson DATE 3/25/82

PROJECT SONGS 2 & 3 JOB NO. 10079-006

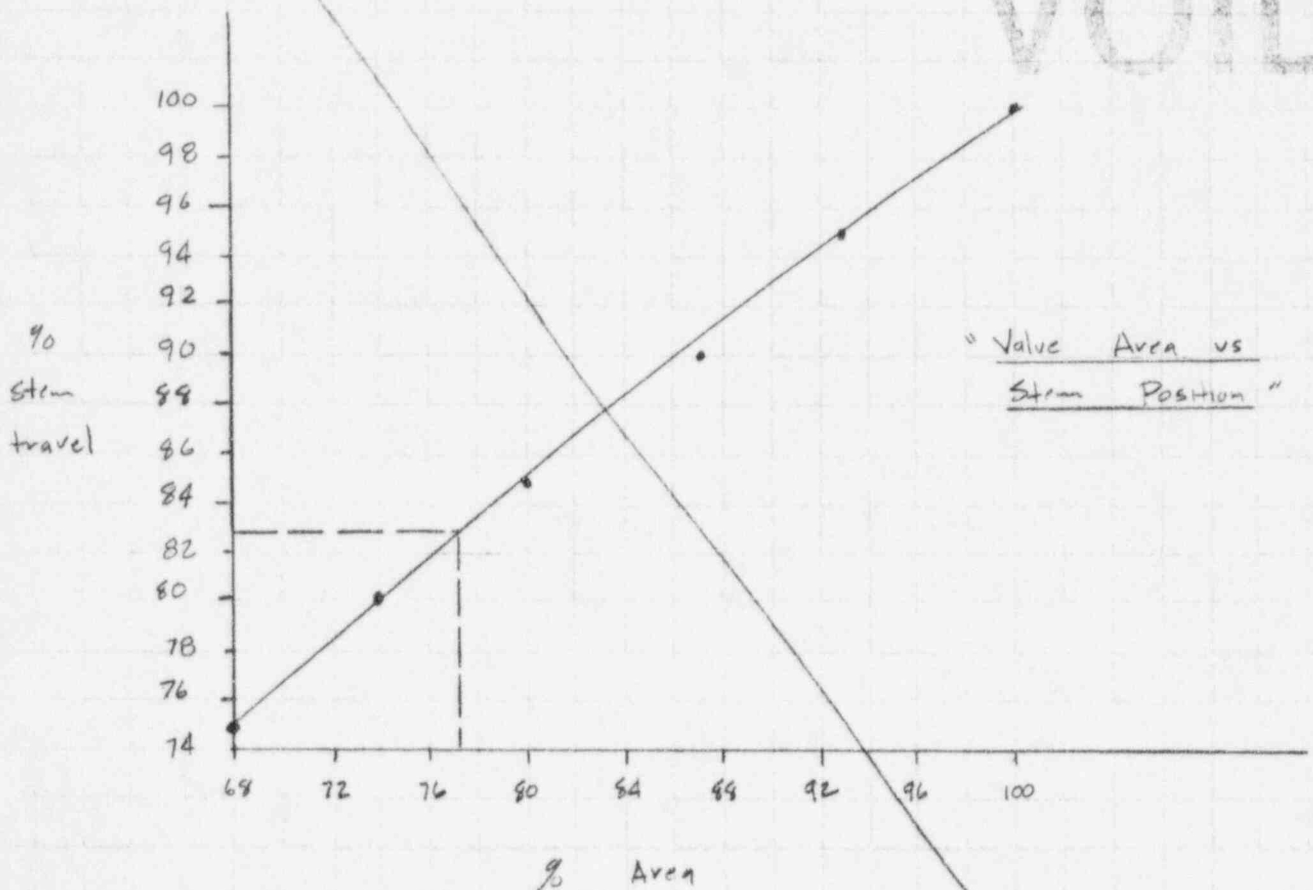
SUBJECT CCW Isolation valve stroke time SHEET 46 OF 51 SHEETS

Assume stem position Linear with time

100% open = 12 secs

$\frac{10}{12}(100) = 83\%$ travel @ 10 secs

VOID



Thus @ 10 sec the stem travel = 83%
and the open area = 77%

$$\text{Area} = \frac{(8^2)(\pi/4)(.77)}{144} = .269 \text{ ft}^2$$

BECHTEL

CALCULATION SHEET

LAO 0513 8-73

(3) CALC. NO. N4080-3

SIGNATURE G. Thurston DATE March 19, 1982 CHECKED JE Dean DATE 3/25/82

PROJECT SONGS 2 & 3 JOB NO. 10079-006

SUBJECT CCW Isolation valve stroke time SHEET 47 OF 51 SHEETS

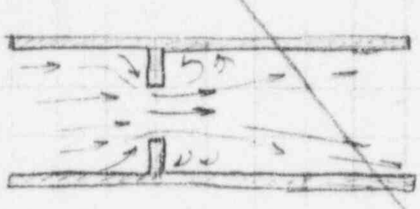
Velocity @ Min Area = $V = \frac{Q}{A}$

$Q = \frac{2000}{(60)(7.48)} = 4.456 \ FT^3/sec$

$V = \frac{4.456}{.269} = 16.56 \ Ft/sec$

VOID

Head Loss :



Valve Model

$h_L = K\frac{V^2}{2g} = 1.5\frac{V^2}{2g}$ K = 1.5 for sudden contraction + expansion

$h_L = (1.5)\frac{(16.56)^2}{(2)(32.2)} = 6.39 \ ft = \underline{2.76 \ PSI}$

OK allowable = 3.0 PSI

As an alternate method assume Cv vers position is similar to steam isolation valve manufactured by same vendor — reference 2

BECHTEL

CALCULATION SHEET

(3)

LAO 0513 8-73

CALC. NO. N4080-3

SIGNATURE G. Thurston DATE March 19, 1982 CHECKED JFL... DATE 3/24/82

PROJECT SONGS 2&3 JOB NO. 10079-006

SUBJECT CCW Isolation valve stroke time SHEET 48 OF 51 SHEETS

From reference 2

Wide open C_v = 77,781 (MSIV 40 x 30 x 40 Valve)

C_v @ 83% position = 26632

$$\% \; C_v = \frac{26632}{77781} = 34.24\%$$

Use same ratio for CCW Valve

wide open C_v = 9848

@ 83% = C_v = 3371

$$Q = C_v \sqrt{\Delta p \left(\frac{62.4}{\rho}\right)} \qquad \rho = 62$$

$$\Delta p = \frac{Q^2}{C_v^2} = \frac{(2000)^2}{(3371)^2} = .35 \text{ PSI} \quad \text{ok}$$

ok as allowable = 3 psi.

VOID

BECHTEL POWER CORPORATION
LOS ANGELES, CALIFORNIA

SOUTHERN CALIFORNIA EDISON COMPANY
ROSEMEAD, CALIFORNIA

SAN ONOFRE NUCLEAR GENERATING STATION
UNITS 2&3

CONTROL VALVES

FORM NUMBER 100

REVISION NO	BY	DATE	REVISION(I) C/N NO) TO
1		100776	

SHEET 14 OF 26

SPEC. NO. 507-58 — REV

DATE 10/07/76 — CONTRACT

REQ. — P.O. SEE LINE 4C

BY — CHKD — APPR

GENERAL	1	TAG NO.	*2 HV 6366	*3 HV 6366	*2 HV 6367	*3 HV 6367
	2	SERVICE	CCW TO EMERGENCY COOLING UNIT E401	CCW TO EMERGENCY COOLING UNIT E401	CCW FRM EMERGENCY COOLING UNIT E401	CCW FRM EMERGENCY COOLING UNIT E401
	3	LINE NO./VESSEL NO.	281	281	283	283
	4A	CLASSIFICATIONS	21NB	21NB	21NB	21NB
	B	P&ID NO. : COORDINATES	40172 : B-7	40172 : B-7	40172 : B-7	40172 : B-7
	C	P.O. NUMBER	507-58	507-58	507-58	507-58
	D	APPLICABLE NOTES	CA,ZC,ZY,ZZ,	CA,ZC,ZY,ZZ,	CA,ZC,ZY,ZZ,	CA,ZC,ZY,ZZ,
	E	APPLICABLE NOTES				
	F	LOCATION				
BODY	5	TYPE OF BODY	GATE-ROTARY STEM TYPE	GATE-ROTARY STEM TYPE	GATE-ROTARY STEM TYPE	GATE-ROTARY STEM TYPE
	6	BODY SIZE : PORT SIZE	10 INCH : FULL	10 INCH : FULL	10 INCH : FULL	10 INCH : FULL
	7	GUIDING : NO. OF PORTS	STEM : SINGLE	STEM : SINGLE	STEM : SINGLE	STEM : SINGLE
	8	END CONN. & RATING	BW150 LB	BW150 LB	BW150 LB	BW150 LB
	9	BODY MATERIAL	SA216 WCC CAST STEEL	SA216 WCC CAST STEEL	SA216 WCC CAST STEEL	SA216 WCC CAST STEEL
	10	PACKING MATERIAL	J-C 1625GF	J-C 1625GF	J-C 1625GF	J-C 1625GF
	11	LUBRICATOR : ISO. VALVE	NONE : NONE	NONE : NONE	NONE : NONE	NONE : NONE
	12	BONNET TYPE	BOLTED	BOLTED	BOLTED	BOLTED
	13	PLUG FORM	WEDGE DISC	WEDGE DISC	WEDGE DISC	WEDGE DISC
	14	TRIM MATERIAL	STELL.	STELL.	STELL.	STELL.
	15	PACKING GLAND	BOLTED	BOLTED	BOLTED	BOLTED
	16A	CONSTRUCTION	OUTSIDE SCREW AND YOKE	OUTSIDE SCREW AND YOKE	OUTSIDE SCREW AND YOKE	OUTSIDE SCREW AND YOKE
	B	LINE SIZE VALVE	YES	YES	YES	YES
	C					
	D					
ACTUATOR	17	MODEL NO. & SIZE	"D-2" POW-R-SEAL	"D-2" POW-R-SEAL	"D-2" POW-R-SEAL	"D-2" POW-R-SEAL
	18	TYPE OF ACTUATOR	ELECTRIC MOTOR	ELECTRIC MOTOR	ELECTRIC MOTOR	ELECTRIC MOTOR
	19	CLOSE AT : OPEN AT	N/A : N/A	N/A : N/A	N/A : N/A	N/A : N/A
	20	PUSH DOWN TO	N/A	N/A	N/A	N/A
	21	FLOW ACTION TO	N/A	N/A	N/A	N/A
	22	FAIL POSITION	AS-IS	AS-IS	AS-IS	AS-IS
	23	HANDWHEEL & LOCATION	YES SIDE	YES SIDE	YES SIDE	YES SIDE
	24	AIR SUPPLY PRESSURE	N/A	N/A	N/A	N/A
	25A	STEM TRAVEL INDICATOR	YES	YES	YES	YES
	B	LIMIT SWITCH	PER SPEC	PER SPEC	PER SPEC	PER SPEC
	C					
	D					
	E	-MOTOR REQUIREMENTS	460V/60HZ 3-PHASE	460V/60HZ 3-PHASE	460V/60HZ 3-PHASE	460V/60HZ 3-PHASE
	F	-MOTOR REQUIREMENTS	INTERMITTANT DUTY	INTERMITTANT DUTY	INTERMITTANT DUTY	INTERMITTANT DUTY
	G					
	H					TORQUE
	J					
TRANS	26					
	27					
	28					
	29A					
	B					
POSIT	30	POSITIONER REQUIRED				
	31	FILT. REG. GAGES : BY-PASS	N/A : N/A : N/A	N/A : N/A : N/A	N/A : N/A : N/A	N/A : N/A : N/A
	32	INPUT SIGNAL				
	33A	OUTPUT SIGNAL				
	B					
SERVICE	34	FLOW UNITS, UNLESS OTHERWISE SPECIFIED : LIQUID GPM : STEAM LB/HR : GAS SCFM				
	35	FLUID	WATER	WATER	WATER	WATER
	36A	QUANTITY MAX.	2000 GPM	2000 GPM	2000 GPM	2000 GPM
	B	-CV	--	--	--	--
	37A	QUANTITY NORM.	1750 GPM	1750 GPM	1750 GPM	1750 GPM
	B	-CV				
	38	VALVE CV				
	39	INLET PRESS. : DELTA P SIZ.	112 PSIG : 3 PSID	112 PSIG : 3 PSID	112 PSIA : 3 PSID	112 PSIA : 3 PSID
	40	MAX. SHUT-OFF DELTA P	150 PSID	150 PSID	150 PSID	150 PSID
	41	TEMP. MAX. : NORM.	150 F : 105 F	150 F : 105 F	200 F : 185 F	200 F : 185 F
	42	OPER. SP. GR. : MOL. WT.	1.0 : --	1.0 : --	1.0 : --	1.0 : --
	43	OPER. VISC. : % FLASH	-- : 0	-- : 0	-- : 0	-- : 0
	44	SUPERHEAT : SOLIDS	0 F : NIL	0 F : NIL	0 F : NIL	0 F : NIL
	45A					
	B					
	46	MANUFACTURER	WKM	WKM	WKM	WKM
	47	MODEL NUMBER	"D-2" POW-R-SEAL	"D-2" POW-R-SEAL	"D-2" POW-R-SEAL	"D-2" POW-R-SEAL

CALCULATION SHEET CALC. NO. N-4080-3 △3

SIGNATURE G. Thurston DATE 3/22/82 CHECKED [initials] DATE 3/22/82

PROJECT SONGS 2&3 JOB NO. 10079-006 SHEET 49 OF 51

SUBJECT CCW Isolation Valve Stroke Time

NOTES — CARD

(CA) EQUIPMENT REQUIREMENTS PER PENETRATION BLDG
(ZC) RADIATION DOSAGE REQUIREMENTS: 5X10 EXPONENT 6 RADS
(ZY) CONTAINMENT ISOLATION VALVE
(ZZ) ACTIVE COMPONENT

2 HV 6366
CONNECTING PIPING CONFIGURATION: LINE SIZE 10 INCH; SCHEDULE- STD; MATERIAL- CARBON STEEL ASME SA-106 GR. B — 901
VALVE PROCESS DESIGN DATA FOR NAMEPLATE USE IS AS FOLLOWS: 150 PSIG @ 150 F — 903
VALVE STROKE TIME SHOULD BE 10 SECONDS — 907

VOID

FORM NUMBER 100

file

ACF INDUSTRIES

INCORPORATED

W-K-M VALVE DIVISION

P. O. BOX 2117, HOUSTON, TEXAS 77001, (713) 499-1511, CABLE ADDRESS: WILKOVAC, TELEX NO. 762919

10079
507-6
XB 4324

August 27, 1975

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LOS ANGELES

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PROJ. ENG.
ASST. PROJ. ENG.
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PROJ. COST E.
PROJ. SCH.
PROJ. T. E.

file

Bechtel Power Corporation
P. O. Box 60860
Terminal Annex
Los Angeles, California 90060

Attention: Vendor Print Control

Gentlemen:

Subject: San Onofre Nuclear Generation Station
Units 2 & 3
Bechtel Job 10079
Main Steam Containment Isolation Valves
Bechtel File SO23-507-6
Purchase Order J4141821

Please find attached W-K-M Cv information for the main steam containment isolation valves. This information is not required per Bechtel Specifications, but is supplied in reference to questions and Telexes from Bechtel to W-K-M.

Very truly yours,

James E Olson

J. E. Olson
Western District Sales Manager
Controls/Power Sales

VOID

JEO/jt

Attachment

3

CALCULATION SHEET CALC. NO. N-4080-3

SIGNATURE G. Thurston DATE 3/23/92 CHECKED F.N.lx DATE 3/25/92

PROJECT SONGS 2&3 JOB NO. 10079-006 SHEET 50 OF 51

SUBJECT CCW Isolation Valve Stroke Time

Cv AS A FUNCTION OF TRAVEL
40x30x40 900 MSIV

CALCULATION SHEET CALC. NO. N-4080-3

SIGNATURE G. Thurston DATE 3/22/82 CHECKED JF Nelson DATE 3/25/82

PROJECT SONGS 2 & 3 JOB NO. 10079-003 SHEET 51 OF 51

SUBJECT CCW Isolation Valve Stroke Time

TRAVEL	% VALVE TRAVEL	% Cv	Cv	TRAVEL	% VALVE TRAVEL	% Cv	Cv
.3125	1	.0242	18.82	15.9375	51	8.18	6362.49
.625	2	.0547	42.55	16.25	52	8.511	6619.94
.9375	3	.0921	71.64	16.5625	53	8.856	6888.29
1.25	4	.139	108.12	16.875	54	9.215	7167.52
1.5625	5	.191	148.56	17.1875	55	9.588	7457.64
1.875	6	.245	190.56	17.5	56	9.975	7758.65
2.1875	7	.301	234.12	17.8125	57	10.377	8071.33
2.5	8	.361	280.79	18.125	58	10.792	8394.13
2.8125	9	.429	333.68	18.4375	59	11.221	8727.81
3.125	10	.504	392.02	18.75	60	11.664	9072.38
3.4375	11	.587	456.57	19.0625	61	12.664	9383.5
3.75	12	.678	527.36	19.375	62	12.486	9711.74
4.0625	13	.776	603.58	19.6875	63	12.962	10081.97
4.375	14	.879	683.69	20.0	64	13.491	10493.43
4.6875	15	.984	765.37	20.3125	65	14.074	10946.90
5.0	16	1.092	849.37	20.625	66	14.710	11441.59
5.3125	17	1.204	936.48	20.9375	67	15.4	11978.27
5.625	18	1.318	1025.15	21.25	68	16.143	12556.19
5.9375	19	1.436	1116.94	21.5625	69	16.940	13176.1
6.25	20	1.558	1211.83	21.875	70	17.79	13837.24
6.5625	21	1.691	1315.28	22.1875	71	18.693	14539.6
6.875	22	1.828	1421.84	22.5	72	19.65	15283.97
7.1875	23	1.968	1530.73	22.8125	73	20.661	16070.33
7.5	24	2.112	1642.73	23.125	74	21.667	16852.81
7.8125	25	2.258	1756.29	23.4375	75	22.627	17599.51
8.125	26	2.408	1872.97	23.75	76	23.697	18431.76
8.4375	27	2.561	1991.97	24.0625	77	24.876	19348.8
8.75	28	2.717	2113.31	24.375	78	26.164	20350.62
9.0625	29	2.876	2236.98	24.6875	79	27.561	21437.22
9.375	30	3.038	2362.99	25.0	80	29.067	22608.6
9.6875	31	3.203	2491.33	25.3125	81	30.682	23864.77
10.0	32	3.372	2622.78	25.625	82	32.407	25206.49
10.3125	33	3.543	2755.78	25.9375	83	34.241	26632.99
10.625	34	3.729	2900.45	26.25	84	36.183	28143.5
10.9375	35	3.932	3058.35	26.5625	85	38.235	29739.57
11.25	36	4.144	3223.24	26.875	86	40.397	31421.19
11.5625	37	4.363	3393.59	27.1875	87	42.667	33186.82
11.875	38	4.591	3570.93	27.5	88	45.478	35373.24
12.1875	39	4.827	3754.49	27.8125	89	48.59	37793.79
12.5	40	5.070	3943.5	28.125	90	51.962	40416.56
12.8125	41	5.322	4139.5	28.4375	91	55.594	43241.57
13.125	42	5.582	4341.74	28.75	92	59.487	46269.58
13.4375	43	5.849	4549.41	29.0625	93	63.64	49499.83
13.75	44	6.125	4764.09	29.375	94	68.053	52932.3
14.0625	45	6.409	4984.99	29.6875	95	72.727	56567.79
14.375	46	6.701	5212.10	30.0	96	77.661	60405.5
14.6875	47	6.997	5442.34	30.3125	97	82.855	64445.45
15.0	48	7.272	5656.23	30.625	98	88.31	68688.40
15.3125	49	7.560	5880.24	30.9375	99	94.025	73133.59
15.625	50	7.863	6115.92	31.25	100	100.	77781.60

LAO 0513 8-73

(4)

CALCULATION SHEET

CALC. NO. N4080-3

SIGNATURE J F Watson DATE 1/17/83 CHECKED Ed Wiley DATE 1/17/83

PROJECT SONGS 2&3 JOB NO. 10079-006

SUBJECT Containment Spray & Emergency Cooler Activation Time SHEET 52 OF 55 SHEETS

Revision 4

Table of Contents

VOID

CONTROL NO. 05931

CERTIFICATE OF AUTHENTICITY

CONTINUATION

This is to certify that the microphotographic images appearing in this microform are direct and facsimile reproductions of the original records of the Southern California Edison Company and were microfilmed in the regular course of business. The microfilming has been performed according to established routine Company Policy for systems utilization and/or maintenance and preservation of records through the storage of such microforms in protected locations.

THE DOCUMENTS CONTAINED ON THIS MICROFORM ARE ORIGINAL RECORDS OF:

Southern California Edison

For the MATERIAL & ADMINISTRATIVE SERVICES - CDM/SONGS Department
San Onofre Nuclear Generating Station Design Calculations

This microform file is a complete record of the transaction herein recorded. The documents are arranged on this microform in the following manner:

- ( ) By month in Location and Work Order sequence
- ( ) Alphabetical order by ______
- (X) Numerical order by Design Cal.No.
- ( ) Order of Customer Service Store Number
- ( ) Order of Payroll Location Number
- ( ) Grievance File Number sequence
- ( ) Date order
- ( ) Other ______

The hardcopy documents used to create this microform have been authorized for destruction after verification of correctness and acceptability of the microfilming.

It is further certified that on the date specified below, the micrographic images appearing on this microform were made at a reduction ratio of 29 :1 under my direction and control.

The above information is deemed necessary in compliance with the Federal Power Commission Order No. 450 - Regulations to govern the Preservation of Public Utilities and Licensees – issued March 14, 1972. This order has subsequently been approved by the Public Utilities Commission of the State of California on October 29, 1974.

2-15-94
DATE MICROFILMED

Jean Williams
CAMERA OPERATOR

AWS BLDG., D-2-P, SONGS
LOCATION

Napoleon Glass
AUTHORIZED SIGNATURE
SUPERVISOR MICROGRAPHICS

(4)

BECHTEL

CALCULATION SHEET

LAO 0513 8-73

CALC. NO. N4080-3

SIGNATURE JF Watson DATE 1/17/83 CHECKED Ed Wilcox DATE 1/17/83

PROJECT SONGS 2&3 JOB NO. 10079-006

SUBJECT Containment Spray & Emergency Cooling Actuation Times SHEET 53 OF 55 SHEETS

I Task - Incorporate 12 second stroke time for Containment Spray Isolation Valves (HV 9367 & 9368), ref(b), - changed from 10 seconds originally used, and incorporate new CSAS actuation pressure set point of 20 PSIG - changed from 12 psig, ref(a).

VOID

II References -

a) letter JJ Wambold to HF McCluskey 5/26/81, EB-17121 (CSAS setpoint)

b) letter DE Nunn to HF McCluskey 6/30/82 EB-19665 (valve stroke)

c) Calc N4080-4, E.Q. Thermal Analysis, P. Barbour, 10/12/78

III Results - An additional 1.6 seconds is added to the CS system response for the offsite power available event. There is no change to the system response for the LOP event.

The system response times are now:

1) off site power available 46.5 seconds (changed)
2) Loss of offsite power 55 seconds (unchanged)

Valve is now limiting component for O.P. available event, Pump is limiting for LOP event.

BECHTEL — **CALCULATION SHEET** — 4 — LAO 0513 8-73

SIGNATURE J F Watson DATE 1/17/83 CHECKED Ed Wilcox DATE 1/17/83 CALC. NO. N4080-3

PROJECT SONGS 2 & 3 JOB NO. 10079-006

SUBJECT Containment Spray & Emergency Cooler Actuation Times SHEET 54 OF 55 SHEETS

IV Criteria - none

V Codes and Standards - none

VI Assumptions - No new assumptions beyond those used in previous revisions, respectively.

VOID

VII General Method - Revise system response time line to incorporate new valve stroke time and CSAS set point.

VIII Calculation -

1) During a MSLB, Containment Pressure will exceed 20 psig within 12 seconds, per plot (p 7 of 68) ref (c).

2) Per reference (3) to revision 1 of this calculation, the CS isolation valves pass full rated flow at ½ open.

BECHTEL

LAO-0514 11/76

CALCULATION SHEET

12400 E. IMPERIAL HWY.
NORWALK, CALIFORNIA 90650

(4)

CALCULATION NO. N 4080-3

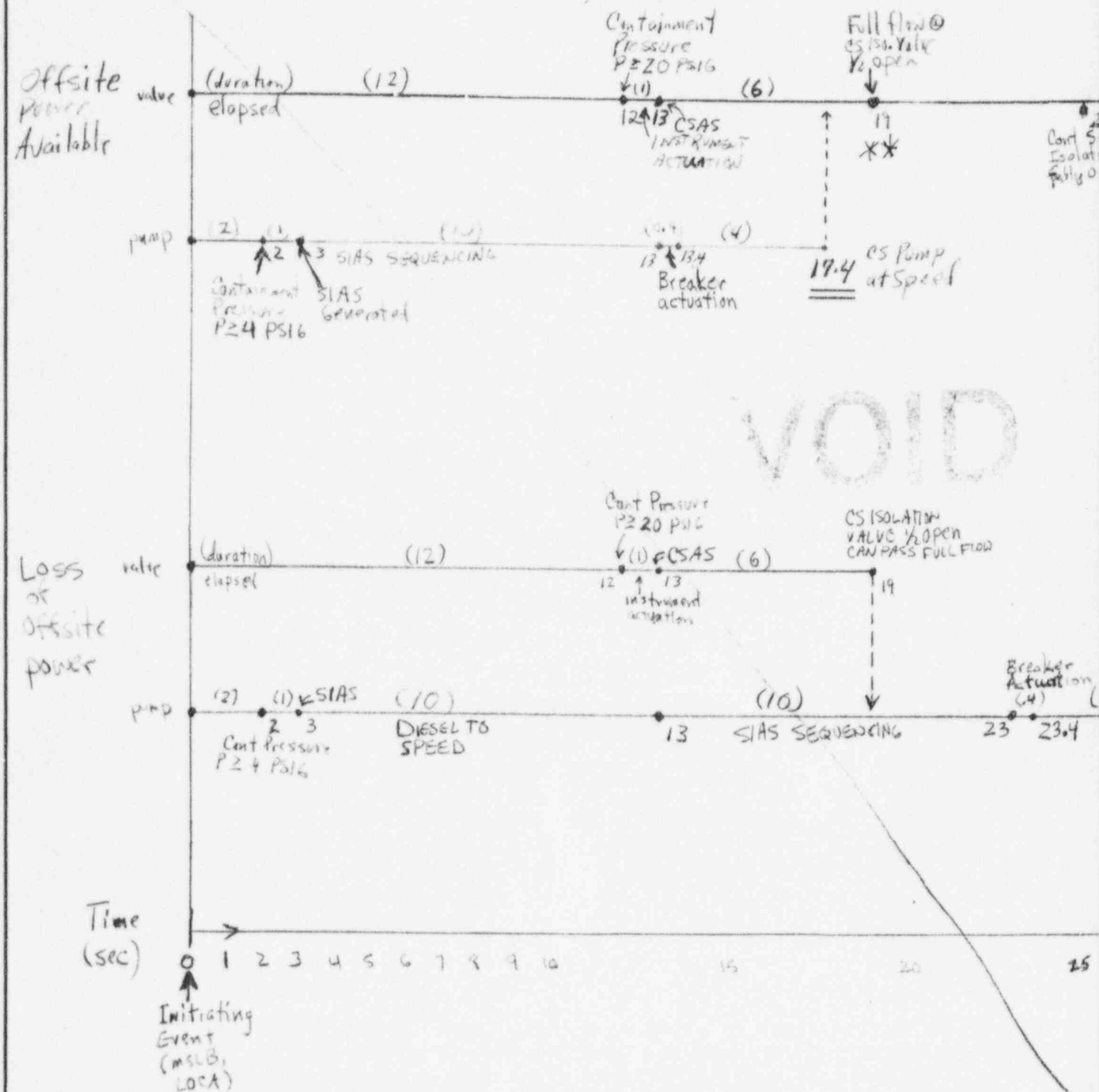
SIGNATURE JF Watson DATE 1/17/83 CHECKED [illegible] DATE 1/17/83

PROJECT SONGS 2&3 JOB NO. 10079-006

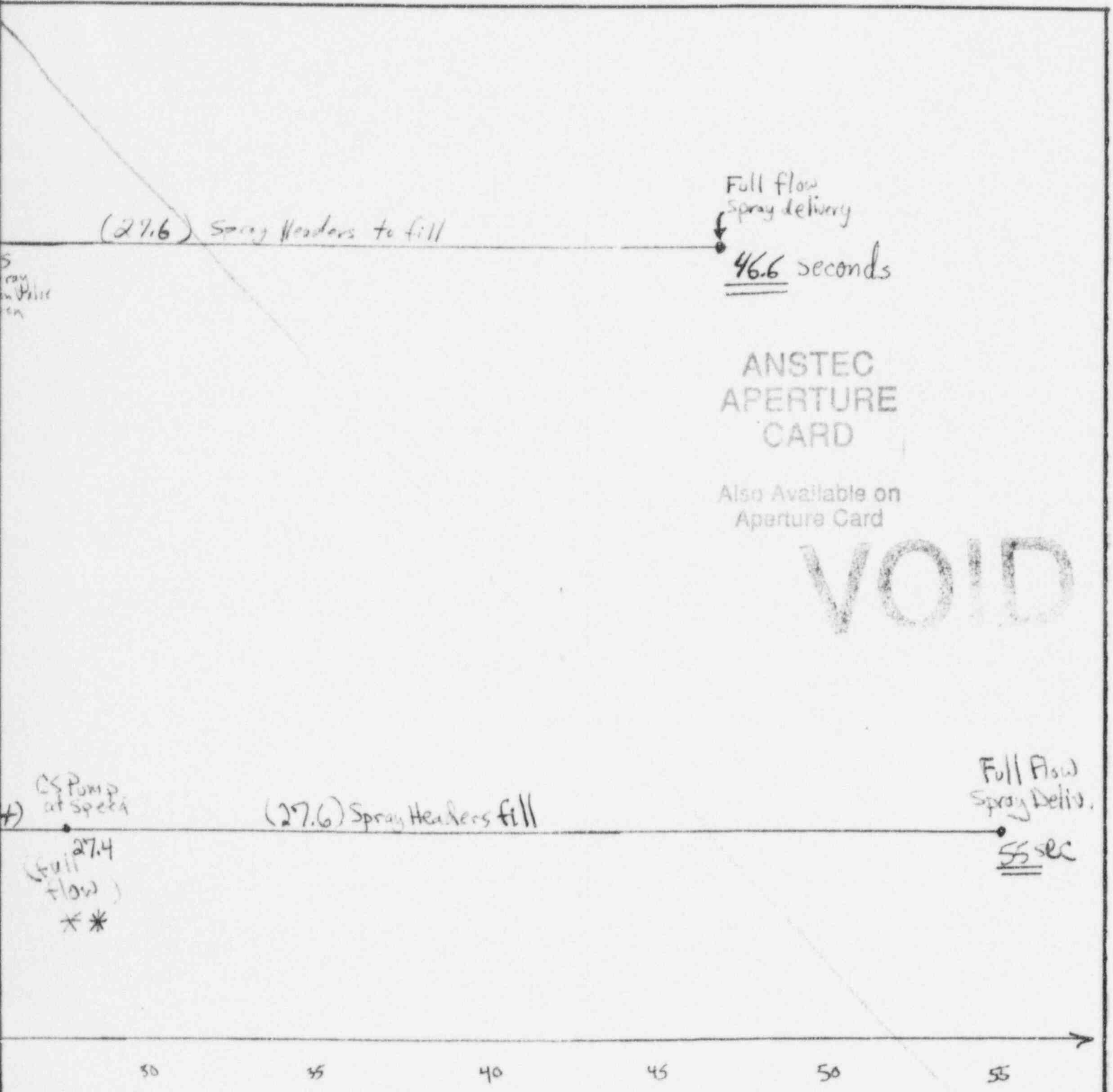
SUBJECT Containment Spray Actuation Time SHEET 55 OF 55 SHEETS

VIII Calculation -

Containment Spray System Delivery Response Time Line



** Full flow rate in lines achieved



9606040035-03

Southern California Edison Company	CALC. NO. N-4080-003		ICCN NO / PRELIM. CCN NO. N-1		PAGE 1	TOTAL NO. OF PAGES 30
INTERIM CALCULATION CHANGE NOTICE (ICCN)/ CALCULATION CHANGE NOTICE (CCN) COVER PAGE	BASE CALC. REV. 5	UNIT 2 & 3	CCN CONVERSION : CCN NO. CCN- 1			CALC. REV. 5
	CALCULATION SUBJECT : CONTAINMENT SPRAY (CS) AND EMERGENCY COOLING UNIT (ECU) ACTUATION TIMES					
CALCULATION CROSS-INDEX ☒ New/Updated index included ☐ Existing index is complete	ENGINEERING SYSTEM NUMBER / PRIMARY STATION SYSTEM DESIGNATOR 1206, 1500 / BKA, GNF					Q-CLASS II
1. BRIEF DESCRIPTION OF ICCN / CCN:	CONTROLLED PROGRAM OR DATABASE ACCORDING TO SO123-XXIV-5.1 ☐ PROGRAM ☐ DATA BASE		PROGRAM / DATABASE NAME (S) ☐ ALSO, LISTED BELOW N/A		VERSION/RELEASE NO.(S) N/A	

Revise sheets 2, 4-16, 18, and 21-28; Add sheets 5A, 21A, 27A, and 38-40; Delete sheets (NONE)

This change incorporates:

1) Increased Agastat sequencing time delay relay repeatability from vendor specification of +/- 10% of the relay setting to +/- 2.5 seconds for sequencing the containment spray (CS) pumps and the component cooling water (CCW) pumps.

2) Reduced CS pump and CCW pump starting acceleration times of 1.9 and 2.5 seconds, respectively, compared to the 4.0 and 4.5 seconds used in the previous analyses.

3) A separate 0.4 second breaker closing time for starting the ECU fans, CCW pumps, and CS pumps in place of the prior assumption that the breaker closure time was included in the motor acceleration time.

4) A new evaluation of the startup of Emergency Cooling Units with no Loss of Offsite Power which assumes a malfunction in the operating CCW train which requires an ESF sequenced startup of a non-running CCW pump with the sequencing commencing with SIAS. A credible event causing this scenario would be a LOVS on the operating CCW bus, but with with no LOOP.

Incorporation of the above changes results in no change in overall actuation time for the CS with or without LOOP, and no change in overall actuation time for the ECU with LOOP. The overall actuation time for the ECU with no LOOP increases from 15 seconds to 24 seconds. The additional delay in actuating ECUs with no LOOP has no impact on analyses of record for Containment pressure-temperature response to design basis LOCA or MSLB events because the ECU start times actually used in the P-T AORs bound the value from this actuation timing analysis.

INITIATING DOCUMENT (DCP, FCN, OTHER) N/A REV. ______

2. OTHER AFFECTED DOCUMENTS (CHECK AS APPLICABLE FOR CCN ONLY):
(SEE CHANGE TO CALC CROSS INDEX, CALC SH. #2)

◉ YES ○ NO OTHER AFFECTED DOCUMENTS EXIST AND ARE IDENTIFIED ON ATTACHED FORM 26-503.

3. APPROVAL : DISCIPLINE / ESC : Nuclear Safety Anal.

PAUL BARBOUR/ PB 9/20/95 — ORIGINATOR (Print name/initial/date)
[signature] 9/20/95 — ESS (Signature/date)
OTHER (Signature/date)

ALLEN EVINAY/ AE / 9/20/95 — IRE (Print name/initial/date)
[signature] 9/26/95 — DM (Signature/date)
OTHER (Signature/date)

4. ASSIGNED SUPPLEMENT ALPHA DESIGNATOR : ______

CONVERSION TO CCN DATE 9/26/95 Tanya Castello — SCE CDM - SONGS

CALCULATION CROSS INDEX

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	CCN CONVERSION: CCN NO. CCN- 1

Calculation No. N-4080-003

Sheet No. 2

Calc. rev. number and responsible supervisor initials and date	INPUTS These interfacing calculations and/or documents provide input to the subject calculation, and if revised may require revision of the subject calculation. Calc/Document No.	Rev. No.	OUTPUTS Results and conclusions of the subject calculation are used in these interfacing calculations and/or documents. Calc/Document No.	Rev. No.	Does the output interface calc/document require revision? YES/NO	Identify output interface calc/document CCN, DCN TCN/Rev. or FIDCN
AJB 12/23/93 DJS 9/20/95	Calculations:		UFSAR, SONGS Units 2&3, Section 6.2.2 Tables 6.2-30 & 6.2-31	~~10~~ 9	Yes	SAR23-270***
	M-0014-009	0				
	N-4080-002	1				
	N-4080-007	2	Calculation M-0014-003	0	Yes/supersede	AJB-93-141*
	E4C-016	5				
	SO23-944-C50 (CE-NPSD-570-P, Rev. 03-P)	0	Calculation N-4080-004	1	Yes	9030001/1 thru 9030004/1**
5	Drawings:		Calculation N-1140-020	0	No	N/A
	40383	10				
	40397	8	Calculation N-4080-026	0	No	N/A
	40421, sheet 1	16				
	40494	6	Calculation N-4080-027	0	No	N/A
	40114B	12				
	90004	55				
5	Isometric Drawings:					
	S2-1206-ML-047, sheet 1	9				* NEDOTRAK Log Item
	S2-1206-ML-047, sheet 2	8				
	S2-1206-ML-048, sheet 1	4				**NEDOTRAK Action Items
	S2-1206-ML-049, sheet 1	3				*** EXISTING UNPROCESSED SAR CHANGE WILL BE UPDATED BY MEMO FROM NFM/NSA TO LICENSING TO REFLECT CHANGES IN THIS CCN. [signature] 9-20-95
	S2-1206-ML-050, sheet 1	4				
	S2-1206-ML-051, sheet 1	3				
	S2-1206-ML-052, sheet 1	4				
5	Vendor Prints:					
	SO23-405-9-70	1				
	SO23-410-1-158	3				

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NES&L DEPARTMENT

CALCULATION SHEET

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	CCN CONVERSION: CCN NO. CCN -- 1

Project or DCP/MMP N/A Calc. No. N-4080-003

Subject Containment Spray (CS) & Emergency Cooling Unit (ECU) Actuation Times Sheet No. 4

REV	ORIGINATOR	DATE	IRE	DATE	REV	ORIGINATOR	DATE	IRE	DATE
5	Paul Barbour	12/23/93	Allen Evinay	12/23/93					
	Paul Barbour	08/28/95	Allen Evinay	08/28/95					

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5	Paul Barbour	12/23/93	Allen Evinay	12/23/93					
	Paul Barbour	08/28/95	Allen Evinay	08/28/95					

1.0 PURPOSE

The purpose of this calculation is to determine a conservative time interval between the occurrence of the design basis loss of coolant accident (LOCA) or main steam line break (MSLB) in containment and the time at which a single train of the containment spray (CS) system or a post accident emergency cooling unit (ECU) is fully functional for containment heat removal. The containment spray and emergency cooling unit delay times are determined with and without a loss of off-site power (LOOP).

This revision of the calculation specifically includes engineered safety features (ESF) analysis set points of 5 psig for safety injection and containment emergency cooling unit actuation and 20 psig for containment spray system actuation. This revision also specifically calculates a spray piping fill time consistent with the performance of a 7.5% degraded containment spray pump identified in calculation M-0014-009 [Ref. 6.1].

This revision of the calculation also incorporates an increase in the Agastat sequencing time delay relay repeatability from the vendor specification of ±10% of the relay setting to ±2.5 seconds for sequencing the containment spray (CS) pumps and the component cooling water (CCW) pumps. The revision also includes shorter CS pump and CCW pump acceleration times of 1.9 and 2.5 seconds, respectively, as requested by Reference 6.26.

The results of this calculation are included in UFSAR Chapter 6, tables 6.2-30 and 6.2-31, which present design basis delay times for containment heat removal system operation following a design basis LOCA or MSLB in containment. For conservatism, the delay times developed in this calculation are based on the containment pressure response to the design basis MSLB (main steam line break at 102% reactor power) since this accident provides a slower rate of containment pressure rise than does the design basis LOCA.

The delay times determined in this calculation provide a basis for modeling the start of containment heat removal systems in analyses to determine the containment pressure and temperature response to the design basis LOCA and MSLB events. These delay times are applicable only to large break events with containment pressure ramps that reach the containment high and high-high pressure analysis setpoints within the times used in this calculation. In-containment high energy line break events which provide slower rates of containment pressurization should be individually evaluated for the timing of heat

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removal system operation using the methodology of this calculation, but based on a calculated break-specific time to reach the high and high-high containment pressure analysis setpoints.

This calculation revision is required to support closure of disposition step 2 of NCRs 93030001, 2, 3, and 4 [Ref. 6.7] by providing minimum CS and ECU start time data for use in revising the design basis LOCA and MSLB analyses of record.

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2.0 RESULTS, CONCLUSIONS, AND RECOMMENDATIONS

2.1 Results

The results of this calculation show that, following a design basis loss of coolant accident (DB LOCA) or a design basis main steam line break (DB MSLB), the containment emergency cooling units and containment spray system will be fully functional after the time intervals identified below. Delay times reflecting loss of offsite power (LOOP) and no loss of offsite power (no LOOP) are provided. For the LOOP case, the loss of power is assumed to occur at a point in time following the LOCA or MSLB such that the loss of voltage signal (LOVS) which starts the emergency diesel generator, occurs coincident with the generation of the safety injection actuation signal (SIAS) occurring on containment high pressure (SIAS/LOVS event). The values in brackets {} are the values of record from the previous revisions of this calculation used to support the original licensing of SONGS Units 2 and 3.

SUMMARY OF RESULTS

Emergency Cooling Unit and Containment Spray Actuation Times

	No Loss of Power	With Loss of Power
Emergency Cooling Unit Delay Time (seconds)	**24** {13}	**34** {33}
Containment Spray Delay Time (seconds)	**49** {46.6}	**59** {55}

These delay times are specifically applicable to the DB LOCA (double-ended RCS suction leg slot break) or DB MSLB (steam line break at 102% power). Containment high energy line break events which provide slower rates of containment pressurization than the DBA events cited should be individually evaluated for the timing of heat removal system operation using the methodology of this calculation, but based on break-specific times to reach the high and high-high containment pressure setpoints.

Timelines describing the sequence of events and individual delay times associated with each component of the overall actuation time are provided in Section 8 (Calculations) as Figures 1 and 2 on pages 24 and 28 for the emergency cooling units and the containment spray, respectively.

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The change in analysis setpoint for containment high pressure from 4 psig to the currently used 5 psig [Ref. 6.2] had no effect on the delay time calculation. The 2 seconds previously allowed for the containment pressure to reach the high pressure setpoint envelopes the higher setpoint.

The 11-second increase in the delay time for emergency cooling unit operation with no LOOP reflects current station operating practice of normally operating only a single CCW pump train rather than always running both train pumps with only one train performing a cooling function. In this case, a loss of voltage signal (LOVS) on the operating CCW pump train without a loss of offsite power (LOOP), or some other operating CCW train-related malfunction, will force a delay in the availability of the alternate CCW train. In this event, ESF sequencing which initiates on SIAS would start the available non-operating CCW train in the 4th load group, 15 ±2.5 seconds after initiating ESF sequencing. In addition, prior ECU startup analyses credited full functional capability at the time the CCW block valves were 10 seconds into their 12-second full open stroke time when the valves were 83% open. However, now that ECU availability is delayed until the idle CCW train is operational (with or without LOOP), the the CCW block valves to the ECUs are fully open 9 seconds prior to the CCW pump reaching full speed.

The 1-second increase in the delay time for emergency cooling unit operation with LOOP results from the net effect of increasing the tolerance on the sequencing time delay relays for component cooling water pump start combined with a reduction in the CCW pump acceleration time used in the current analysis.

The change in containment spray system flow rate to allow for up to 7.5% spray pump degradation [Ref. 6.1] increased the spray piping/header fill time by about 3.5 seconds which is the major contributor to the changes in spray start time. Minor changes in other components of the overall delay time for the spray system actuation, including a ±2.5 second uncertainty in the repeatability of sequencing the containment spray pump and a compensating reduction in the spray pump motor acceleration time, also contributed small differences to the results.

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2.2 Conclusions & Recommendations

The overall delay times employ constituent response times which are consistent or conservative with respect to Station response time and operability testing success criteria. Therefore, this calculation revision does not impact Station procedures.

The overall and constituent delay times from the prior revisions of this calculation are included in UFSAR table 6.2-30 and 6.2-31. Therefore, a UFSAR change request has been initiated to conform these tables to the current analysis of record.

The analyses of record for containment pressure and temperature response to the design basis LOCA and MSLB events used to support containment functional design and equipment qualification are N-4080-026 (Supplement A, LOCA) and N-4080-027 (Supplements A and B, MSLB) [Refs. 6.9 and 6.8, respectively]. These calculations use emergency cooling unit and containment spray start times which conservatively envelope the values generated in this calculation. Therefore, these P/T calculations are not impacted by this revision.

The original analysis of record for the containment P/T response to the design basis MSLB event for equipment qualification [N-4080-004, Ref. 6.23] used emergency cooling unit and spray start times which do not envelope the values in this calculation. Calculation N-4080-004 has been revised by CCN to identify Supplement A to N-4080-027 [Ref. 6.8] as the current analysis of record for containment P/T response to the design basis MSLB for equipment qualification.

Calculation M-0014-003 [Ref. 6.24] is an early analysis of the fill time for containment spray piping inside containment. The current piping fill analysis contained in this revision of the emergency cooling unit and containment spray system startup delay times supersedes the analysis in Reference 6.24, and that calculation will be obsoleted.

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3.0 ASSUMPTIONS

3.1 Instrument response and ESF signal generation time is assumed to be 1 second. This value is consistent and conservative with respect to the ESF response times calculated and used in the Plant Protection System Setpoint Calculation, CE-NPSD-570-P [Ref. 6.2]. According to sections 4.9 and 4.10 of Reference 6.2, the total ESFAS response time for either containment high pressure or high-high pressure is estimated to be 0.551 seconds, which is below the 1 second analysis response time assumed in this calculation. The 1-second response time also coincides with the combined "sensor and ESF logic" and "subgroup relay" delay times identified in General Engineering Procedure SO23-XV-6, "Technical Specification Response Time Surveillance Implementing Procedure Master List" [Ref. 6.3]. The 1-second ESF response time used in this calculation and in Reference 6.2 is split in to the "sensor and ESF logic" and "subgroup relay" delay times to facilitate response time testing by the Reference 6.3 procedure.

3.2 Closing time for the electrical power breakers supplying the motors for the containment spray pumps, the component cooling water pumps and the emergency cooling unit fans are assumed to be 0.4 seconds. The breaker closing time is normally a very short interval, and a typical value from vendor equipment catalog data [Ref. 6.4] shows closure times of about 4.5 cycles (0.075 seconds) for the 5Kv breakers used to supply the 4160 volt power to the component cooling water and containment spray pumps. The assumption of 0.4 seconds for breaker closure time will conservatively envelop the expected closure time.

3.3 For the loss of offsite power case, the LOOP is assumed to occur at a finite time following the LOCA or MSLB such that the diesel start in response to the loss of voltage signal (LOVS) occurs coincident with the generation of the safety injection actuation signal (SIAS), a SIAS/LOVS event. Since, as identified in Design Input 4.5, the bounding time for the containment pressure to reach the high pressure analysis setpoint of 5 psig is taken to be 2 seconds following either the design basis LOCA or MSLB event and the ESF delay time to generate the SIAS is assumed to be 1 second (Assumption 3.1, above), the diesel generators will be starting 3 seconds following the design basis pipe break event.

3.4 The Agastat sequencing time delay relays used for starting the CS pumps and the CCW pumps will be assumed to actuate within ± 2.5 seconds of their setting. On this basis, conservative sequencing delays of 12.5 seconds (10 ± 2.5 sec) and 17.5 seconds (15 ± 2.5 sec) will be assumed for the containment spray pumps and component cooling water pumps, respectively. These delay times are conservative

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with respect to the vendor specification for sequencing time delay relay repeatability of ±10% of the Agastat relay setting as shown in Reference 6.25.

3.5 The bounding time for the containment pressure to rise to the high pressure analysis setpoint of 5 psig following the design basis LOCA or MSLB pipe break event will be assumed to be 2 seconds. This time delay is based on the containment pressure response to the design basis steam line break event (MSLB at 102% power). For this break, the containment pressure has increased by 6.5 psi at 2 seconds following the break [Ref. 6.8]. For the design basis LOCA event, the containment pressure has increased by 11.7 psi at 2 seconds following the break [Ref. 6.9].

3.6 The bounding time for the containment pressure to rise to the high-high pressure analysis setpoint of 20 psig following the design basis LOCA or MSLB pipe break event will be assumed to be 9 seconds. This time delay is based on the containment pressure response to the design basis MSLB at 102% power. For this break, the containment pressure has increased by about 20 psi at 8 seconds and by at lease 21.5 psi at 9 seconds following the break [Ref. 6.8]. For the design basis LOCA event, the containment pressure has increased by 20 psi at about 4.1 seconds, and by 34 psi at 9 seconds following the break [Ref. 6.9].

3.7 The containment spray piping riser is assumed to be filled with water to within 10 feet of the lower (first) ring header as required by Technical Specification Surveillance Requirement 4.6.2.1.b.4 [Ref. 6.15]. The water level in the spray riser piping is established using Station Procedure SO23-3-3.11.2 [Ref. 6.16]

3.8 The containment spray headers are assumed to fill one at a time from the bottom ring to the top ring. As each spray ring is being filled, it is further assumed that the flow rate of water into the ring available to fill the ring is reduced by having each nozzle in the ring immediately begin leaking water at a flow rate set by an assumed water pressure in the ring of 5 psi above the containment pressure. This is a conservative assumption since the nozzles can only begin to leak water after the water reaches them, and the pressure driving the leakage would only be the static head at each nozzle location which, on average, would be expected to be less than the assumed 5 psi for the ring being filled. As the riser between the rings is filled, the full spray rings leak water at a flow rate consistent with the 5 psi assumed for the higher ring being filled plus the static pressure between the ring being filled and the full ring below. The nozzle spray flow rate as a function of nozzle pressure drop is defined in Design Input 4.11.

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3.9 The filling of the spray headers will be assumed to start at the time the spray pump reaches full speed. The filling flow rate will be assumed to be 1900 gpm. This value is conservatively chosen to be less than that calculated in Case 7 of Reference 6.1 (1949 gpm; see Design Input 4.10). This flow rate is representative of the minimum value during injection mode operation with the RWST full, the containment at the design pressure of 60 psig, the spray block valves full open, but without the full nozzle pressure drop as would be the case while the headers are filling. For the case of containment spray actuation with no LOOP, the spray block valves are only 65% open at the time the spray pump reaches full speed, and about 4 seconds remain before the block valves are full open (see section 8.2.1). Based on Case 5 of Reference 6.1, the filling flow rate with the valves half open would be greater than 1650 gpm, or 87% of the valves full open flow rate (1686 gpm is shown in Ref. 6.1). Using linear interpolation, the filling flow with the block valves 65% open would be about 90% of the maximum filling flow rate. The assumption of the maximum filling flow rate from the time the block valves are 65% open, with the spray pump at full speed, is justified since no credit is taken for the substantial amount of water which will enter the assumed empty portion of the riser during the 1.9 seconds that the pump is accelerating to full speed while the block valves are moving from about 49% open to 65% open. It is estimated that over 40 gallons of water would enter the assumed empty portion of the spray riser system, which is enough to fill the 10 feet of the initial 8" diameter riser piping and about half the horizontal 6" diameter distribution pipe in the 1st ring header before the calculation assumes any water enters the dry part of the piping system.

3.10 The spray piping filling time will be calculated for the "A" spray train (header number 1) since the total length of all 3 ring headers for this train is about 19 feet longer than that for the "B" train.

3.11 The time to accelerate the CS pump to full speed following closure of the pump breaker is assumed to be 1.9 seconds per Reference 6.26.

3.12 The time to accelerate the CCW pump to full speed following closure of the pump breaker is assumed to be 2.5 seconds per Reference 6.26. This value is conservative with respect to a vendor-supplied acceleration time of 2 seconds at 75% voltage shown in Reference 6.13.

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4.0 DESIGN INPUT

4.1 The analysis setpoint for containment high pressure is 5 psig [Ref. 6.2]. This value is consistent with the actual containment high pressure setpoint of 3.4 psig established in Reference 6.2 and incorporated into the Station Technical Specifications [Ref. 6.15, Unit 2 as an example]. The high pressure setpoint initiates the safety injection actuation signal (SIAS) and containment cooling actuation signal (CCAS). The SIAS signal initiates startup of the high and low pressure safety injection pumps and the containment spray pumps (P-012 and P-013) through the ESF sequencer. The CCAS signal will start the emergency cooling units (E-399, E-400, E-401 and E-402) and cause the component cooling water block valves to the emergency cooling units to open (2(3)HV-6366 through 2(3)HV-6373).

4.2 The analysis setpoint for containment high-high pressure is 20 psig [Ref 6.2]. This value is consistent with the actual containment high-high pressure setpoint of 14.0 psig established in Reference 6.2 and incorporated into the Station Technical Specifications [Ref. 6.15, Unit 2 as an example]. The high-high pressure setpoint initiates the containment spray actuation signal (CSAS) which causes the containment spray block valves, 2(3)HV-9367 and 2(3)HV-9368, to open.

4.3 The diesel generator delay for the LOOP case is 10 seconds [Section 4.8.5.D of Ref. 6.5]. This time interval includes generator start, attainment of rated voltage and frequency, and breaker closure energizing the 4160 volt ESF bus. This value is the same as the surveillance test acceptance value of 10 seconds cited in Section 7.1.16.2.2 of Reference 6.17.

4.4 The nominal delays for sequencing the first 4 ESF load groups are [Ref. 6.6]:

Group 1	0 seconds
Group 2	5 seconds
Group 3	10 seconds
Group 4	15 seconds

The emergency fan cooler motors are in Group 1 [Ref. 6.6].
The containment spray pump motors are in Group 3 [Ref. 6.6].
The component cooling water pump motors are in Group 4 [Ref. 6.6].

As identified in Assumption 3.4, the repeat accuracy of the load group delay times is ±2.5 seconds applied to the Agastat time delay relay setting.

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4.5 The maximum stroke time for opening the containment spray block valves, 2(3)HV-9367 and 2(3)HV-9368, is 12 seconds [Refs. 6.10 and 6.11].

4.6 The maximum stroke time for opening CCW isolation valves 2(3)HV-6366 through 2(3)HV-6373, which permit cooling water to flow through the containment emergency cooling units, is 12 seconds [Refs. 6.10 and 6.11].

4.7 (Replaced by Assumption 3.11.)

4.8 (Replaced by Assumption 3.12.)

4.9 The maximum time required to accelerate an emergency cooling unit fan motor to full speed following closure of the fan motor power supply breaker is 10 seconds [Ref. 6.3]. This value is conservative with respect to a vendor-supplied acceleration time of 7.8 seconds at 80% voltage shown in Reference 6.14.

4.10 The spray pump flow rate delivered to the containment riser while filling of the spray ring headers is in progress (prior to establishment of full containment spray flow at design nozzle pressure drop) will be taken to be 1650 gpm with the spray isolation valve 2(3)HV-9367 or 2(3)HV-9368 one-half open and 1900 gpm with the spray block valves full open. These values have been conservatively selected to be less than the minimum flow rates calculated for cases 5 and 7, respectively, of Reference 6.1 for a 7.5% degraded spray pump drawing water from a full RWST and pumping into a 60 psig containment building during the time that the spray piping is filling, before the full nozzle pressure drop is developed.

4.11 The Sprayco 1713A hollow cone bottom ramp spray nozzles have a design flow rate of 15.2 gpm at a 40 psid nozzle pressure drop [Appendix 2 of Ref. 6.1]. With turbulent flow conditions, the flow rate will vary as the square root of the nozzle pressure drop.

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5.0 METHODOLOGY

The start times for the containment sprays and emergency cooling units are determined by combining in series (and in parallel, if appropriate) the time intervals for each action which must occur to establish a functioning heat removal system. The constituents of the total delay times are identified below.

A. Emergency Cooling Unit Operation

1) Time to reach containment high pressure analysis setpoint following the design basis LOCA or MSLB

2) Sensor and instrumentation delays to generate the containment cooling actuation signal (CCAS)

3) Assuming LOOP, time to start the diesel generator, reach design voltage and frequency, and energize the 4160 volt ESF bus (with no LOOP, the diesel generator delay is not applicable)

4) Time to open the component cooling water (CCW) block valves to the emergency cooling units

5) Time for the emergency cooling unit fan motors, which are in the 1st ESF load group, to be energized and accelerate to full speed (breaker closure time plus motor acceleration time)

6) Also, with or without LOOP, ESF sequencing delay in starting the operable CCW pumps which start in the 4th load group

6a) With a loss of voltage signal (LOVS) on the operating CCW train (but with no LOOP) or another malfunction in the operating CCW train, the ESF sequencing delay will still apply to restoring CCW flow, but without the diesel generator starting delay

7) Time to accelerate the CCW pumps to full speed, restoring CCW flow, assuming a LOOP had occurred (breaker closure time plus motor acceleration time)

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B. Containment Spray System Operation

1) Time to reach containment high pressure analysis setpoint following the design basis LOCA or MSLB

2) Sensor and instrumentation delays to generate the safety injection actuation signal (SIAS) which initiates automatic sequencing of ESF equipment and starts the containment spray pump in the 3rd load group (with LOOP, sequencing is delayed until the ESF bus is energized by the emergency diesel generator)

3) Assuming LOOP, time to start the diesel generator, reach design voltage and frequency, and energize the 4160 ESF bus (with no LOOP, the diesel generator delay is not applicable)

4) Time for the spray pump motors to be energized and accelerate to full speed (breaker closure time plus motor acceleration time)

5) Time to reach containment high-high-pressure analysis setpoint following design basis LOCA or MSLB

6) Sensor and instrumentation delays to generate the containment spray actuation signal (CSAS) which initiates opening of the containment spray isolation valves and allow spray water to begin filling the spray piping in containment

7) Time to open the containment spray isolation valves

8) Time to fill the spray rings and establish full containment spray flow

REV	ORIGINATOR	DATE	IRE	DATE	REV	ORIGINATOR	DATE	IRE	DATE
5	Paul Barbour	12/23/93	Allen Evinay	12/23/93					
	Paul Barbour	08/28/95	Allen Evinay	08/28/95					

6.0 REFERENCES

6.1 Supplement A to Mechanical Calculation M-0014-009, Rev. 0, "Containment Spray Pumps Inservice Testing Minimum Requirements", July 28, 1994

6.2 ABB-CE Calculation CE-NPSD-570-P, Rev. 03-P, "Plant Protection System Setpoint Calculation", October, 1991, SCE Document No. SO23-944-C50-0

6.3 General Engineering Procedure SO23-XV-6, Rev. 0, thru TCN 0-2, "Technical Specification Response Time Surveillance Implementing Procedure Master List", April 27, 1989

6.4 Gould-Brown Bovari Switchgear Division Bulletin 8.2-1E, "ITE Type HK Stored Energy Metal-Clad Switchgear", Table 9, page 43 (copy of page 43 provided in Appendix A)

6.5 Specification SO23-403-12, Rev. 2, "Diesel Driven Electrical Generating Sets for SONGS Units 2 and 3", October 3, 1975

6.6 Electrical Calculation E4C-016, Rev. 5, "ESF Sequencing", May 4, 1984

6.7 NCRs 93030001, 2, 3, and 4; Containment Spray Pumps 1 & 2 for SONGS Units 2 & 3

6.8 Supplements A and B to Nuclear Calculation N-4080-027, Rev. 0, "Containment P/T Analysis for Design Basis MSLB", November 4, 1994 and March 14, 1995

6.9 Supplement A to Nuclear Calculation N-4080-026, Rev. 0, "Containment P/T Analysis for Design Basis LOCA", February 6, 1995

6.10 Engineering Procedure, SO23-V-3.5, TCN 7-32, "Inservice Testing of Valves Program", December 9, 1993

6.11 Surveillance Operating Instruction, SO23-3-3.30, TCN 7-26, "In-service Valve Testing, Quarterly", September 10, 1993

6.12 [Reference Deleted]

REV	ORIGINATOR	DATE	IRE	DATE	REV	ORIGINATOR	DATE	IRE	DATE
5	Paul Barbour	12/23/93	Allen Evinay	12/23/93					
	Paul Barbour	08/28/95	Allen Evinay	08/28/95					

6.24 Mechanical Calculation M-0014-003, Rev. 0, "Containment Spray Flow History", May 28, 1975

6.25 Amerace Corporation, Industrial Electrical Products Division, Bulletin E70-1, "Agastat Nuclear Qualified Time Delay Relays", E7000 Series Operating Characteristics from Specifications on Page 4 (copy of the table provided in Appendix B)

6.26 Memorandum, D. Stickney to A. Brough, "Analysis for Obtaining a ±2.5 Seconds of Relay Setting on Agastat Timing Relay for Load Sequence Timing Tolerance in Tech Spec 4.8.1.1.2.d.13.", July 21, 1995 (copy of the memo is provided in Appendix C)

REV	ORIGINATOR	DATE	IRE	DATE	REV	ORIGINATOR	DATE	IRE	DATE
5	Paul Barbour	12/23/93	Allen Evinay	12/23/93					
	Paul Barbour	08/28/95	Allen Evinay	08/28/95					

8.0 CALCULATIONS

8.1 Emergency Cooling Units

The timing of the automatic startup of the emergency cooling units following a design basis LOCA or MSLB, with and without loss of offsite power, is developed in the following two sub-sections. The total delay time is developed using a chronology of events approach. Timelines describing the sequence of events for emergency cooling unit startup, with and without loss of offsite power, are provided in Figure 1. The delay times associated with each component of the overall delay time, which are provided in the chronologies below, have been included on the timelines in parentheses.

8.1.1 ECU Actuation With No Loss of Offsite Power (see Figure 1.A)

(A) DB LOCA or MSLB occurs — zero seconds

(B) Containment pressure reaches the analysis setpoint for containment high pressure (5 psig, Des. Input 4.1) — 2 seconds (Assump. 3.5)

(C) SIAS generated
LOVS occurs on operating CCW train (without LOOP) or other malfunction
Sequencing of ESF equipment begins
CCAS generated
CCW block valves to ECUs begin to open
ECU fan motor breaker coils energized (ECUs are in the first ESF load group per Design Input 4.4)
— 1 second after reaching hi pressure setpoint (Assump. 3.1)

(C') ECU fan motors start — 0.4 sec after ESF start signal; brkr closure time (Assump. 3.2)

(D) Emergency cooling unit motor and fan at rated speed — 10 sec after brkrs close (Des. Input 4.9)

(E) CCW isolation valves to ECUs are fully — 12 seconds valve stroke time (Des. Input 4.6)

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△	Paul Barbour	08/28/95	Allen Evinay	08/28/95	△				
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(F)	CCW pump motor breaker coils energized (CCW pump motors are in the 4th load group per Des. Input 4.4)	17.5 sec after ESF start (Assump. 3.4)
(G)	CCW pump motors start	0.4 sec brkr closure time (Assump. 3.2)
(H)	CCW pump at full speed, full CCW flow to ECU established	2.5 sec after brkrs close (Assump. 3.12)

Elapsed time following DB LOCA or MSLB for emergency cooling unit fan to reach full speed
$= A + B + C + C' + D$
$= 0 + 2 + 1 + 0.4 + 10 = 13.4$ seconds

Elapsed time following DB LOCA or MSLB for emergency cooling unit fan to be at full speed with CCW block valves full open
$= A + B + C + E$
$= 0 + 2 + 1 + 12 = 15$ seconds

Elapsed time following DB LOCA or MSLB for emergency cooling unit fan to be at full speed, CCW block valves fully open, and restarted CCW pump at full flow
$= A + B + C + F + G + H$
$= 0 + 2 + 1 + 17.5 + 0.4 + 2.5 = 23.4$ seconds
= **24 seconds, rounded**

The limiting action for establishing emergency cooling unit full operability with no loss of offsite power but with a loss of voltage signal on the operating CCW train, following a design basis LOCA or MSLB, is restarting the CCW pumps through the ESF sequencing time delay relays. The total delay time for emergency cooling unit operability in this case is 24 seconds.

8.1.2 ECU Actuation With Loss of Offsite Power (see Figure 1.B)

(A)	DB LOCA or MSLB occurs	zero seconds
(B)	Containment pressure reaches the analysis setpoint for containment high pressure (5 psig, Des. Input 4.1)	2 seconds (Assump. 3.5)
(C)	SIAS generated CCAS generated LOVS is present and EDG starts due to LOOP	1 second after reaching hi pressure setpoint (Assump. 3.1)
(D)	EDG @ full speed and frequency and ESF bus energized Sequencing of ESF equipment begins CCW block valves to ECUs begin to open ECU fan cooler motor brkr coils energized (ECUs are in first ESF load group per Design Input 4.4)	10 seconds after EDG start (Des. Input 4.3)
(D')	ECU fan cooler motors start	0.4 sec after ESF start signal; brkr closure time (Assump. 3.2
(E)	ECU motor and fan at rated speed	10 seconds after brkrs close (Des. Input 4.9)
(F)	CCW isolation valves to ECUs are fully open	12 seconds from time valves begin to open (Des. Input 4.6)
(G)	CCW pump motor brkr coils energized (CCW pump motors are in the 4th ESF load group per Des. Input 4.4) group per Des. Input 4.4)	17.5 seconds after start of ESF sequencing (Assump 3.4)
(G')	CCW pump motor starts	0.4 sec brkr closure time (Assump. 3.2
(H)	CCW pump at full speed	2.5 seconds after brkrs close (Assump. 3.12)

Elapsed time following DB LOCA or MSLB for emergency cooling unit fan to reach full speed

= A + B + C + D + D' + E
= 0 + 2 + 1 + 10 + 0.4 + 10 = 23.4 seconds

Elapsed time following DB LOCA or MSLB for emergency cooling unit fan to be at full speed with CCW block valves full open

= A + B + C + D + F
= 0 + 2 + 1 + 10 + 12 = 25 seconds

Elapsed time following DB LOCA or MSLB for emergency cooling unit fan to be a full speed, CCW block valves fully open and restarted CCW pump

= A + B + C + D + G + G' + H
= 0 + 2 + 1 + 10 + 17.5 + 0.4 + 2.5 = 33.4 seconds
= **34 seconds, rounded**

The limiting action for establishing emergency cooling unit full operability with loss of offsite power and the loss of voltage signal simultaneous with the safety injection actuation signal (SIAS/LOVS event), following a design basis LOCA or MSLB, is restarting the CCW pumps through the ESF sequencing time delay relays. The total delay time for emergency cooling unit operability in this case is 34 seconds.

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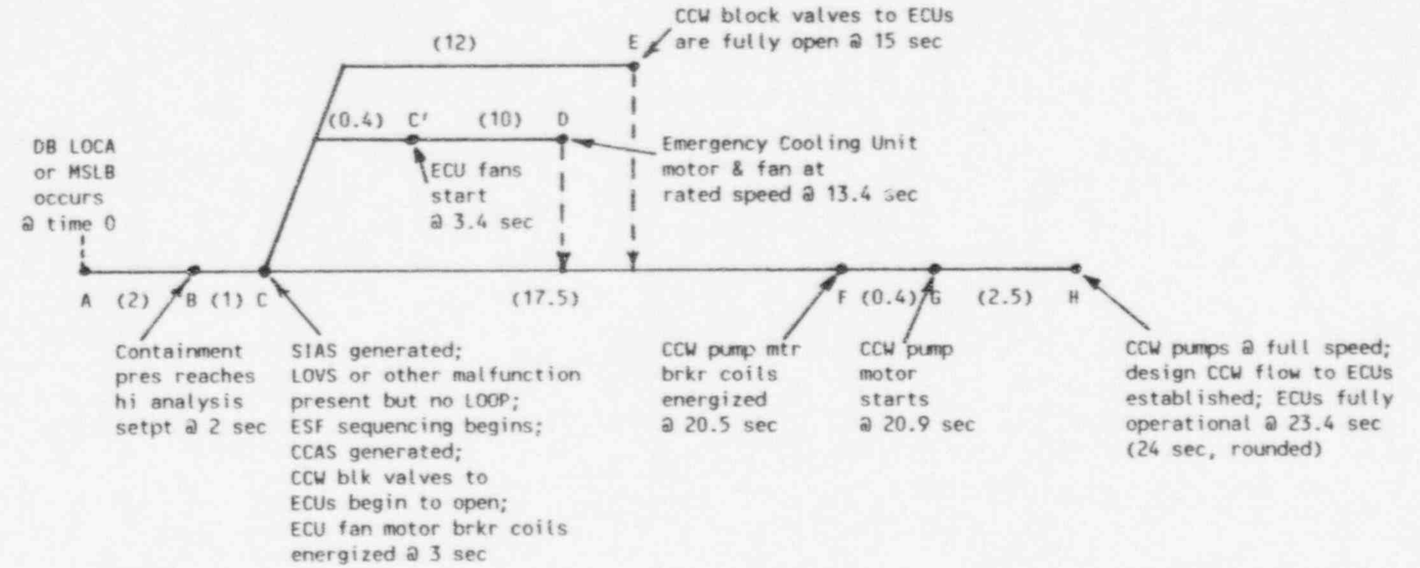
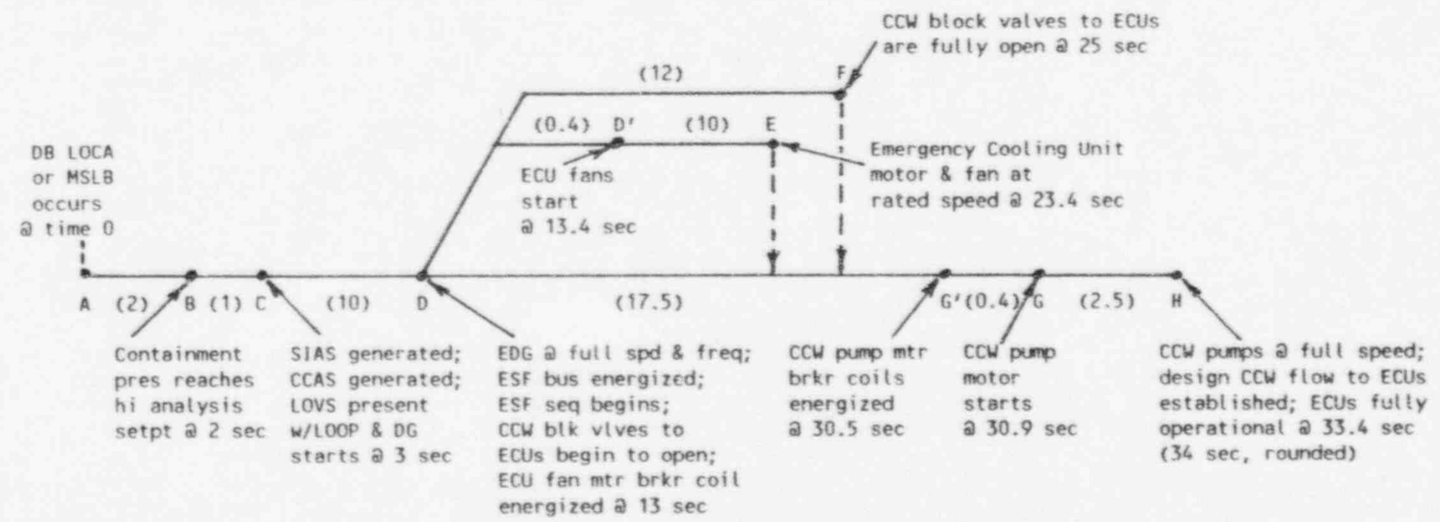
5	Paul Barbour	12/23/93	Allen Evinay	12/23/93					
	Paul Barbour	08/28/95	Allen Evinay	08/28/95					

FIGURE 1 - Emergency Cooling Unit Actuation Timelines

A. ECU ACTUATION WITH NO LOSS OF OFFSITE POWER



B. ECU ACTUATION WITH LOSS OF OFFSITE POWER



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5	Paul Barbour	12/23/93	Allen Evinay	12/23/93					
	Paul Barbour	08/28/95	Allen Evinay	08/28/95					

8.2 Containment Spray System

The timing of the automatic startup of the containment spray system following a design basis LOCA or MSLB, with and without loss of offsite power, is developed in a manner similar to that used for the emergency air coolers. The time to fill the empty spray piping and ring headers inside containment is calculated separately in sub-section 8.2.3. Timelines describing the sequence of events for containment spray startup, with and without loss of power, are provided in Figure 2. The delay times associated with each component of the overall delay time, which are provided in the chronologies below, have been included on the timelines in parentheses.

8.2.1 CS Actuation With No Loss of Offsite Power (see Figure 2.A)

(A)	DB LOCA or MSLB occurs	zero seconds
(B)	Containment pressure reaches the analysis setpoint for containment high pressure (5 psig, Des. Input 4.1)	2 seconds (Assump. 3.5)
(C)	SIAS generated Sequencing of ESF equipment initiated	1 second after reaching hi pressure setpoint (Assump. 3.1)
(D)	Containment pressure reaches the analysis setpoint for containment high-high pressure (20 psig, Des Input 4.2)	9 seconds (Assump. 3.6)
(E)	CSAS generated Containment spray block valves begin to open	1 second after reaching hi-hi pressure setpoint (Assump. 3.1)
(F')	Containment spray pump motor breaker coils energized (Spray pump motors are in the 3rd ESF load group per Des. Input 4.4)	12.5 seconds after start of ESF sequencing (Assump. 3.4)
(F)	Containment spray pump motor starts	0.4 sec after ESF signal; brkr closure time (Assump. 3.2)

(G)	Containment spray pump at full speed Spray block valves are about 65% open (7.8 seconds of the 12 second valve stroke time have elapsed)	1.9 seconds after breaker closure (Assump. 4.11)
(H)	Containment spray block valves full open	12 seconds after CSAS generated (Des. Input 4.5)
(I)	Spray piping and ring headers filled and full containment spray flow established from the spray system	31.1 seconds after CSP at full speed (see 8.2.3)

Elapsed time following DB LOCA or MSLB for containment spray pumps to reach full speed = A + B + C + F' + F + G
= 0 + 2 + 1 + 0.4 + 12.5 + 1.9 = 17.8 seconds

Elapsed time following DB LOCA or MSLB for containment spray block valves to be full open = D + E + H
= 9 + 1 + 12 = 22 seconds

Elapsed time following DB LOCA or MSLB for containment spray system to be fully functional assuming full header filling flow rate credited at time CSP reaches full speed (Assump 3.9) = A + B + C + F' + F + G + I
= 0 + 2 + 1 + 0.4 + 12.5 + 1.9 + 31.1 = 48.9 seconds
= **49 seconds, rounded**

The controlling actions for establishing containment spray following a design basis LOCA or MSLB with no loss of offsite power are the opening the spray block valves in parallel with the sequenced starting of the spray pumps, followed by the actual filling of the dry containment spray riser and ring header piping. In this case the containment spray pump is at full speed about 2 seconds before the block valves are fully open, and the total delay time for establishing full containment spray flow is 49 seconds.

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5	Paul Barbour	12/23/93	Allen Evinay	12/23/93					
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8.2.2 CS Actuation With Loss of Offsite Power (see Figure 2.B)

(A)	DB LOCA or MSLB occurs	zero seconds
(B)	Containment pressure reaches the analysis setpoint for containment high pressure (5 psig, Des. Input 4.1)	2 seconds (Assump. 3.5)
(C)	SIAS generated LOVS is present and EDG starts due to LOOP	1 second after reaching hi pressure setpoint (Assump. 3.1)
(D)	Containment pressure reaches the analysis setpoint for containment high-high pressure (20 psig, Des. Input 4.2)	9 seconds (Assump. 3.6)
(E)	CSAS generated	1 second after reaching hi-hi pressure setpoint (Assump. 3.1)
(F)	EDG at full speed and frequency and ESF bus energized Sequencing of ESF equipment begins Containment spray block valves begin to open with CSAS already present	10 seconds after EDG start (Des. Input 4.3)
(G')	Containment spray pump motor breaker coils energized (CS pump motors are in the 3rd ESF load group per Des. Input 4.4)	12.5 seconds after start of ESF sequencing (Assump. 3.4)
(G)	Containment spray pump motor starts	0.4 sec brkr closure time (Assump. 3.2)
(H)	Containment spray block valves full open	12 seconds after ESF bus is loaded with CSAS present (Des. Input 4.5)
(I)	Containment spray pump at full speed	1.9 sec after brkr closure (Assump. 3.11)

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(J) Spray piping and ring headers filled and full containment spray flow established from the spray train — 31.1 seconds after CSP at full speed (see 8.2.3)

Elapsed time following DB LOCA or MSLB for containment spray block valves to be full open

= A + B + C + F + H

= 0 + 2 + 1 + 10 + 12 = 25 seconds

Elapsed time following DB LOCA or MSLB for containment spray pump to be at full speed

= A + B + C + F + G' + G + I

= 0 + 2 + 1 + 10 + 0.4 + 12.5 + 1.9 = 27.8 seconds

Elapsed time following DB LOCA or MSLB for containment spray system to be fully functional assuming full header filling flow rate credited at time CSP reaches full speed (with all valves wide open at that time)

= A + B + C + F + G' + G + I + J

= 0 + 2 + 1 + 10 + 0.4 + 12.5 + 1.9 + 31.1 = 58.9 seconds

= **59 seconds, rounded**

The limiting action for establishing containment spray flow with loss of offsite power following a design basis LOCA or MSLB is the sequenced starting of the containment spray pump and subsequent filling of the dry spray riser and ring header piping. The total delay time for this case is 59 seconds.

REV	ORIGINATOR	DATE	IRE	DATE	REV	ORIGINATOR	DATE	IRE	DATE
5	Paul Barbour	12/23/93	Allen Evinay	12/23/93					
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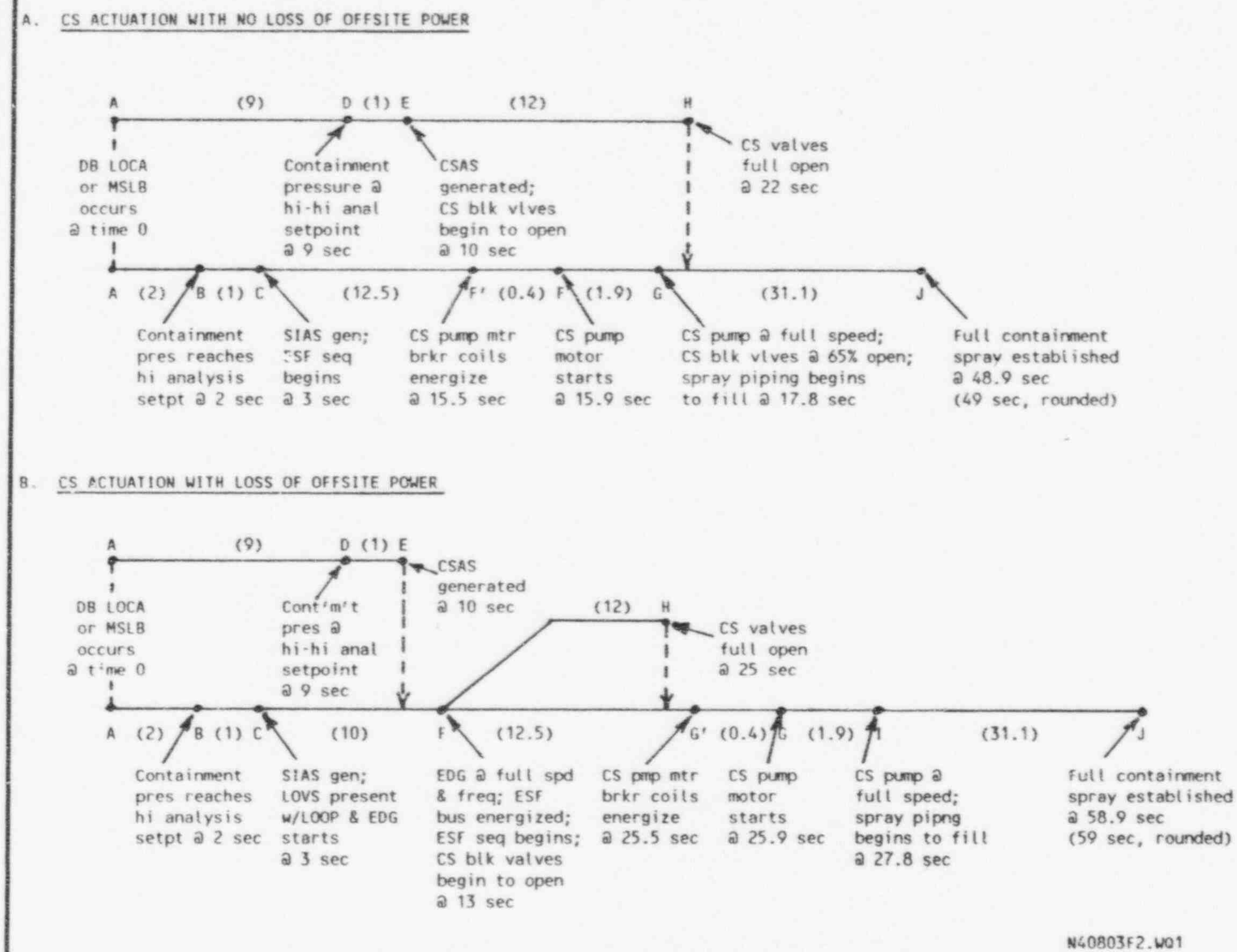

FIGURE 2 - Containment Spray Actuation Timelines

REV	ORIGINATOR	DATE	IRE	DATE	REV	ORIGINATOR	DATE	IRE	DATE
△	Paul Barbour	08/28/95	Allen Evinay	08/28/95	△				
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APPENDIX C (3 pages)

To: Alan Brough

DGS **From: Doug Stickney**

Request FOR support

July 21, 1995

Subject: Analysis for Obtaining a +/- 2.5 seconds of Relay Setting on Agastat Timing Relay for Load Sequence Timing Tolerance in Tech Spec 4.8.1.1.2.d.13.

Background:

The agastat time delay relays used in the load sequencer have a manufacturer's stated accuracy of +/- 10% of relay setting. Technical Specification (TS)requires verification that they perform with an accuracy of +/- 10% of design interval. This is a more restrictive requirement and results in many failures during Integrated ESF testing. To correct this situation, a Technical Specification change will be requested to increase the TS criteria to a value which exceeds the manufactures stated tolerance.

Some System safety analyses and procedures (i.e. NFA Calcs & IST programs) use assumptions about load sequencing and pump acceleration times. These assumptions are verified in various surveillances. A review of these analyses shows that changes to NFA calculations are required to support the proposed TS change. These required changes are discussed below.

NFA Changes for CS and CCW Pumps

Some preliminary studies have been performed to evaluate wider allowable load sequencing deviations from a system interaction viewpoint. Based on a review of existing procedures and calculation, the only safety analysis calculations which do not presently allow for a load sequencing deviation of as much as 2.5 seconds are NFA calculations N-4080-026 and 027. These calculations evaluate containment pressure and temperature rise following a LOCA or MSLB, and are sensitive to the start time of both containment spray and containment cooling. Timing assumptions used for these calculations are contained in calculation N-4080-003 Rev 5.

Start time for the containment Emergency Cooling Unit (ECU) is dependent both on CCW pump start and acceleration time, and valve stroke time. However, N-4080-026 & 027 calculations arbitrarily assume a start time for the ECU which matches the start of actual containment spray at 50/60 seconds (no LOP/LOP). This assumption envelopes the start times which would result from increasing

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Appendix C, Continued

allowable agastat delay for the CCW pump from 0.5 to 2.5 seconds (23.2/33.2 seconds). TS table 3.3-5, however, limits total response time to 21.2/31.2 seconds. As a result, surveillance procedure SO23-XV-6 limits CCW pump acceleration time to 4.5 seconds. To increase its agastat time from 0.5 to 2.5 seconds therefore, requires decreasing the allowable pump acceleration time to 2.5 seconds, and changing the TS table 3.3-5.

The containment Spray (CS) pump start times are also critical to the reference N-4080-026 &027 calculations. The analyses assume a 0.5 second load sequencing delay, which equals a CS pump breaker close time of 10.5 seconds, and an acceleration time of 4.4 seconds. A total of 26.9 seconds is available for the containment spray pump to be running at speed with valves full open to avoid exceeding pressure and/or temperature limits. TS table 3.3-5, however, limits this to 25.4 seconds. Since there is at most a 1.5 second margin in N-4080-026 & 27 calculations above the TS limit, changing the Tech Spec to gain 2.0 seconds for the agastat is not an option. This Technical Specification limit translates into a 3.9 second acceleration requirement, assuming a 0.5 second delay in the load sequencer. Therefore, in order to permit a 2.5 second load sequencer delay for the CS pump breakers, it is necessary to impose a 1.9 second limit for CS pump acceleration.

Action requested:

1. Consider +/- 2.5 second agastat deviation times, 1.9 seconds CS pump acceleration time and 2.5 seconds CCW pump acceleration time as an assumed inputs to N-4080-026 and 027 calculations.

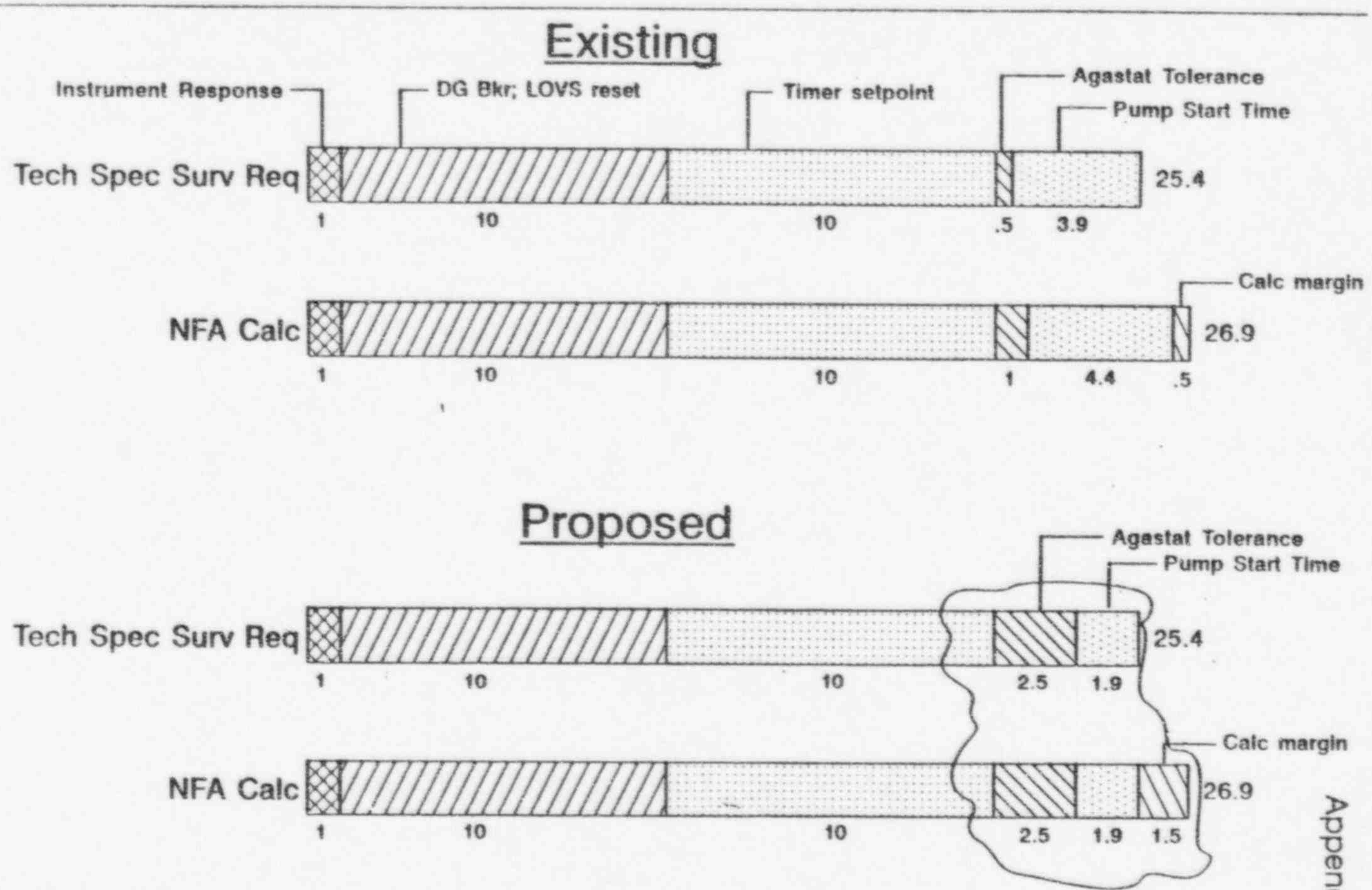
2. Identify any other NFA effected documents, and re-evaluate them by considering +/- 2.5 seconds instead of existing +/- 10% of design interval. -

The results of your evaluation along with evalauations and calculations performed by others for this purpose will be used as a justification and supporting evidence for Technical Specification change request.

Containment Spray Pump Response Time

Tech Spec Table 3.3-5

(TS Response Time Requirement is 25.4 seconds)



All times in seconds.
T=0 seconds defined as the time at which containment pressure = HI setpoint.
Agastat tolerance can be increased to ± 2.5 sec. Overall response time is unchanged.

Appendix C, Concluded

NES&L DEPARTMENT

CALCULATION SHEET

Project or DCP/MMP N/A Calc. No. N-4080-003

Subject Containment Spray (CS) & Emergency Cooling Unit (ECU) Actuation Times Sheet No. 40

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CCN CONVERSION: CCN NO. CCN - /

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	Paul Barbour	08/28/95	Allen Evinay	08/28/95					