Report No. 1889

ECCS PASSIVE HEAT SINK

DATA AND INFORMATION

Prepared by:

Gilbert Associates, Inc.
525 Lancaster Avenue
Reading, Pa. 19603

8003120 826

CONTENTS

ECCS PASSIVE HEAT SINK

DATA AND INFORMATION

1.0 INTRODUCTION

This report presents the summarized results of a detailed evaluation and calculation performed in response to the United States Nuclear Regulatory Commission (NRC) request for addition information dated August 12, 1975 relative to Crystal River Unit No. 3 Docket No. 50-302 ECCS parameters and comparison to referenced BAW-10103 Topical Report.

2.0 NUCLEAR REGULATORY COMMISSION ADDITIONAL INFORMATION REQUESTS AND ASSOCIATED RESPONSES AND ACKNOWLEDGEMENTS

2.1 Net Free Containment Volume - Justification should include the total gross internal containment volume and the internal structures and equipment and their volumes which are subtracted to obtain the net free containment volume. A discussion of the uncertainties should be provided.

Response:

Specific internal structures and equipment with their respective volumes, which were subtracted from the calculated internal containment volume of 2,337,910 ft^3 to obtain the net free containment volume, are tabulated below. The volume of major structures, equipment and associated piping and valves were calculated in detail. For miscellaneous small pipe, valves, brackets etc. a factor of 10% was added to the total major volume. As indicated by the tabulated results the calculated net free volume is less than the BAW 10103 value by 7.0%.

TABLE 2.1

NET FREE VOLUME - ft^3	ft^3
BARE PIPE	1,313
PAINTED PIPE	1,194
INSULATED PIPE	4,634
INSULATION	3,126
R. C. PIPE	4,154
INSTRUMENTATION	83
PIPE HANGERS	267
DUCTWORK	1,700
INTERNAL CONCRETE	199,719
CARBON STEEL	4,663
STAINLESS STEEL	163
ELECT. TRAYS ETC.	623
R. C. SYSTEM	39,721
MISC. EQUIP., PIPES, ETC. =	26,000
TOTAL	287,360 ft^3
CONTAINMENT GROSS VOLUME =	2,337,910 ft^3
	- 287,360
CONTAINMENT NET FREE VOLUME =	2,050,550 ft^3
BAW-10103 VALVE	2,205,000 ft^3

2.2 <u>Passive Heat Sinks</u> - Provide the actual passive heat sink structures for your plant. Discuss the method of determining the passive containment heat sinks. Identify each heat sink by category (i.e., cable tray, equipment supports, floor grating, crane wall, etc.) and provide surface area, thickness, materials of construction, thermal conductivity and volumetric heat capacity, by component category used in the containment transient analysis code.

Response:

The method of determining the passive containment heat sinks was by direct computation. (i.e. the actual dimensions of the equipment and structures were taken from scaled drawings and prints, this data was utilized to calculate the thickness and surface areas.) In the case where irregular shapes were encountered, conservative methods of estimating were used. As the portion of equipment and structures where estimating was required is, by percentage, very small the overall effect to the analysis is negligable. Appropriate Requirement Outlines were utilized in determining materials and paint specifications. The mil thickness for paint applied to steel and concrete is considered conservative at 6 mil and 10 mil respectively.

Painted steel is carbon pipe and equipment that is not insulated. Bare (unpainted steel) is stainless steel pipe, equipment and only the external surface sheet of reflective metal insulation. The surface of the additional inner layers of insulation including that of the pipe or equipment covered by the insulation are neglected.

Table No. 2.1 below identifies each heat sink by category and indicates the respective surface area, thickness, material of construction, thermal conductivity and volumetric heat capacity.

TABLE NO. 2.2

CATEGORY	SURFACE AREA ft^2	THICKNESS ft	MATERIAL	FSAR VALUES THERMAL CONDUCTIVITY Btu/h-ft-°F/ft	FSAR VALUES HEAT CAPACITY Btu/ft^2-°F
REACTOR BUILDING WALLS	63,304				
a. Liner Plate		.03125	Steel	26.0	58.80
b. Concrete		3.5	Concrete	0.45	22.62
c. Paint	-------	.0005	Plasite	0.20	40.42
REACTOR BUILDING DOME	18,138				
a. Liner Plate		.03125	Steel	26.0	58.80
b. Concrete		3.0	Concrete	0.45	22.62
c. Paint		.0005	Plasite	0.20	40.42
REACTOR BUILDING INTERNAL CONCRETE	105,941		Concrete	0.45	22.62
Paint	-------	.00083	Plasite	0.20	40.42
REACTOR BUILDING INTERNAL STEEL					
Framing, Equip. & Pipe Restraints, Supports, Polar Crane, Access Hatches, and Grating	149,335	.03122	Steel	26.0	58.80
Paint	-------	.0005	Plasite	0.20	40.42

TABLE NO. 2.2 (Cont'd)

CATEGORY	SURFACE AREA ft^2	THICKNESS ft	MATERIAL	FSAR VALUES THERMAL CONDUCTIVITY Btu/h-ft-°F/ft	HEAT CAPACITY Btu/ft^2-°F
Ventilating Duct - Work, Reinforcing, Hangers 20 gage (Inside & Outside)	111,040	.00299	Steel	26.0	58.80
Paint	-------	.0005	Plasite	0.20	40.42
Instruments, Mounting Brackets, Housings, Valves and Tubing	130	.0148	Steel	26.0	58.80
Paint	-------	.0005	Plasite	0.20	40.42
Hangers and Supporting Steel	10,000	.0262	Steel	26.0	58.80
Paint	-------	.0005	Plasite	0.20	40.42
Pipes & Valves & Equipment	12,000	.0233	Steel	26.0	58.80
Paint	-------	.0005	Steel	26.0	58.80
Cable Trays, Conduit, Boxes, Penetration Enclosures	45,820	.00625	Plasite	0.20	40.42
Paint	-------				

TABLE NO. 2.2 (Cont'd)

CATEGORY	SURFACE AREA ft^2	THICKNESS ft	MATERIAL	FSAR VALUES THERMAL CONDUCTIVITY Btu/h-ft-^oF/ft	FSAR VALUES HEAT CAPACITY Btu/ft^2-^oF
REACTOR BUILDING INTERNAL STAINLESS STEEL					
Framing, Fuel Transfer Canal Liner Plate, Sump Liner Plate	9,361	.01563	Stainless Steel	9.0	54.263
Instruments, Mounting Brackets, Housings, Valves, Tubing	1,475	.0417	Stainless Steel	9.0	54.263
Pipes, Valves & Equipment	11,000	.0676	Stainless Steel	9.0	54.263
Insulation	15,500	.00249	Stainless Steel	9.0	54.263
Cable Trays, Conduit, Boxes, Penetration Enclosures	8,723	.00625	Stainless Steel	9.0	54.263

TABLE NO. 2.2A

SUMMARY

A. The Reactor Building Walls including the concrete wall, steel liner, and paint:

Exposed area, ft^2	63,304
Paint thickness, ft	0.0005
Steel thickness, ft	0.03125
Concrete thickness, ft	3.5

B. The Reactor Building Dome including concrete, steel liner, and paint:

Exposed area, ft^2	18,138
Paint thickness, ft	0.0005
Steel thickness, ft	0.03125
Concrete thickness, ft	3.0

C. Painted internal steel:

Exposed area, ft^2	409,817
Paint thickness, ft	0.0005
Steel thickness, ft	(REF. TABLE NO. 2.2)

D. Unpainted internal stainless steel including outer layer of stainless steel insulation with an area of 15,500 ft^2 and a thickness of 0.00249 (Ref. Table 2.2).

Exposed area, ft^2	46,059
Thickness	(REF. TABLE NO. 2.2)

E. Internal Concrete:

Exposed area, ft^2	105,941
Paint thickness, ft	0.00083
Concrete thickness, ft	1.435 (FSAR)

2.3 Starting Time of Containment Cooling System(s) - Discuss the factors that show that the start time(s) assumed in the containment response analysis represent the earliest possible initiation of system(s) operation.

Response:

BUILDING SPRAY SYSTEM

1. Reactor building spray pump start will not occur until two conditions have been met:

   a) 30 psig pressure exists in containment

   b) Block 4 of the diesel loading sequence must have been loaded resulting from either 4 psig containment pressure or RC pressure < 500 psig or RC pressure < 1500 psig.

   Time required for a): If all instrumentation error was in the conservative direction, actuation would be initiated at 26.6 psig. (The pressure switches will be calibrated to 28.5 psig, +0, -0.5 to insure actuation by 30 psig). All FSAR figures were therefore checked for the shortest time required to reach 26.6 psig. This is found to be 3.6 seconds from FSAR Figure 14-72B.

   Time required for b): The controlling parameter is reactor building pressure. It will take at least 20 seconds for any size break documented in the FSAR to result in RC pressure dropping to 1500 psig, and even longer to reach 500 psig. However, a containment pressure of 4 psig will occur in less than a second and will therefore be the cause of E. S.

actuation and initiation of the timing sequence. Considering calibration set point (3.25 psig, +0, -0.15) and total potential instrument loop error (±0.66 psig), the earliest actuation would occur at 3.25 psig -0.15 - 0.66 = 2.44 psig. FSAR Figure 14-72B indicates the quickest achievement of this pressure: 0.3 seconds. This would result in block loading with BS pump actuation fifteen (15) seconds later. If an undervoltage condition occurs simultaneously, block loading will not start until the emergency diesels are operating. The diesels are required to start in 10 seconds or less, and field tests on this type of diesel have indicated starting times of 7.5 seconds.

Conclusion

Building spray pumps will not start until the E. S. block loading sequence is timed out, which will require a minimum total time of 15.3 seconds after the LOCA if normal AC power is available, or 22.8 seconds if the diesels are required as compared to BAW-10103 of 2.4 seconds.

2. Air Handling Recirculation and Cooling Units

The only requirement for AHF-1A, 1B, & 1C to be operating in the E. S. mode is that block 2 of the diesel loading sequence has been accomplished. When block 2 is loaded, all three fans will go on low speed operation. Initiation of block loading will be 0.3 seconds as in 1 (b) above, and an additional 5 second time delay occurs before block 2 is loaded. An undervoltage condition would have the same effect as described in 1 (b) above.

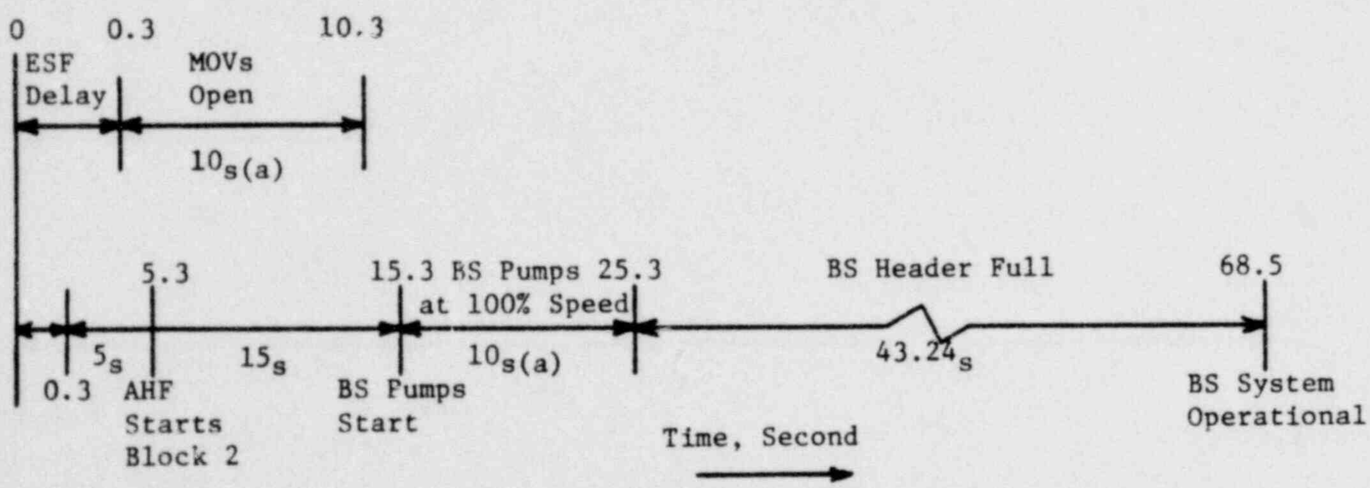
Conclusion

Air handling fans will initiate containment cooling in a minimum of 5.3 seconds if normal AC power is available, or 12.5 seconds if diesels are required as compared to BAW-10103 of no delay.

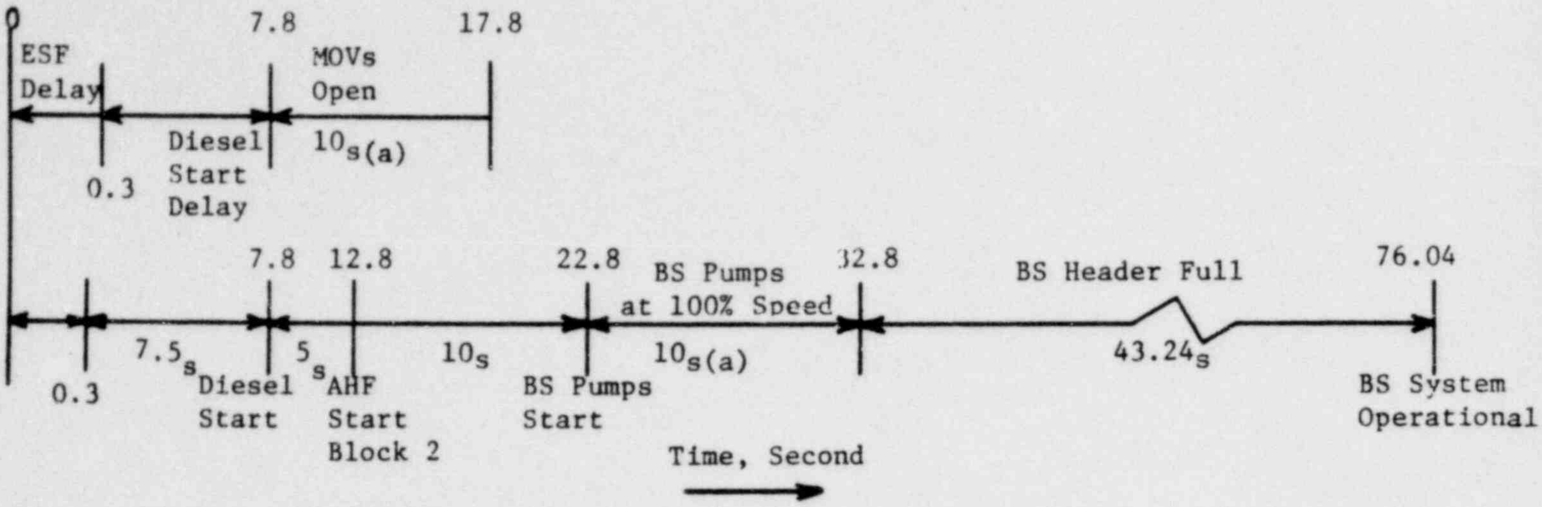
All times are based on the worst case LOCA documented in the FSAR.

A breakdown of the starting time, which yields the quickest activation time for the spray systems is shown below:

Normal AC Power Available



Diesels Required



(a) Assumed Value (Conservative)

Note: The above illustrated times are in excess of those assumed in the containment response analysis (Ref. BAW-10103).

2.4 Containment Initial Conditions - Compare the initial values of temperature, pressure and relative humidity in the containment with the range of values that will be permitted during plant operation.

Response:

INITIAL VALUES

TEMPERATURE	PRESSURE	RELATIVE HUMIDITY
110° F	13.7 psia	100%

PERMISSABLE OPERATING VALUES

TEMPERATURE	PRESSURE	RELATIVE HUMIDITY
90°F - 130°F(b)	12.7 - 17.7 psia	0% - 100%

(b) Anticipated Value (Conservative)

2.5 Containment Spray Water Temperature - Show that the value of containment spray water temperature used in the containment response analysis is the lower bound temperature consistent with the plant operating conditions and that the spray flow rate used is suitably conservative.

Response:

The Borated Water Storage Tank, Sodium Thiosulfate Storage Tank and Sodium Hydroxide Storage Tank are continually and redundantly heated by submersive type heaters or tank heat tracing. The containment spray water temperature used in BAW-10103 report is 40°F. The containment spray water temperature relative to Crystal River Unit No. 3 is as follows:

Borated Water	Sodium Thiosulfate	Sodium Hydroxide
70° F	50° F	75° F

This results in a conservative final containment spray temperature of approximately 69° F.

The spray flow rate used in BAW-10103 is 1,800 gpm which is approaching pump runout conditions. The spray system flow rate for Crystal River Unit No. 3 is designed at 1,500 gpm which is suitably conservative.

2.6 Fan-Cooler Heat Removal Rate - Compare the maximum fan-cooler heat removal rate for Crystal River, Unit 3 with that assumed in BAW-10103. Show that minimum operational values of service water temperature have been used.

Response:

The total fan cooler heat removal rate (HR) as presented in BAW-10103 is a function of reactor building atmosphere temperature. i.e.

$$HR(BTU/S) = 3.0(0.9T^2 - 76.9T + 1670)$$

Imputting CR-3 Reactor Building design temperature of 281°F illustrates that BAW-10103 assumed heat removal (HR) rate is greater than CR-3 plant actual.

Example: BAW-10103 (HR)

$$HR(BTU/S) = 3.0[0.9(281)^2 - 76.9(281) + 1670]$$

$$HR(BTU/S) = 153{,}378 \text{ TOTAL}$$

CRYSTAL RIVER UNIT NO. 3 (HR)

$$HR(BTU/M) = 80 \times 10^6/\text{UNIT} = 2.4 \times 10^8 \text{ TOTAL}$$

$$HR(BTU/S) = 66{,}666 \text{ TOTAL}$$

Based on 105° F cooling water.

This heat removal (HR) rate modified to 80° F cooling water equals approximately

$$HR(BTU/S) = 79{,}000 \text{ TOTAL}$$

The service water temperature used in BAW-10103 report is 40°F. Due to the global location of Crystal River Unit No. 3 the fan cooler design is based on 80°F, therefore, the input of 40°F utilized in BAW-10103 is considered very conservative.

2.7 Conclusion:

The ECCS parameters discussed in this report, with the exception of equipment and structure surface area, are more conservative than those used in the generic evaluation of BAW-10103. Note that although the energy absorption capacity is relatively low, the surface area as calculated in this report included both sides of small gage steel such as cable trays, tray hanger, conduit hanger, etc. and thin plate stainless such as fuel transfer canal liner plate, sump liner plate, stainless steel insulation, etc. This inside, outside and thin plate surface area calculation method amounts to approximately 87,000 ft^2 of painted steel and 28,000 ft^2 of stainless steel. Consideration of this method of computation results in (409,817 ft^2 - 87,000 ft^2) a total of 322,817 ft^2 of painted steel and (46,059 ft^2 - 28,000 ft^2) a total of 18,059 ft^2 of stainless steel. Hence, although the actual surface area exceeds BAW-10103 values the overall thickness are significantly less thus providing a certain amount of conservatism within this parameter.

3.0 REFERENCES

1. United States Nuclear Regulatory Commission's Request for additional information (ECCS), dated August 12, 1975

2. Babcock and Wilcox Topical Report BAW-10103 dated September 1975

3. FINAL SAFETY ANALYSIS REPORT, Crystal River Unit No. 3 Docket No. 50-302