BRANCH TECHNICAL POSITION CSB 6-1

MINIMUM CONTAINMENT PRESSURE MODEL FOR PWR ECCS PERFORMANCE EVALUATION

A. BACKGROUND

Paragraph I.D.2 of Appendix K to 10 CFR Part 50 (Ref. 1) requires that the containment pressure used to evaluate the performance capability of a pressurized water reactor (PWR) emergency core cooling system (ECCS) not exceed a pressure calculated conservatively for that purpose. It further requires that the calculation include the effects of operation of all installed pressure-reducing systems and processes. Therefore, the following branch technical position has been developed to provide guidance in the performance of minimum containment pressure analysis. The approach described below applies only to the ECCS-related containment pressure evaluation and not to the containment functional capability evaluation for postulated design basis accidents.

B. BRANCH TECHNICAL POSITION

1. Input Information for Model

a. Initial Containment Internal Conditions

The minimum containment gas temperature, minimum containment pressure, and maximum humidity that may be encountered under limiting normal operating conditions should be used.

b. Initial Outside Containment Ambient Conditions

A reasonably low ambient temperature external to the containment should be used.

c. Containment Volume

The maximum net free containment volume should be used. This maximum free volume should be determined from the gross containment volume minus the volumes of internal structures such as walls and floors, structural steel, major equipment, and piping. The individual volume calculations should reflect the uncertainty in the component volumes.

2. Active Heat Sinks

a. Spray and Fan Cooling Systems

The operation of all engineered safety feature containment heat removal systems operating at maximum heat removal capacity; i.e., with all containment spray trains operating at maximum flow conditions and all emergency fan cooler units operating, should be assumed. In addition, the minimum temperature of the stored water for the spray cooling system and the cooling water supplied to the fan coolers, based on technical specification limits, should be assumed.

At the operating license stage, applicants should provide a detailed list of passive h sinks, with appropriate dimensions ar roperties.

b. Heat Transfer Coefficients

The following conservative condensing heat transfer coefficients for heat transfer to the exposed passive heat sinks during the blowdown and post-blowdown phases of the loss-of-coolant accident should be used (See Figure 2):

(1) During the blowdown phase, assume a linear increase in the condensing heat transfer coefficient from $h_{initial}$ = 8 Btu/hr-ft^2-°F, at t = 0, to a peak value four times greater than the maximum calculated condensing heat transfer coefficient at the end of blowdown, using the Tagami correlation (Ref. 2),

$$h_{max} = 72.5 \left[\frac{Q}{Vt_p}\right]^{0.62}$$

where h_{max} = maximum heat transfer coefficient, Btu/hr-ft^2-°F

Q = primary coolant energy, Btu

V = net free containment volume, ft^3

t_p = time interval to end of blowdown, sec.

(2) During the long-term post-blowdown phase of the accident, characterized by low turbulence in the containment atmosphere, assume condensing heat transfer coefficients 1.2 times greater than those predicted by the Uchida data (Ref. 3) and given in Table 3.

(3) During the transition phase of the accident, between the end of blowdown and the long-term post-blowdown phase, a reasonably conservative exponential transition in the condensing heat transfer coefficient should be assumed (see Figure 2).

The calculated condensing heat transfer coefficients based on the above method should be applied to all exposed passive heat sinks, both metal and concrete, and for both painted and unpainted surfaces.

Heat transfer between adjoining materials in passive heat sinks should be based on the assumption of no resistance to heat flow at the material interfaces. An example of this is the containment liner to concrete interface.

C. REFERENCES

1. 10 CFR §50.46, "Acceptance Criteria for Emergency Core Cooling Systems for Light Water Nuclear Power Reactors," and 10 CFR Part 50, Appendix K, "ECCS Evaluation Models."

2. T. Tagami, "Interim Report on Safety Assessments and Facilities Establishment Project in Japan for Period Ending June 1965 (No. 1)," prepared for the National Reactor Testing Station, February 28, 1966 (unpublished work).

POOR ORIGINAL

3. H. Uchida, A. Oy , and Y. Toga, "Evaluation of Post-Inc nt Cooling Systems of Light-Water Power Reactors," Proc. Third International Conference on the Peaceful Uses of Atomic Energy, Volume 13, Session 3.9, United Nations, Geneva (1964).

POOR ORIGINAL

TABLE 1

IDENTIFICATION OF CONTAINMENT HEAT SINKS

1. Containment Building (e.g., liner plate and external concrete walls, floor, and sump, and liner anchors).

2. Containment Internal Structures (e.g., internal separation walls and floors, refueling pool and fuel transfer pit walls, and shielding walls).

3. Supports (e.g., reactor vessel, steam generator, pumps, tanks, major components, pipe supports, and storage racks).

4. Uninsulated Systems and Components (e.g., cold water systems, heating, ventilation, and air conditioning systems, pumps, motors, fan coolers, recombiners, and tanks).

5. Miscellaneous Equipment (e.g., ladders, gratings, electrical cable trays, and cranes).

TABLE 2

HEAT SINK THERMOPHYSICAL PROPERTIES

Material	Density lb/ft^3	Specific Heat Btu/lb-°F	Thermal Conductivity Btu/hr-ft-°F
Concrete	145	0.156	0.92
Steel	490	0.12	27.0

TABLE 3

UCHIDA HEAT TRANSFER COEFFICIENTS

Mass Ratio (lb air/lb steam)	Heat Transfer Coefficient (Btu/hr-ft^2-°F)	Mass Ratio (lb air/lb steam)	Heat Transfer Coefficient (Btu/hr-ft^2-°F)
50	2	3	29
20	8	2.3	37
18	9	1.8	46
14	10	1.3	63
10	14	0.8	98
7	17	0.5	140
5	21	0.1	280
4	24		

Figure 1
Area of Steel Heat Sinks Inside Containment

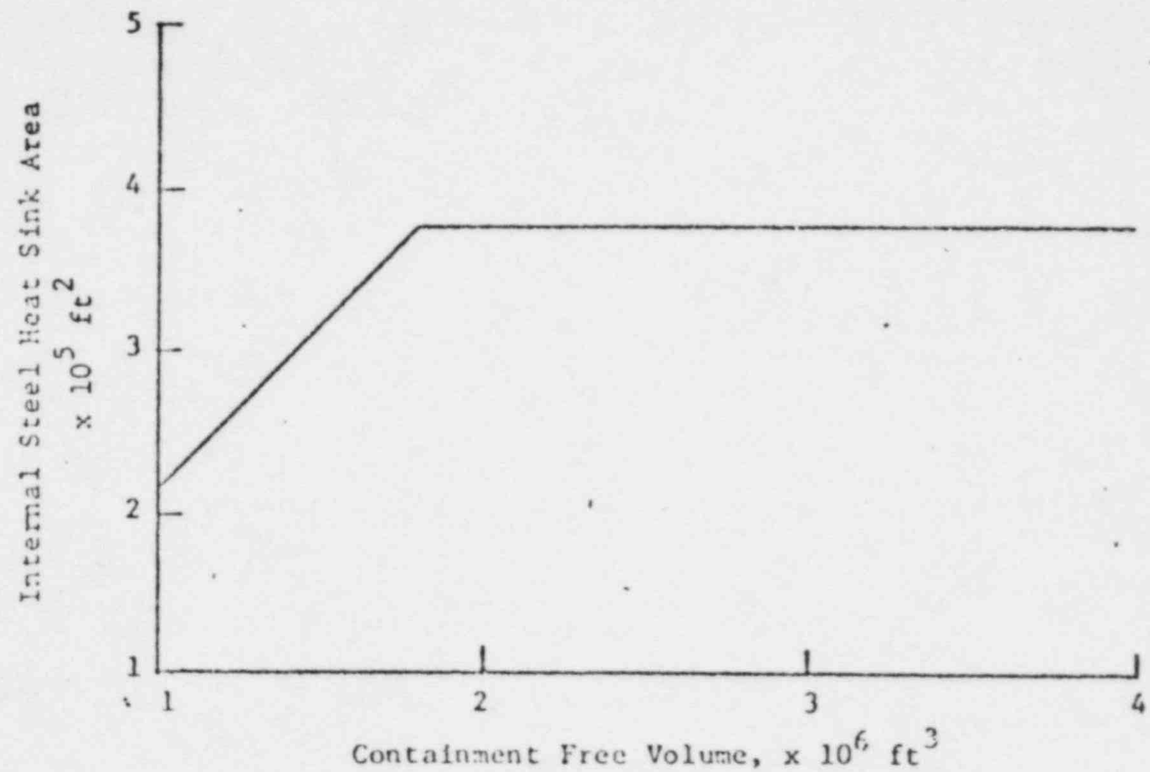

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Figure 2

Condensing Heat Transfer Coefficients for Static Heat Sinks