APPENDIX A

MODIFIED CONTAINMENT SPRAY SYSTEM

In order to keep containment atmospheric temperatures below 235°F following a steam line break (SLB), immediate containment spray must be available. The spray must cool both inside and outside the steam drum cavity while at the same time maintaining adequate core spray. In addition, the containment spray must produce sufficient iodine washout 15 minutes following a LOCA or SLB.

In the modified containment spray system (shown schematically on Figure 1), motor-operated valve MO-7064 opens automatically on a containment pressure of ≤ 2.2 psig following a reactor coolant line break. Spray flow is provided to both inside and outside the steam drum cavity. The spray nozzles are sized such that sufficient core spray flow is still maintained. After 15 minutes, valve MO-7068 is manually opened which provides sufficient spray for iodine washout. Also, in the event that MO-7064 should fail, MO-7068 can be used as a manual backup.

The above modification consists of four changes to the existing containment spray system:

1. The 15-minute time delay on MO-7064 is removed. Thus, containment spray is promptly initiated at a containment pressure of ≤ 2.2 psig.

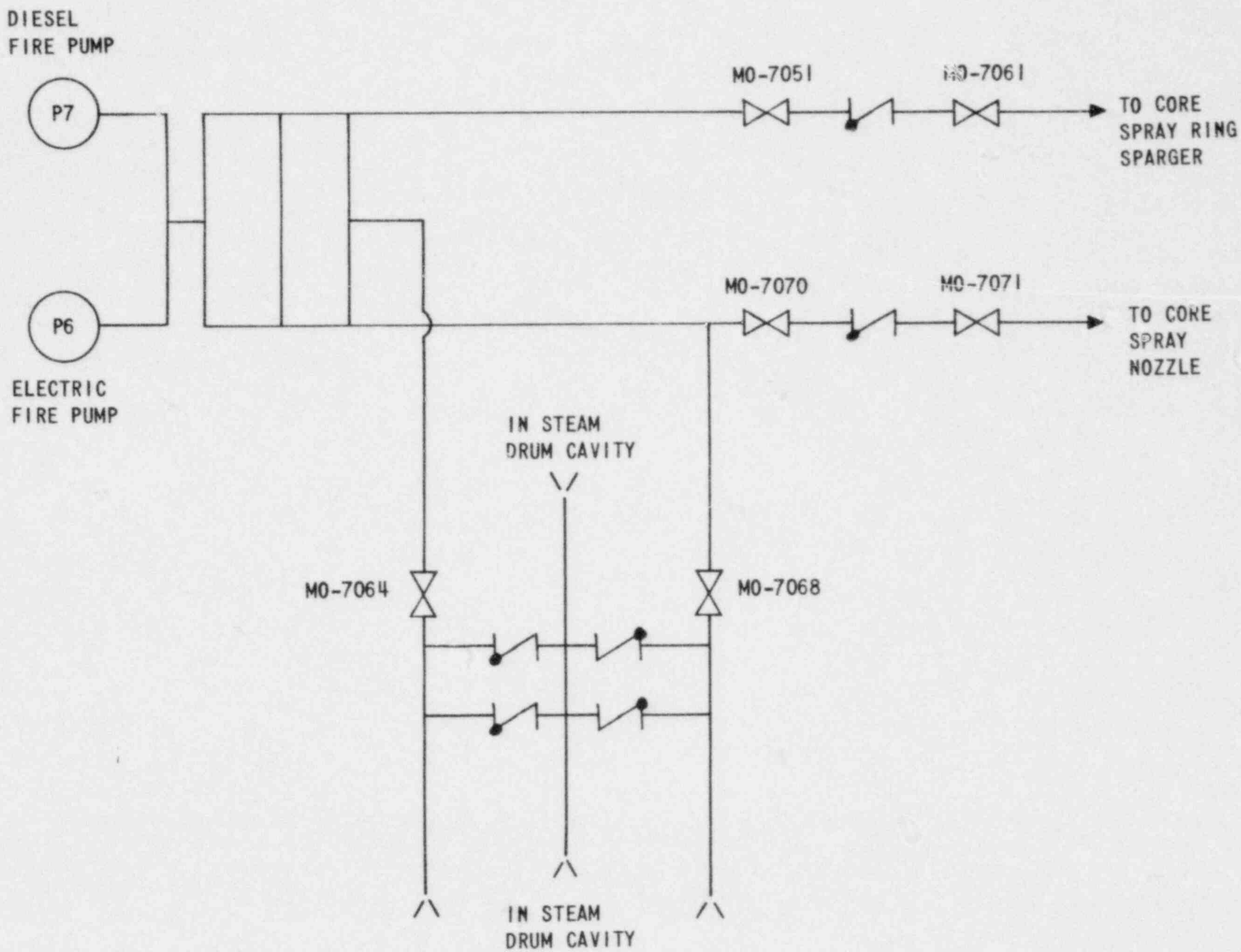
2. The circuit breaker to MO-7068 is enabled such that this valve can be manually opened from the control room. The valve will be manually opened 15 minutes after reactor scram due to a LOCA or SLB to wash out iodine. It can also be used as a manual backup in the event of a failure of MO-7064.

3. Spray lines are extended from the containment spray headers to the steam drum cavity such that containment spray will simultaneously spray inside and outside the cavity.

4. All the containment spray nozzles will be replaced with nozzles which will provide adequate containment spray while at the same time maintaining sufficient core spray.

APPENDIX A

FIGURE 1 - CONTAINMENT/CORE SPRAY SYSTEM



APPENDIX B

CONTAINMENT RESPONSE

The containment response to a reactor coolant break was calculated using the CONTEMPT computer code. The code models the containment sprays by removing from the superheated atmosphere that quantity of energy required to raise the 70°F spray water to saturated steam at the containment conditions.

Containment temperature responses as calculated by CONTEMPT for two break sizes are shown in Figures 1 and 2. A delay in containment spray of 75 seconds was assumed to account for starting of the fire pump and filling of the spray line. A spray flow of 50 gpm was chosen to establish a minimum flow. The CONTEMPT calculations show that the 50 gpm spray is sufficient to cool the superheated atmosphere. Once the blowdown has nearly ceased, the sprays cause the atmosphere to cool rapidly to saturation temperature. This is illustrated in Figure 1 for the 0.63 ft^2 SLB. However, for large blowdown rates, the 50 gpm spray is not sufficient to absorb energy at a rate equal to that being added during the blowdown. (See Figure 2.) The atmospheric temperature during rapid blowdown may briefly exceed 235°F, but will decrease after blowdown ceases. For smaller breaks, the 50 gpm spray flow is adequate to absorb the superheat until Reactor Depressurization System (RDS) actuation. This is also shown in Figure 2 in which the 50 gpm spray more than kept up with the blowdown from the 0.05 ft^2 break, but was unable to do so during the subsequent RDS actuation.

The CONTEMPT code modeled the containment as a single room or compartment. Actually, the steam drum cavity within the containment is a separate room with a leakage area (approximately 100 ft^2) to the rest of containment. Since nearly all of the steam lines are located within the steam drum cavity, a steam line break is more probable in this area. The net effect of this is that for a total spray flow of 50 gpm, the temperatures outside the steam drum cavity will be less than predicted by the single compartment model while those inside will be greater than predicted.

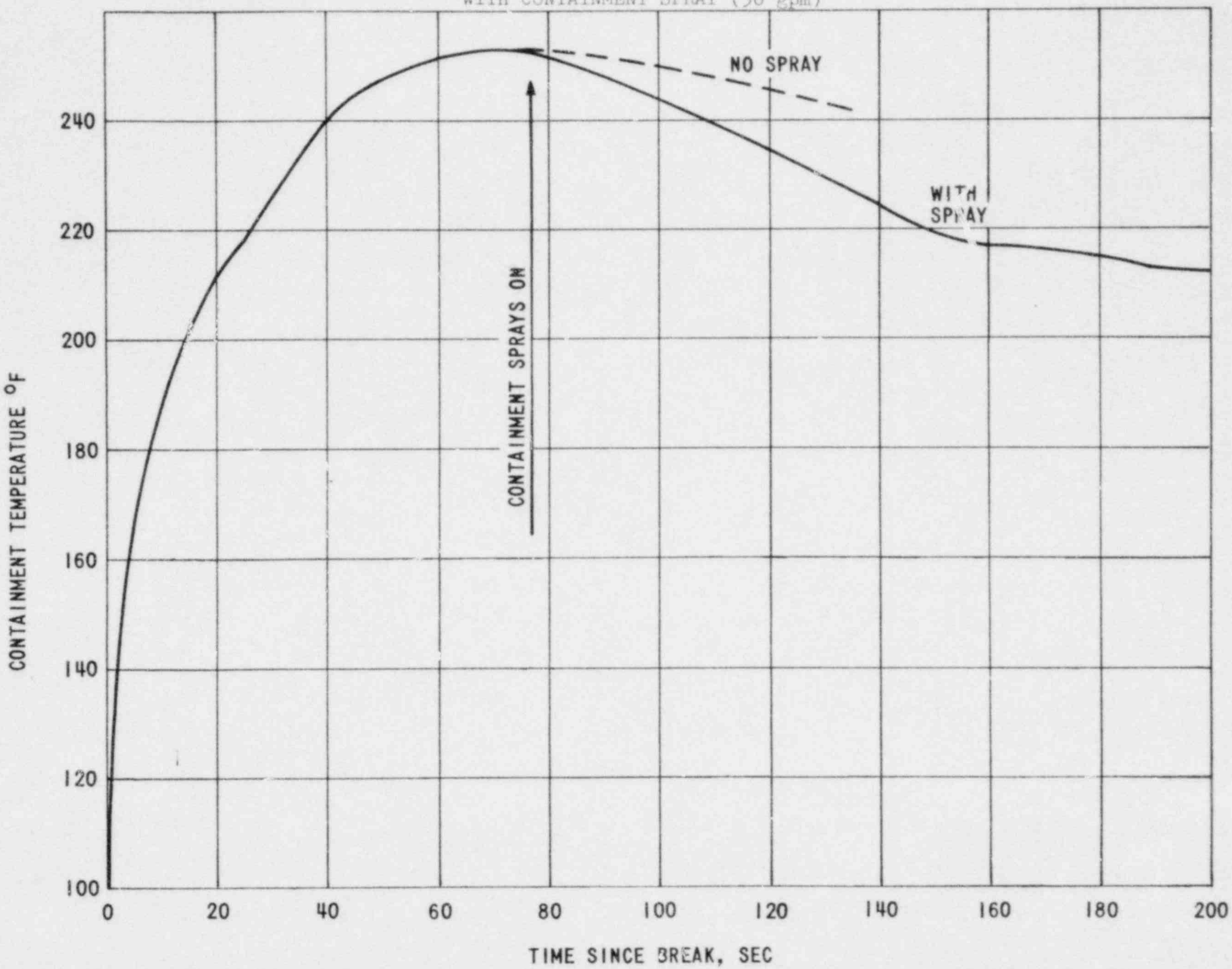
However, the modified containment spray system will provide more than 50 gpm spray to areas both inside and outside the steam drum cavity. Thus, the conclusion reached above is still valid; namely, that there is sufficient spray to keep the atmospheric temperatures below 235°F except for short periods during large blowdowns.

Although the atmospheric temperature following a large SLB may exceed 235°F, it will do so for less than two minutes. For this short period of time, the thermal capacity of the vital equipment is considered sufficient to assure equipment operability for the time period required (less than two minutes following the large steam break). It should be noted that containment air temperatures are predicted to exceed 235°F only for the hypothetical large steam line break and not for smaller breaks which are more likely. It is also noteworthy that the redundant core spray nozzle isolation valves reside outside the steam drum cavity where they would be subjected to a less severe environmental transient.

It is concluded that the predicted large break contaimnent air temperatures are acceptable based on the following considerations: (1) The extremely low probability that the containment air temperature will exceed the equipment qualification temperature; (2) there is sufficient equipment thermal capacity to assure its functionability for the time required; and, (3) the redundancy inherent in the core spray system.

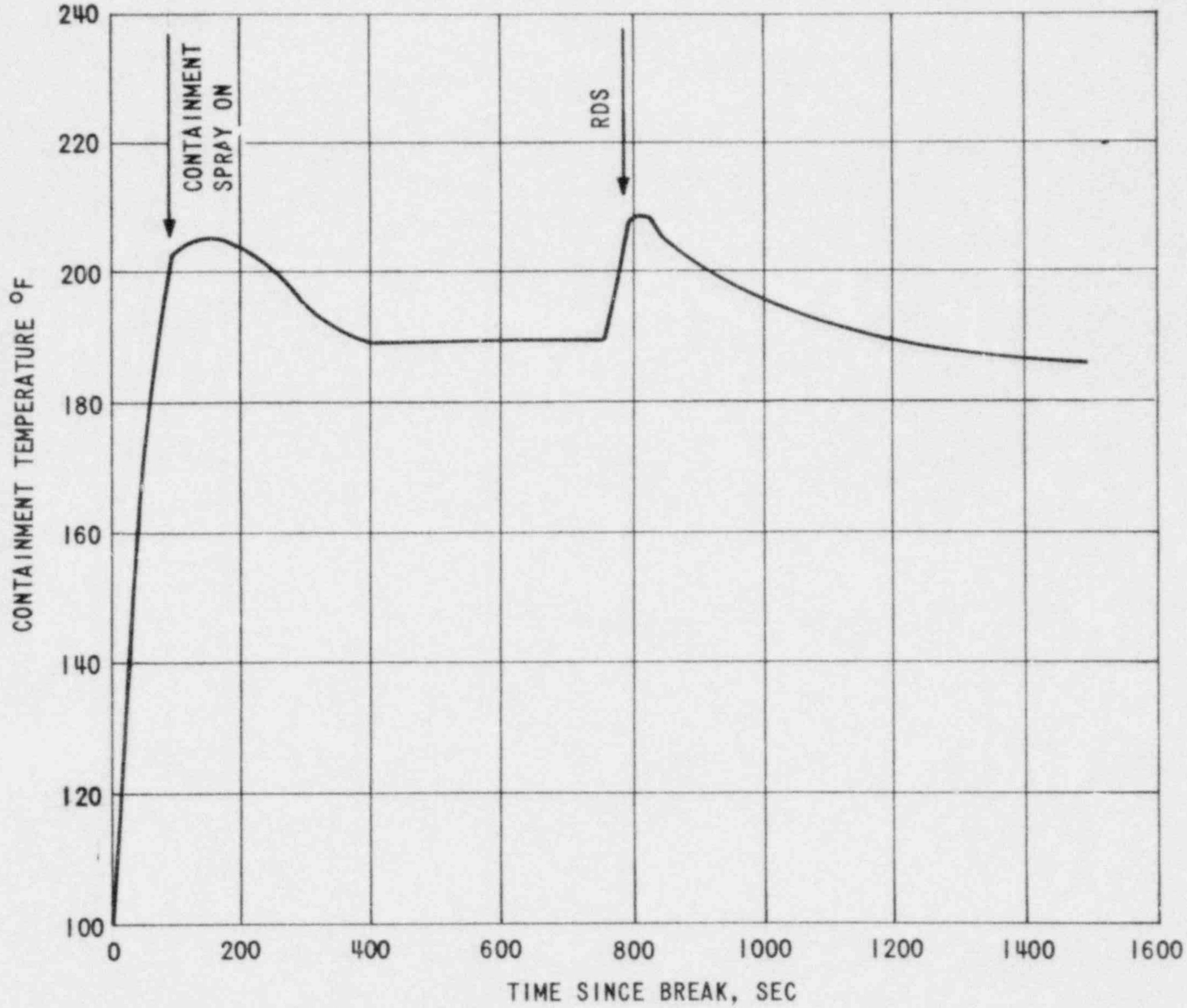
APPENDIX B

FIGURE 1 - 0.63 ft^2 STEAM LINE BREAK WITH CONTAINMENT SPRAY (50 gpm)



APPENDIX B

FIGURE 2 - 0.05 ft^2 STEAM LINE BREAK
WITH CONTAINMENT SPRAY (50 gpm)



APPENDIX C

ECCS AND CONTAINMENT SPRAY PERFORMANCE OF MODIFIED SYSTEM

I. ECCS Performance

The core spray ring and nozzle were tested and found to provide adequate core spray flow distribution at flows of 292 gpm and 296 gpm, respectively. Thus, it must be demonstrated that at least this amount of spray flow is provided from either line at the maximum post-accident reactor pressure.

Following a break in a non-ECCS line (any line except for the core spray nozzle and ring spray lines) the maximum reactor pressure will be that at which the RDS valves reopen following RDS depressurization. These valves were tested and found to reopen on pressure differentials of 42, 47 and 48 psid. Thus, a pressure differential of 50 psid is conservatively assumed to be necessary to reopen the valves. The peak containment pressure following a large LOCA from full power has been reported in the FHSR to be 20 psig. Thus, the maximum reactor pressure following a non-ECCS line break is 70 psig.

Considering breaks in an ECCS line, the most severe break is that of a nozzle line since it has the larger capacity. For a nozzle line break the reactor depressurizes to below 38 psig. Thus, the maximum reactor pressure following a nozzle line break is 38 psig.

For non-ECCS breaks, adequate core spray flow is 292 gpm at a reactor pressure of 70 psig. For a core spray nozzle line break, adequate spray flow is 292 gpm at 38 psig reactor pressure. The core spray ring was tested at pressures of 25 and 75 psig and a flow of 292 gpm to assure that the different reactor pressures would not deleteriously affect the core spray distribution.

Core spray and containment spray flows for both non-ECCS and nozzle line breaks were calcualted using the FLONET computer code. The results of this analysis assuming various single failures are listed in Table 1. Note that for all cases there is at least one core spray line which satisfies the 292 gpm requirement.

II. Containment Spray Performance

The analyses results presented on Table 1 show that for all possible single failures, containment spray flow exceeds 50 gpm to both the steam drum cavity and the remainder of containment. Thus, the containment analysis presented in Appendix B is valid.

In addition to condensing steam, the containment spray system will wash out iodine from the atmosphere. The original containment spray system provided at least 334 gpm of spray at 15 minutes following the break. The modified containment spray system provides 259 gpm of spray under the same conditions. However, droplets from the modified system nozzles will be about an order of magnitude smaller in size than those from the existing nozzles. Since the iodine washout capability changes linearly with flow but nonlinearly with droplet size, the increase in iodine washout due to the droplet size reduction is much more significant than the decrease in washout due to the reduced flow. Therefore, iodine washout capability is not reduced with the modified system.

APPENDIX C

TABLE 1: CONTAINMENT AND CORE SPRAY FLOWS

Failure	Break	Containment Spray Steam Drum (Gpm)	Containment Spray Enclosure (Gpm)	Containment Pressure (Psig)	Core Spray Nozzle (Gpm)	Core Spray Ring (Gpm)	Reactor Pressure (Psig)
None	Non-ECCS	64	67	10	363	270	70
Diesel/ Generator	Non-ECCS	66	70	10	-	292	70
Fire Pump	Non-ECCS	61	64	10	330	246	70
Backup Cont Spray Valve	Non-ECCS	62	66/137*	10	332	257	70
None	Nozzle	60	63	10	-	339	38
Fire Pump	Nozzle	55	58	10	-	306	38
Backup Cont Spray Valve	Nozzle	57	60/123*	10	-	327	38

*Primary Spray/Backup Spray

APPENDIX D

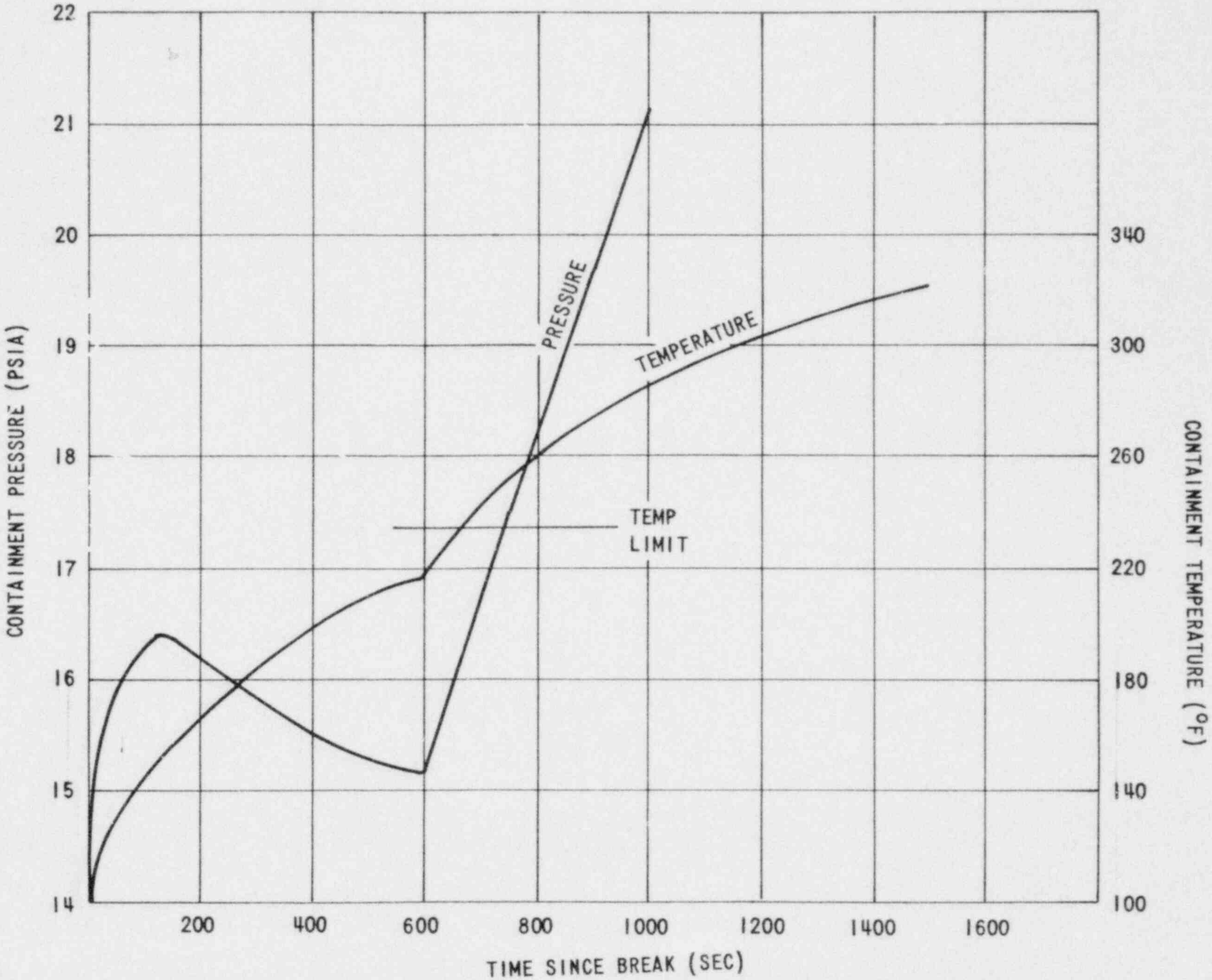
OPERATOR RESPONSE TIME REQUIRED FOR SMALL STEAM LINE BREAKS

For small steam line breaks with break flows of 75 lb/sec and less, the containment pressure does not reach the containment high-pressure trip set point. This is due to the containment ventilation system which acts to maintain containment pressure. Therefore, for this class of breaks the reactor must be manually scrammed and containment sprays manually initiated.

The containment pressure and temperature response to a 75 lb/sec steam line break with a manual reactor trip at 600 seconds assuming no containment spray is shown in Figure 1. As is evident from the figure, the operator has more than 10 minutes from the break occurrence before he must initiate containment spray. A 75 lb/sec break is 27% of rated steam flow. Thus, a feedwater/steam flow mismatch as well as a significant loss in electric output will be immediately evident. Also, high air temperature and dew point alarms both inside and outside the steam drum cavity will alert the operator very soon after the break.

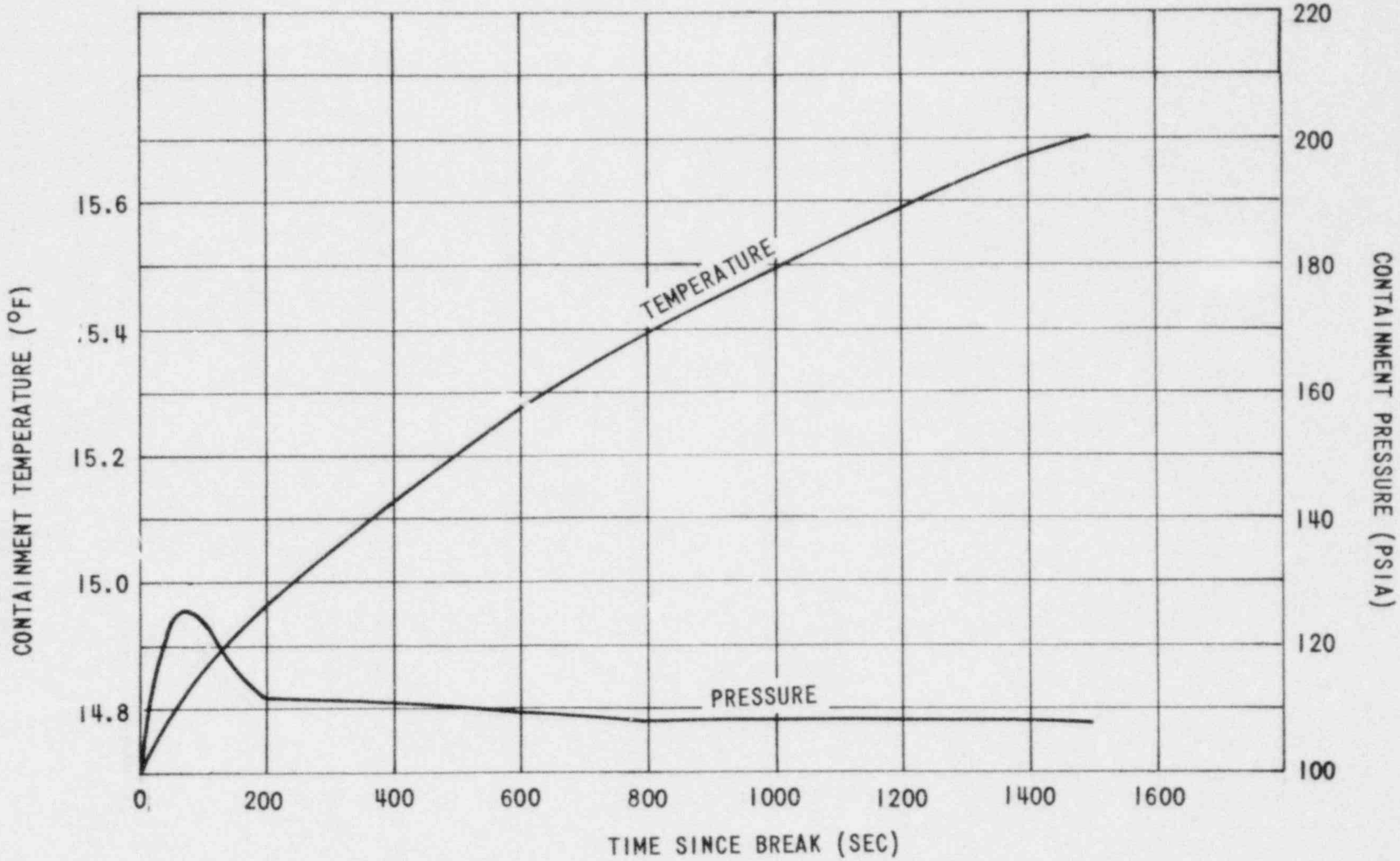
For smaller breaks, the temperature transients are less severe which increase the time allowed for operator action. As shown in Figure 2, the operator has much more than 30 minutes to take action for a 22.5 lb/sec steam line break.

FIGURE 1 - 75 lb/sec STEAM LINE BREAK
MANUAL REACTOR TRIP @600 sec



<u>APPENDIX D</u>

FIGURE 2 - .008 ft^2 STEAM LINE bREAK (22.5 lb/sec)



APPENDIX E

OPERATOR ACTION FOR SMALL BREAK SYSTEMS

Symptoms associated with a small steam break are listed on Table 1, along with the location of the indicators and the detector alarm settings (control grade equipment). Operator actions based on these symptoms are noted on Table 1.

In addition to these indications, the operator would probably hear the small break; particularly if the break were large enough to cause rapid heating of the containment and still not cause automatic containment isolation (ie, 50-75 lbm/sec steam leaks). For breaks of this size, containment air and dew point temperatures both inside and outside the steam drum cavity would rise very rapidly causing an immediate high-temperature/dew point recorder alarm on the control room front panel. The loss of steam to the turbine would result in an approximate reduction of 20 MWe in turbine generator output and 30% closing of the turbine control valves. These changes would result in step changes on the steam flow and turbine cam position charts.

Feedwater flow would probably stay the same. The operator would respond at once by noting the chart readings and power output of the generator. With the control panels and console situated as they are in the control room at Big Rock Point, all indications can be seen from one location. The farthest distance between charts is about 20 feet. The containment pressure indicator as well as the control switches for scram, emergency condenser, and enclosure spray are within five feet; therefore, the actual time to perform necessary actions would be short and well within 10 minutes.

POOR ORIGINAL

APPENDIX E

TABLE 1 - SMALL BREAK SYMPTOMS - OPERATOR GUIDELINES

<table>
<tr><th>Symptom</th><th>Alarm Initiator</th><th>Location of Indicator</th><th>Detector</th><th>Action</th></tr>
<tr><td>*Reactor Building Ventilation Trouble Annunciator</td><td>C20 Panel in Sphere</td><td>Control Room Front Panel</td><td>RTD & Dew Point</td><td>1. Check steam flow.
2. Check feedwater flow.
3 Check electric output.
4. Check dew point recorder.</td></tr>
<tr><td>Containment Building Temperature Annunciator</td><td>Temperature/Dew Point Recorder</td><td>Control Room Front Panel</td><td>RTD & Dew Point

<u>NOTE</u>: This alarm is brought in by the individual high-temperature alarm from each recorder point on TR-9623 as listed below:

Point No | Service | Alarm Point
1 | Personnel Lock | ≤ 100°F RTD
2 | Personnel Lock | ≤ 80°F Dew Point
3 | New Fuel Storage | ≤ 100°F RTD
4 | New Fuel Storage | ≤ 80°F Dew Point
5 | Emerg Cond Area | ≤ 100°F RTD
6 | Emerg Cond Area | ≤ 80°F Dew Point
7 | Sphere Exhaust Air | ≤ 105°F RTD
8 | Sphere Exhaust Air | ≤ 80°F Dew Point
9 | Sphere Inlet Air | ≤ 120°F RTD
10 | Sphere Inlet Air | ≤ 120°F Dew Point
11 | Condenser-Pipe Tunnel | ≤ 120°F RTD
12 | Condenser-Pipe Tunnel | ≤ 120 F Dew Point</td><td>1. Check steam flow chart.
2. Check feedwater chart.
3. Check MWE and turbine control valve positions.
4. If steam flow and MWE output drops with no feedwater change or increased feedwater, scram reactor and check vent valves closed.
5. Initiate emergency condenser operation.
6. If enclosure pressure begins to rise, immediately initiate primary containment spray. Do not wait for automatic actuation.
7. Place both fire pumps in service.
8. Verify primary containment spray flow. If no flow, actuate secondary containment spray.</td></tr>
<tr><td>Drop in Steam Flow</td><td>-----</td><td>Bailey Chart Steam Flow Gauge on Control Room Front Panel</td><td>-----</td><td>1. Check feedwater flow.
2. Check turbine cam position.
3. Check dew point temperature recorder.

If feedwater flow did not change and dew point recorder shows increase, scram reactor and check vent valves closed. Use emergency condenser to reduce pressure in the reactor.</td></tr>
<tr><td>Unexplained Drop in Turbine Generator Output</td><td>-----</td><td>Output Gauge Cam Position on Control Room Front Panel</td><td>-----</td><td>1. Check steam flow.
2. Check feedwater flow.
3. Check dew point recorder.

Same action as for drop in steam flow.</td></tr>
</table>

*Could be caused by pipeway high temperature or high dew cell reading.

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