C-E Power Systems
Combustion Engineering, Inc.
1000 Prospect Hill Road
Windsor, Connecticut 06095

Tel. 203/688-1911
Telex 99297

POWER
SYSTEMS

Docket No.: STN-50-470F

July 1, 1982
LD-82-063

Mr. Darrell G. Eisenhut, Director
Division of Licensing
U. S. Nuclear Regulatory Commission
Washington, D. C. 20555

Subject: Description of Thermal Equivalence and Unusual Time Margin Analyses

Reference: R. L. Tedesco Letter to A. E. Scherer, dated May 5, 1982

Dear Mr. Eisenhut:

The referenced letter requested that C-E provide descriptions of the methods that will be used in our thermal equivalence and time margin analyses. Descriptions of these methods are enclosed. This completes our action on open item number 1 to the CESSAR-FSAR.

If you have any questions, please contact either myself or Mr. G. A. Davis of my staff at (203)688-1911, Extension 2803.

Very truly yours,

COMBUSTION ENGINEERING, INC.

A. E. Scherer
Director
Nuclear Licensing

AES:ctk

Enclosure

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THERMAL EQUIVALENCE

C-E's preferred method of establishing an environmental test profile for testing Class 1E Equipment for a design basis break inside containment is to adhere to NUREG 0588 Rev. 1, Category I, Section 1.1 and 1.2 and CENPD-255 Rev. 3 in developing a test profile which will envelope all temperature and pressure transients for the required spectrum of design basis breaks.

A second method of establishing a test profile is based on a thermal equivalence analysis. This method of establishing a profile will be used in lieu of the preferred method whenever the preferred method represents severe over-testing of a particular component.

The essence of the thermal equivalence method is to determine the most severe break size dependent containment profile for each critical surface of a component and to conservatively determine the surface temperatures resulting from the containment profile. In short, the limited time duration of the profile thus determined is credited in terms of the temperature rise of the component surfaces. Each surface has its own characteristic thermal lag time, which acts to delay the change of surface temperatures with respect to the changing containment temperature.

When multiple surfaces are evaluated the most limiting surface with respect to peak temperature and temperature change will be used to establish test requirements.

Thermal Equivalence Methodology:

1) Calculate the conservative time dependent mass/energy release rates to the containment vs. break size. This calculation is done using the SGNIII computer code which is the NRC approved code for containment sizing mass/energy calculations during a Main Steam Line Break. CESSAR FSAR Chapter 6 assumptions and input data are used to maximize the steaming rates. Generic CESSAR data will be used; this data conservatively envelopes all plant specific System 80 data.

2) Calculate the conservative time dependent containment pressure/temperature response to each set of mass/energy data (See Section (1) above). This calculation is done using the CONTRANS computer code, which is the NRC approved code for containment pressure/temperature response. CESSAR FSAR Chapter 6 assumptions and data will be used along with plant specific containment data where required.

3) For a given component of interest, the temperature responses of the component vs. time will be calculated at all pertinent locations and surfaces for each break size. The conservatism and rationale of Section 1.2 NUREG-0588 Rev. 1 will be used to conservatively calculate these temperature responses.

   Specifically, 3 modes of heat transfer from the containment vapor space to the component surface are addressed. These modes are:

Mode	Type of Heat Transfer	Heat Transfer Coefficient	Driving Temperature	Heat Flux, q/A
1	Convection	Reynold's Number Correlation using NUREG-0588 velocity (a)	Vapor Space (b) (T_{vs})	$h\ (T_{vs}-T)_{surf}$
2	Conden-sation (Stagnant)	4x Uchida	T_{sat}(c)	4x Uchida ($T_{sat}-T_{surf}$)
3	Conden-sation (Blowdown Related)	4x Tagami	T_{sat}(c)	4x Tagami ($T_{sat}-T_{surf}$)

NOTES:

(a) Free convection correlation is used if the velocity related correlation is lower than the free convection value; h = max. of ($h_{\text{free convection}}$ or $h_{\text{velocity related}}$)

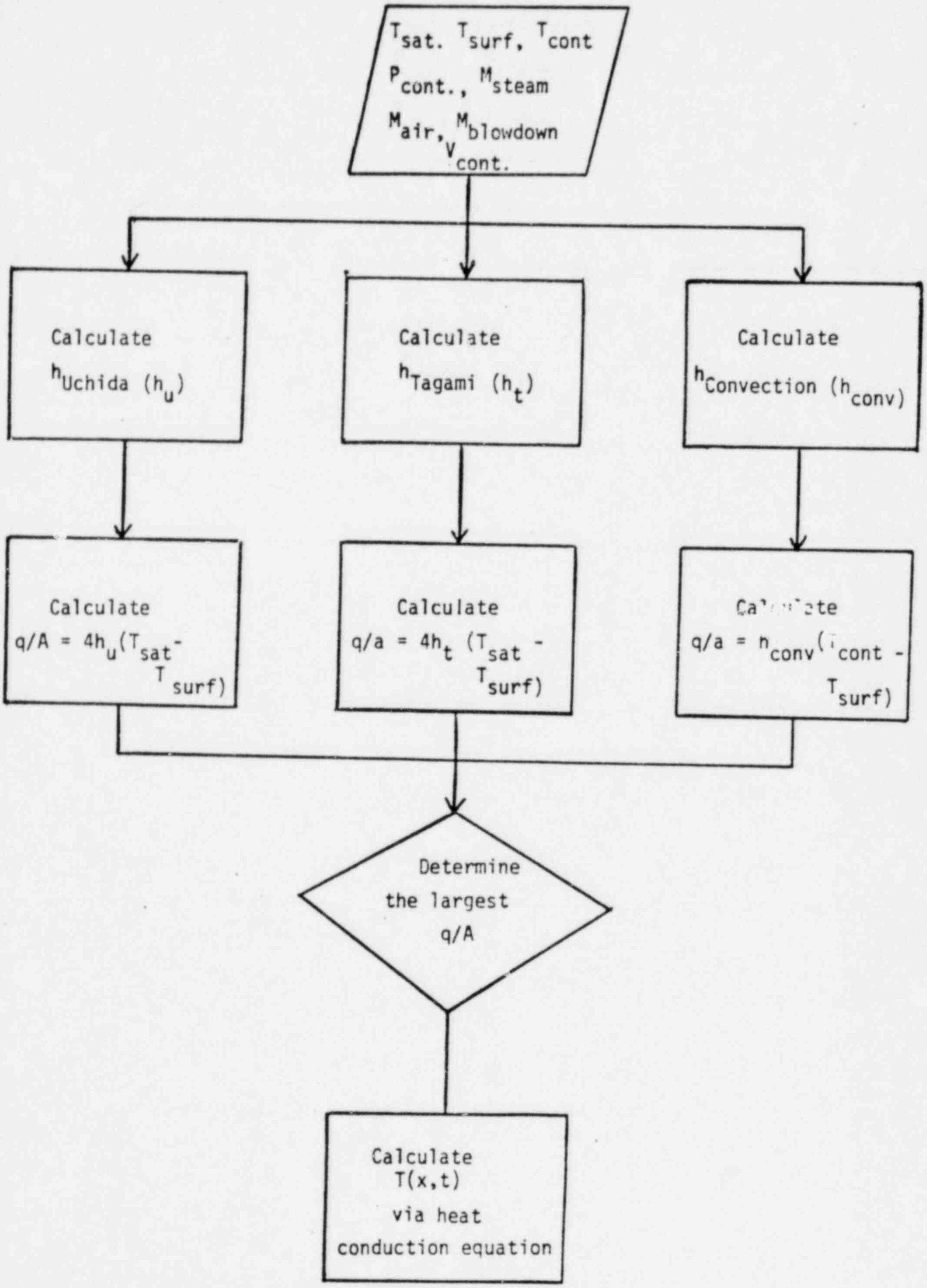
(b) For a conservative MSLB situation, this is a superheated value prior to the onset of containment spray flow.

(c) Saturation temperature corresponding to the steam partial pressure.

The instantaneous heat flux used to heat the component is chosen as the largest of the 3 flux values described above. A flow chart is provided on Page 3 to show the methods of heat transfer mode selection.

4) The data contained in Section three above will be examined to determine the highest temperature of the component at each location for each break size for the entire accident time sequence.

5) The set of peak temperatures for each location is then used to determine the peak testing temperature for the entire component. The ramp rate to reach this temperature is conservatively obtained from the largest size MSLB containment response.



HEAT TRANSFER MODE SELECTION
FLOW CHART

TIME MARGIN

C-E's basic method of establishing an adequate time margin for equipment that is required to be operational following the design basis event is to increase the minimum operability time by 10%.

Normally, a one hour test margin will be included in the minimum test time requirement for the following two cases:

1. Where equipment needs to be operational to perform its safety function for a period of time less than one hour (i.e., within seconds or minutes), and, once its function is complete, subsequent failures are shown not to be detrimental to plant safety.

2. Where equipment is not required to function during a design basis event but must not fail within a short period of time into the event, and subsequent failures are also shown not to be detrimental to plant safety.

However, time margins of less than one hour are included in the minimum required test time typically for equipment whose operability time is seconds or minutes and when severe overtesting may result by applying the one hour time margin. The minimum required test time is the sum of the maximum operability time and thetime margin. The maximum operability time is comprised of the time that the specific trip function is required for the full spectrum of break sizes which establish the particular trip function need and includes time to account for calculational uncertainties. The maximum operability time is determined as follows.

Maximum Operability times are obtained as a function of break area by evaluating each of the design basis events (e.g., Steam Line Break and Feedwater Line Break) for a full spectrum of break areas. To assure that these times are bounding, the initial conditions and trip setpoints which are used in these evaluations are chosen to maximize the time the equipment woud be needed. For example, minimum initial containment pressure is coupled with the upper limit on the High Containment Pressure trip setpoint and maximum initial steam generator pressure is coupled with the lower limit on the Low Steam Generator Pressure trip setpoint. Protection System trips whose setpoints might not be reached for certain plant operating conditions, will not be credited with limiting the bounding time to trip. Thus, for each design basis event, this process yields a bounding time to trip as a function of break area for use in the qualification of Protection System trips. Margins are incorporated by adding a percentage increment to the bounding time to trip versus break area using the method identified in Section 6.3.1.5 of IEEE Standard 323-1974.

The curve of Figure 5-1 is an example of the bounding time to trip as a function of break area. This curve shows the maximum time to occurrence of the High Containment Pressure trip for break areas below 3 ft.^{2} and the maximum time occurrence of the Low Steam Generator Pressure trip for break areas above 3 ft.^{2}.

Certain Protection System trips are not required either for the full spectrum of break areas or for time intervals of greater than several minutes. For example, the Core Protection Calculator-Low DNBR trip, if required to provide protection, will encounter a trip condition within the first few minutes (maximum time for the Plant to reach a new steady state in the event of a small break). Figures 15.1.32-2 through 5 from the CESSAR FSAR illustrate the early occurrence of a new steady state in an increased steam flow transient, similar to a small steam line break. Core and primary system parameters stabilize at about 50 seconds. A maximum stabilization time of 100 seconds has been calculated. Therefore, protection against DNB provided by the Core Protection Calculator-Low DNBR trip is required for a maximum time into the transient of 2 minutes as indicated in Figure 5-2. Consequently, the Core Protection Calculator-Low DNBR trip will be qualified for a time interval which bounds the maximum time to trip, and is more conservative than that obtained using IEEE 323-1974 (e.g., 10 minute qualification time to cover 2 minute requirement).

Minimum Time Margin:

The minimum time margin is determined by multiplying the maximum operability time by a time margin factor. This factor is determined by considering the margins applied to all other test parameters, along with equipment manufacturing tolerances and test sample variations. The magnitude of the factor is modified by the amount of detailed empirical information available associated with manufacturing tolerances, test sample variation and excess margin available from other parameters. For example, as described in the above section a 2 minute operability time was established for the CPC Low DNBR trip function. The minimum required time margin is then established by multiplying 2 minutes by 400% which results in a 8 minute minimum time margin. The actual equipment was then tested for 8 minutes in excess of the maximum operability time (2 minutes). In this case, an extremely conservative time margin factor is used in lieu of equipment specific calculations. Figure 5-3 demonstrates the amount of combined temperature/time margin applied for the Low DNBR trip function equipment qualification.

Test Profile:

Figure 5.3(A), Generic Containment Response Envelope for Unusual Time Margin, shows the actual time/temperature profile which would be required during the equipment test. It is comprised of a generic containment response envelope with 15^{O}F temperature margin added. Figure 5.3 (B), Environmental Containment Response Profile, shows the bounded actual containment response for the spectrum of break sizes for which the CPC trip functions are required under the assumption that the high containment pressure trip is not credited. Figure 5.3(C) shows an overlay of the required test profile (Profile 1) and the bounded actual containment response (Profile 2). Profile 2A shows the bounded actual containment response at time 2 minutes extended to 10 minutes. The area enclosed by Profile 2A represents the 400% time margin factor. The difference between Profiles 1 and 2 (2A) represents the test envelope margin which demonstrates the difference between the total heat applied to the equipment by the generic test profile and the equipment specific DBE requirements under the assumption that high containment pressure trip is not credited. Area A represents the actual equipment service conditions for the largest break which requires a CPC trip when high containment pressure is not credited. It defines the maximum plausible temperature change in the environment for the maximum calculated time to trip. The area under Profile 1 exclusive of region A represents margin and can be used to determine the amount of heat the equipment has been subjected to in excess of that it would experience during its time to trip (approximately 3300%). The area bounded by Profile 3 indicates the maximum temperature this equipment is expected to experience during its operability time considering the spectrum of small break sizes and crediting the proper functioning of all other reactor protection system trip functions. In this case a maximum temperature of 250^{O}F is defined by the high containment pressure trip function. This fact can also be used to assure test requirements bound actual equipment service requirements. After comparing the test results to the minimum test requirement it can be demonstrated by monitoring the equipment performance under test conditions that the equipment is qualified.

Evaluating Total Test Margin When Time Margin Requirement Is Not Bounded:

Where the demonstrated time margin is less than the Time Margins as explained in Reference 3 Par. 6.3.1.5 and Reference 4, Section 3, then one or a combination of methods as explained below will be utilized to determine whether a high probability for equipment survival exists:

1. A quantitative test profile margin comparison may demonstrate equipment qualification by addressing an excessive margin requirement. (i.e., temperature or pressure etc.) as compared to an inadequate time margin requirement.

For example:

Requiring a test at an elevated temperature reflecting appropriate margin may be equivalent in terms of stress to testing at a lower temperature for a longer period. Engineering judgement and the margin requirements defined in References 3 and 4 are utilized to evaluate the adequacy of margin contained in the test profile.

2. A methodology has been developed to explicitly evaluate the effects of manufacturing/production tolerances, test conditions and sample sizes on equipment operability. This approach has been demonstrated for relatively simple circuits when empirical data is available (Reference 2).

3. Failure modes and effects analyses can be used to evaluate the effect on plant safety of a component failure. Results which show that the failure of the component will not prevent the safety function from occurring, will <u>not</u> misinform the plant operator or will <u>not</u> prevent other equipment from performing its safety function are considered sufficient to show adequate qualification exists.

The above approaches are examples of those engineering techniques which can be employed to evaluate whether qualification testing results are adequate.

THERMAL EQUIVALENCE DOCUMENTATION

In the event it is necessary to use time margin evaluation techniques, the following information, as a minimum, will be documented.

1. Application of the thermal equivalence approach will be justified for each piece of equipment, including any judgements regarding the survivability limits of the equipment.

2. The specific heat transfer modeling of the equipment will be described and the selection of the critical surface or surfaces will be justified as limiting with respect to both time and location. The test results will be used to demonstrate the conservatism of the heat transfer modeling.

3. Multiple temperature measurements of the critical surface (s) from testing will envelope the calculated surface temperature transient (s), including the initial ramp. "Soaking" will not be used.

4. The margin between the minimum measured surface temperature and the calculated surface temperature when combined with the other test margins will account for the uncertainties associated with design, production tolerances, test techniques, and the number of units tested, or a temperature margin of $15^{O}F$ degrees by reference to the guideline of IEEE-323-1974.

5. Application of the thermal equivalence approach will be restricted to the limiting super-heated steam harsh environment, based on a spectrum of break sizes.

TIME MARGINS LESS THAN ONE HOUR DOCUMENTATION

In the event it is necessary to use time margin evaluation techniques, the following information, as a minimum, will be doccumented.

1. Application of time margins less than one hour will be justified for each piece of equipment, including any judgements regarding the survivability limits of the equipment.

2. The maximum operability time will be justified with consideration for a spectrum of breaks and the potential need for the equipment later in an event or during recovery operations.

3. It will be demonstrated that failure of the equipment after the maximum operability time will neither mislead the operator to take an improper action nor further degrade the event by causing a failure in systems necessary for mitigation of the event.

4. The margin applied to the minimum operability time when combined with the other test margins will account for the uncertainties associated with the design, production tolerances, testing techniques, and the number of units tested.

References:

1. NRC Letter Docket No. STN-50-470 Application of Thermal Equivalence and Time Margins less than one hour for Environmental Qualification, Mr. Robert L. Tedesco to Mr. A. E. Scherer, dated May 5, 1982.

2. LD-82-025 Transmittal Letter and Attachment of the Qualification Test Report for the Electrical Assembly to Mr. Darrell G. Eisenhut, from Mr. A. E. Scherer, dated March 3, 1982.

3. IEEE Std. 323-1974, "IEEE Standard for Qualifying Class 1E Equipment for Nuclear Power Generating Stations".

4. NUREG-0588 Rev. 1 Interim Staff Position on Environmental Qualification of Safety Related Electrical Equipment.

Figure 5-1

MAXIMUM TIME TO TRIP vs STEAM LINE BREAK AREA FOR INDICATED TRIPS

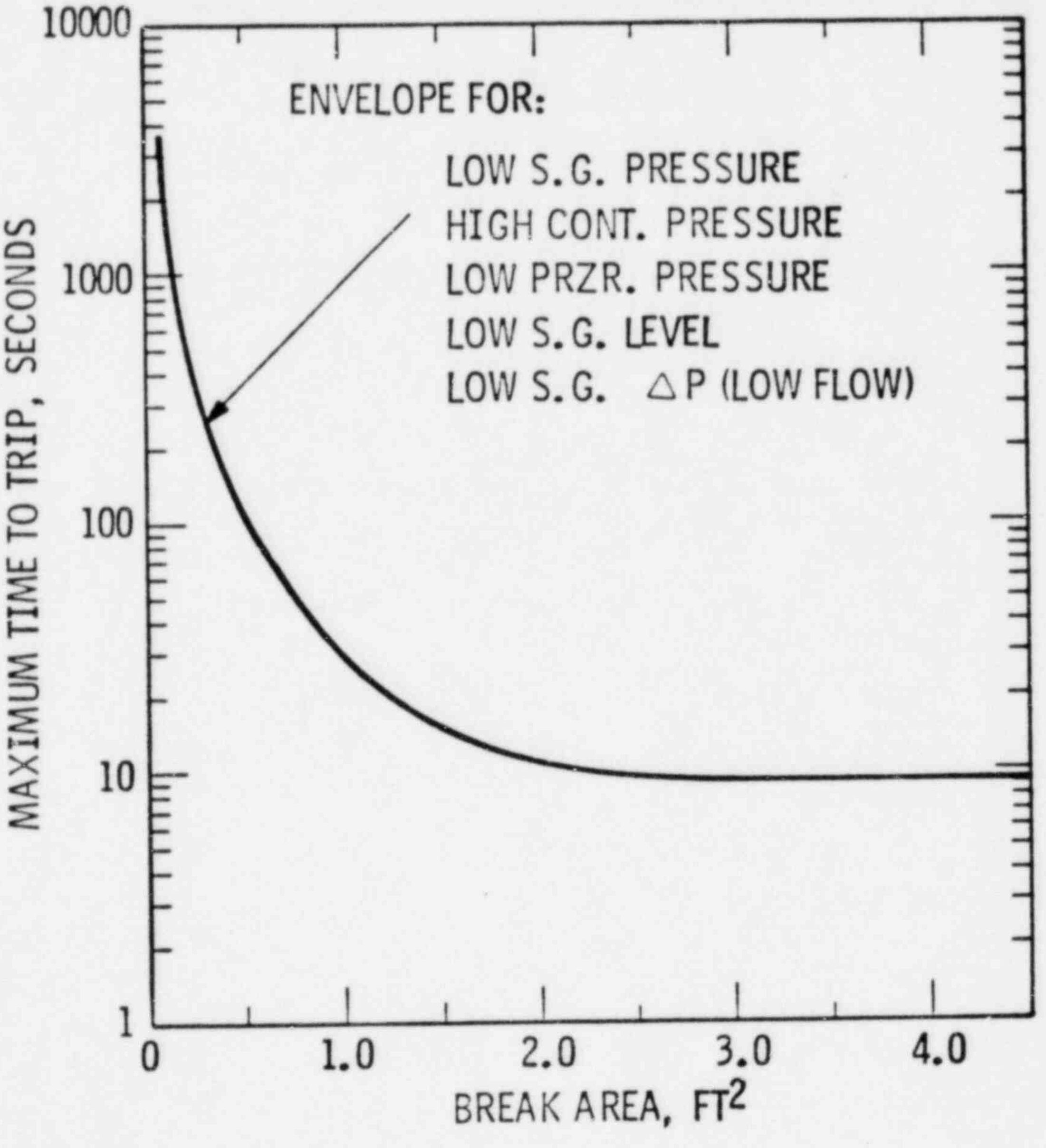


Figure 5-2
MAXIMUM TIME TO TRIP vs STEAM LINE BREAK AREA FOR CPC LOW DNBR TRIP

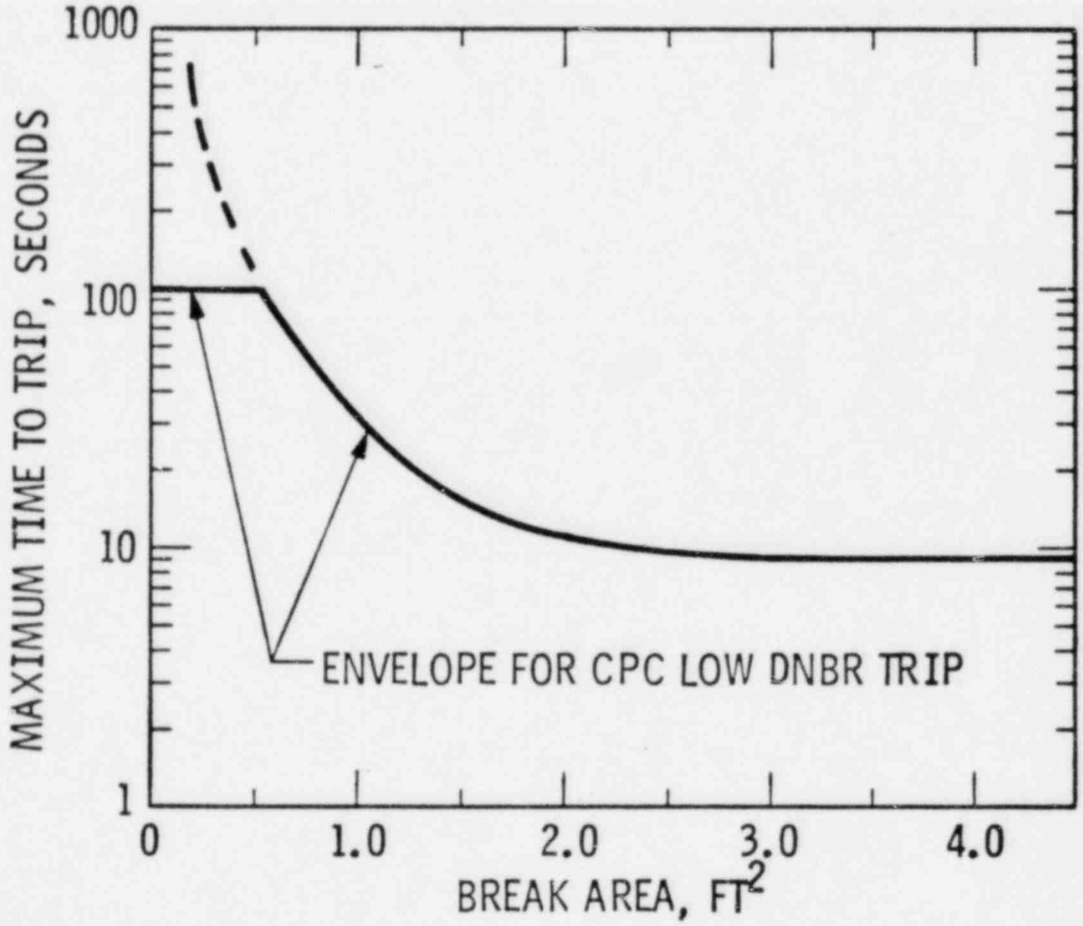


FIGURE 5.3 (A)
GENERIC CONTAINMENT
RESPONSE ENVELOPE
FOR
UNUSUAL TIME MARGIN

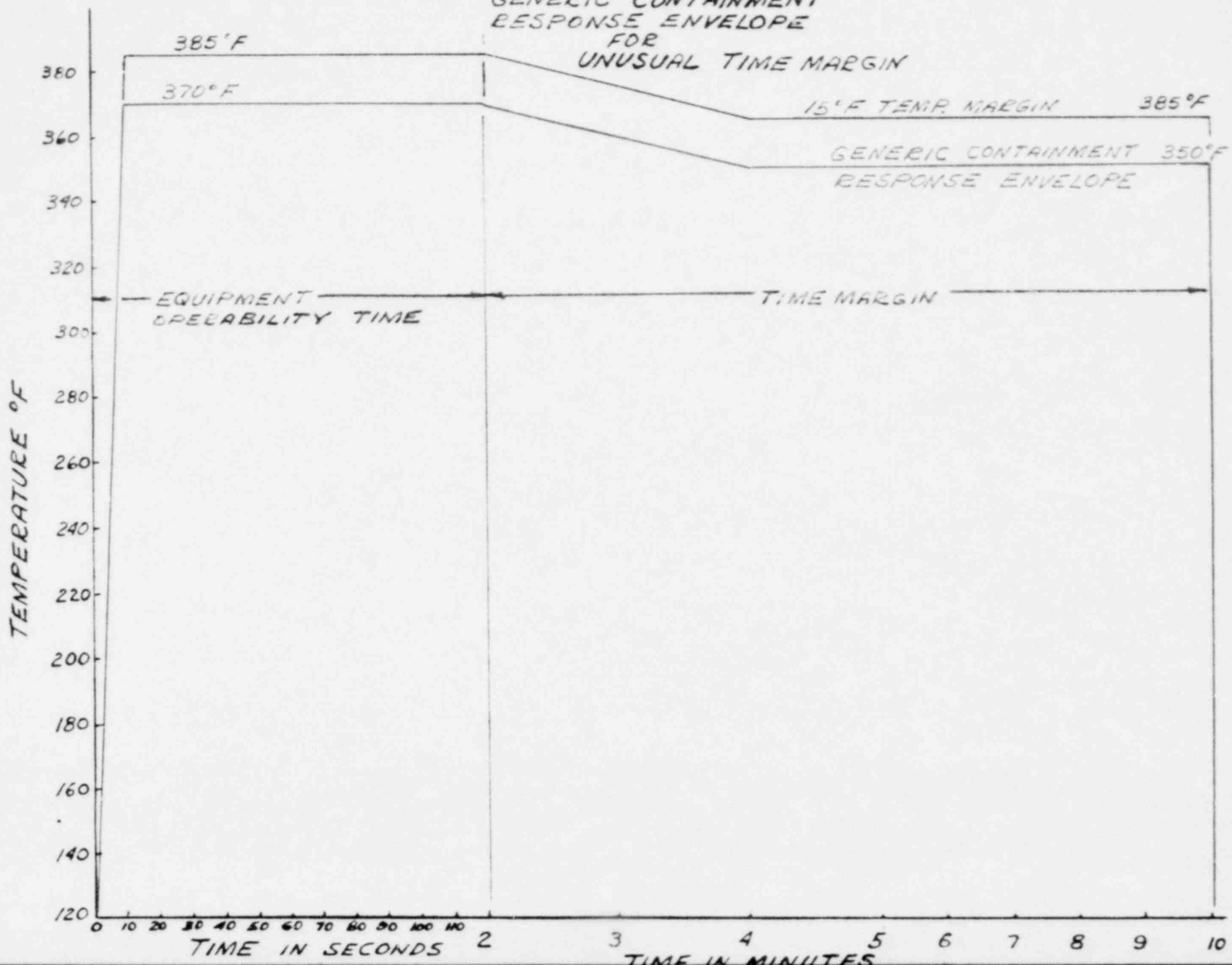


FIGURE 5.3 (B)
ENVIRONMENTAL CONTAINMENT
RESPONSE PROFILE

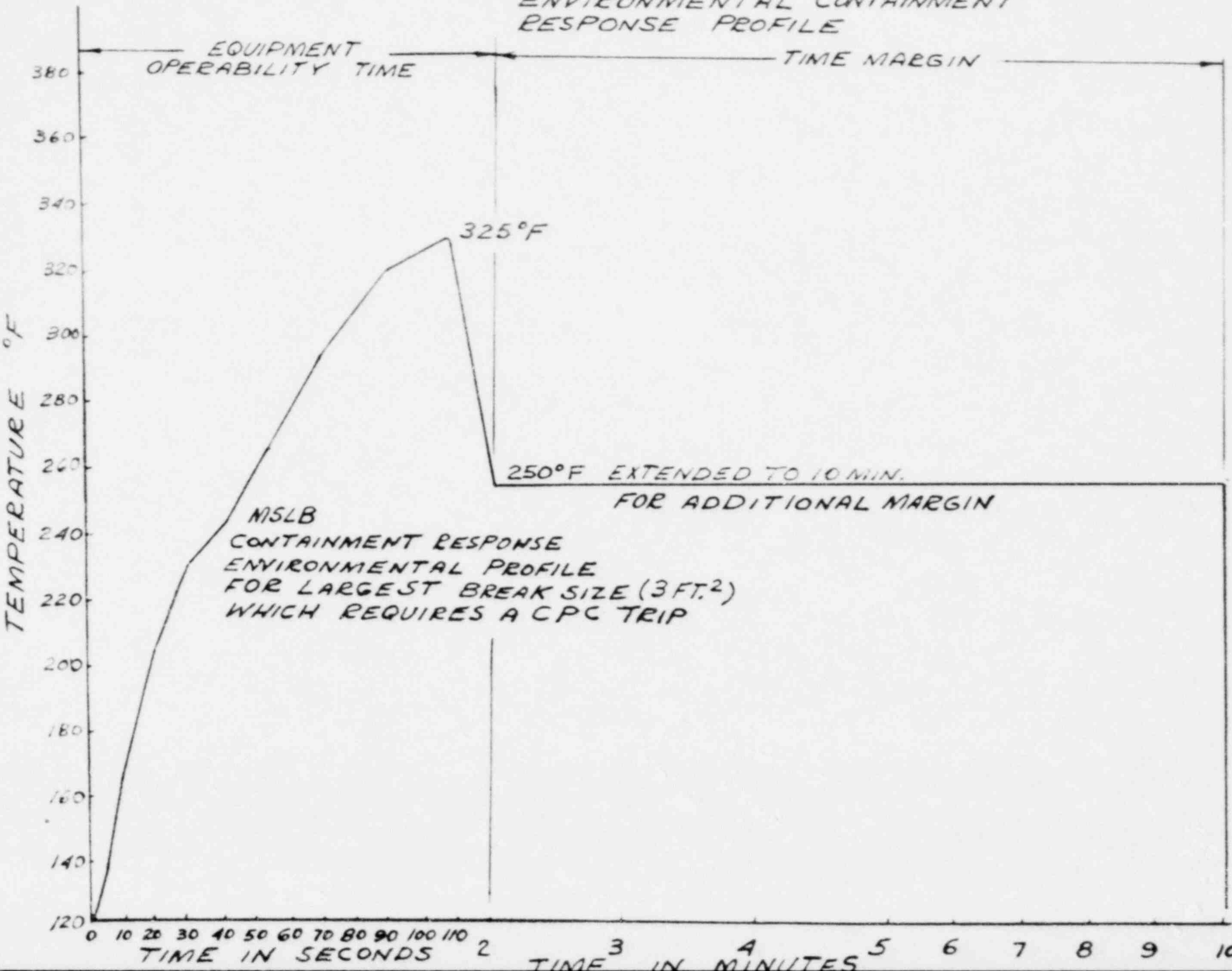


FIGURE 5.3 (C)
TEST MARGIN (TIME & TEMPERATURE)