



Loss of All AC Power

Station Blackout (SBO) Chapter 4.8

Objectives

1. Define the term Station Blackout.
2. Describe the interim response by the NRC to the station blackout concern.
3. Describe the plant response necessary to mitigate the consequences of a station blackout using existing equipment.

Objectives (Continued)

4. Describe the regulatory requirements addressing the station blackout concern.
5. Describe the accident sequence that makes the loss of all alternating current (AC) power a major contributor to the total core damage frequency at some reactor plants.

Station Blackout (Section 4.8.2)

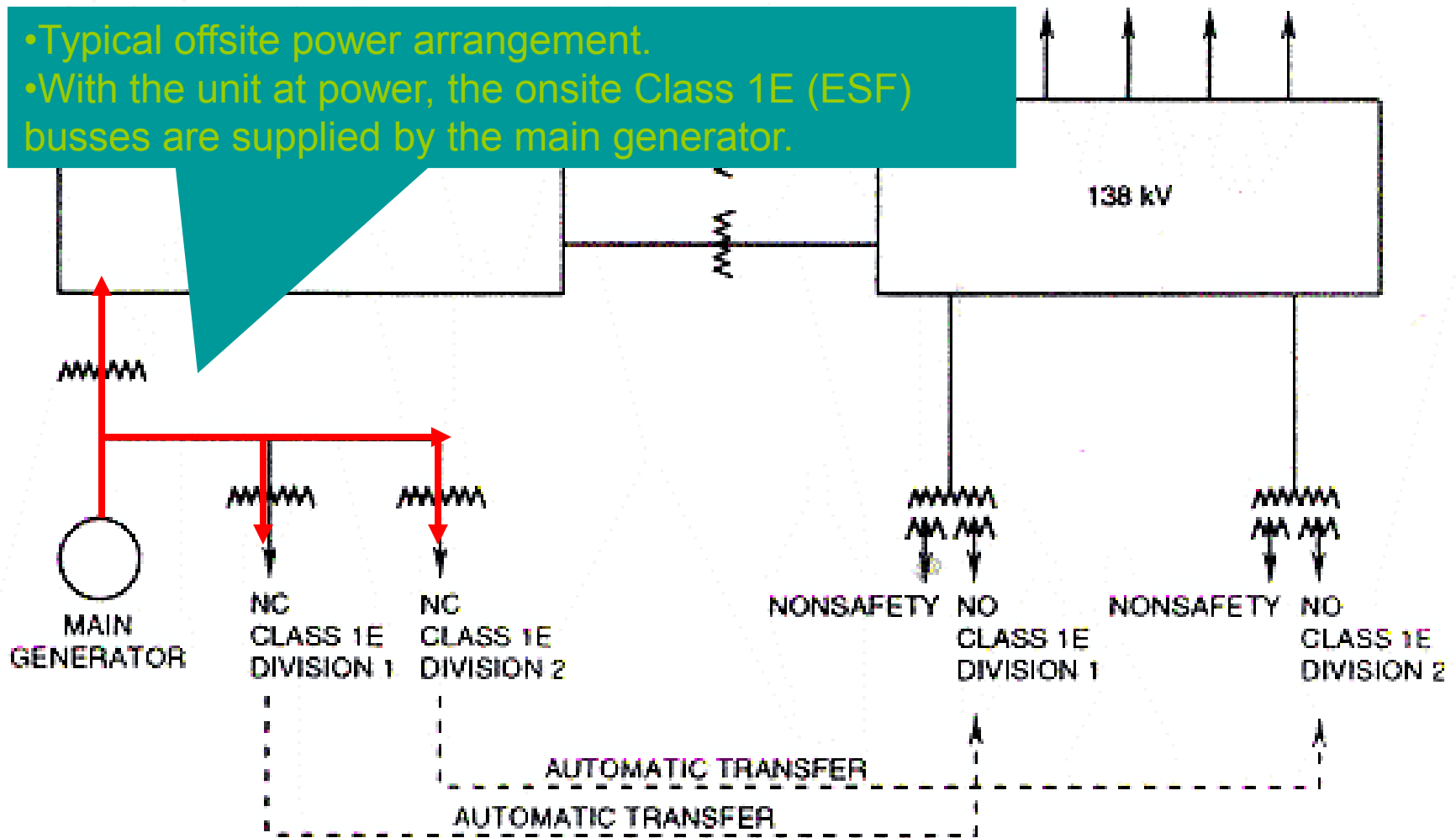
- **10 CFR 50.2 defines *Station Blackout* as the complete loss of alternating current (ac) electric power to the essential and nonessential switchgear buses in a nuclear plant .**
- ***Station Blackout* does not include the loss of available ac power to busses fed by station batteries through inverters or by alternate ac sources as defined in this section, nor does it assume a concurrent single failure or design basis accident.**

Station Blackout (Section 4.8.2)

(continued)

- Any emergency ac power source(s) in excess of the number required to meet minimum redundancy requirements (i.e., single failure) for safe shutdown (non-DBA) is assumed to be available and may be designated as an alternate ac power source(s) provided the applicable requirements are met.

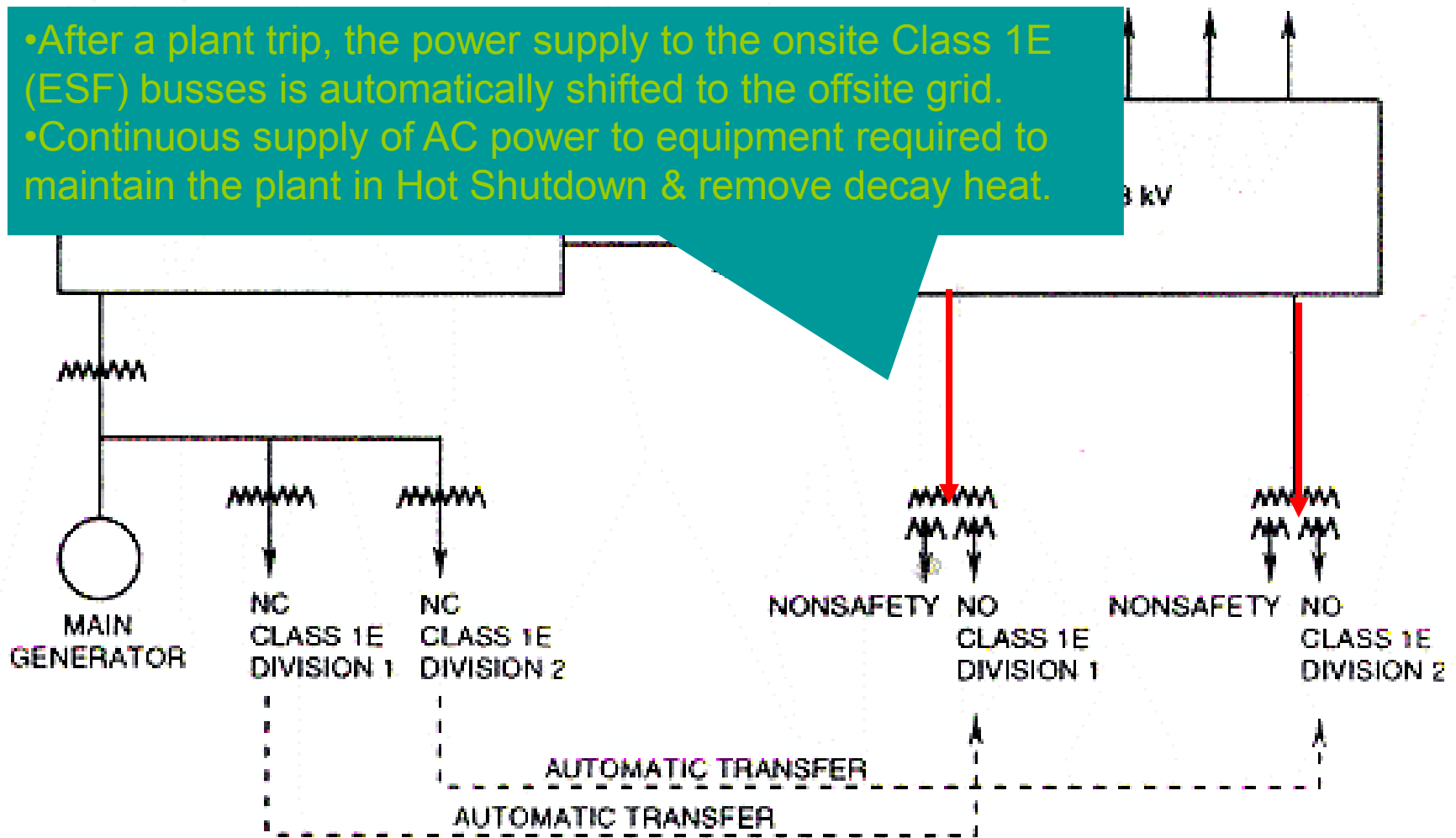
- Typical offsite power arrangement.
- With the unit at power, the onsite Class 1E (ESF) busses are supplied by the main generator.



GDC 17 Offsite Power Systems

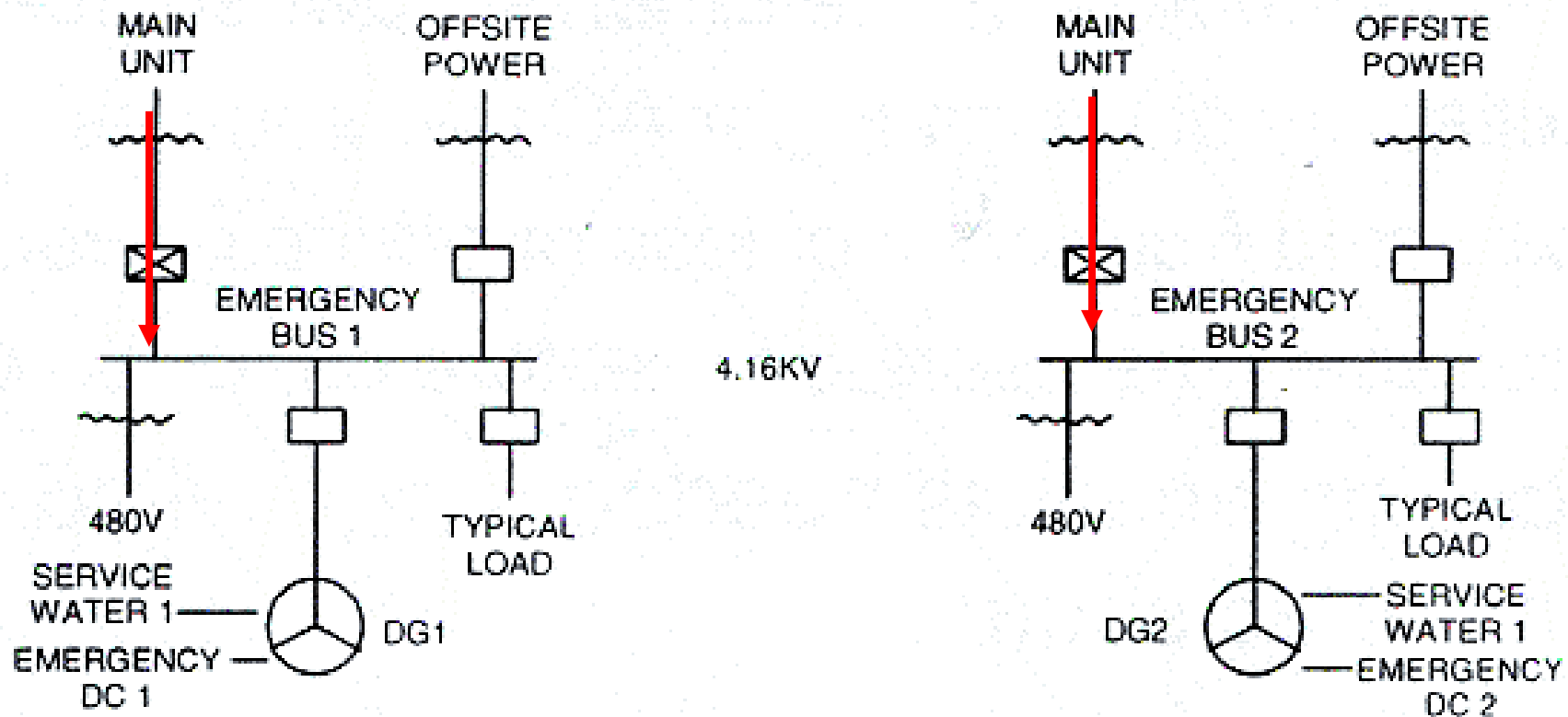
Fig 4.8-1

- After a plant trip, the power supply to the onsite Class 1E (ESF) busses is automatically shifted to the offsite grid.
- Continuous supply of AC power to equipment required to maintain the plant in Hot Shutdown & remove decay heat.

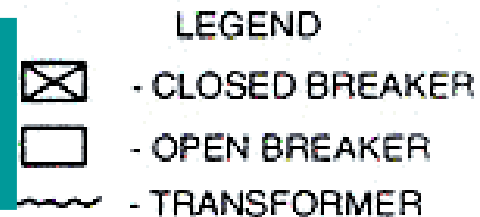


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Fig 4.8-1

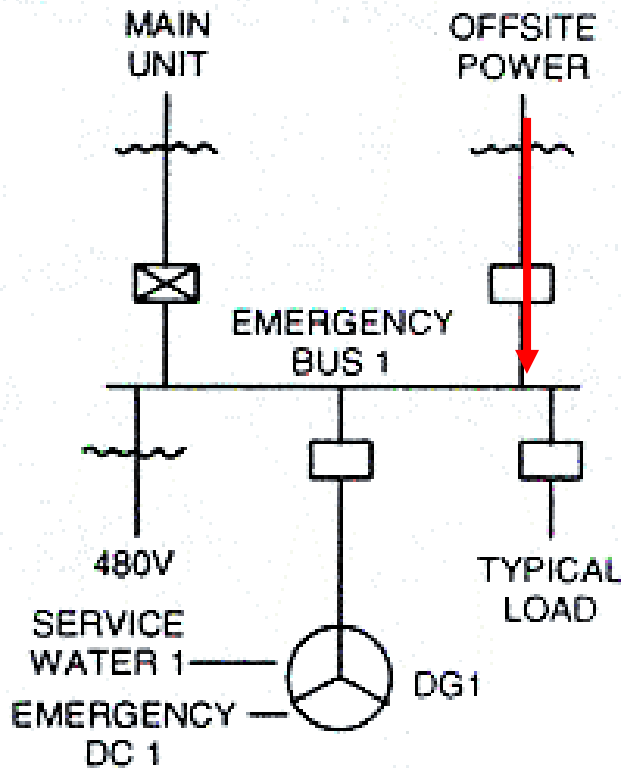


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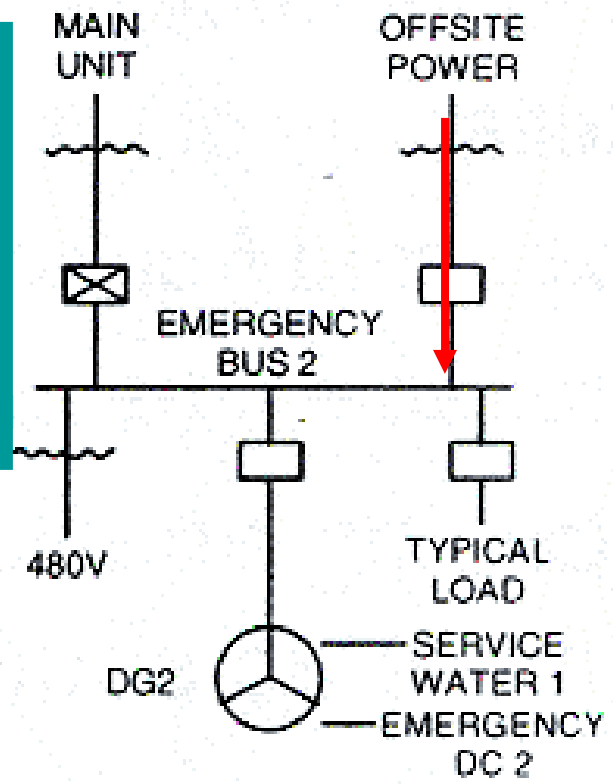





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Fig 4.8-2



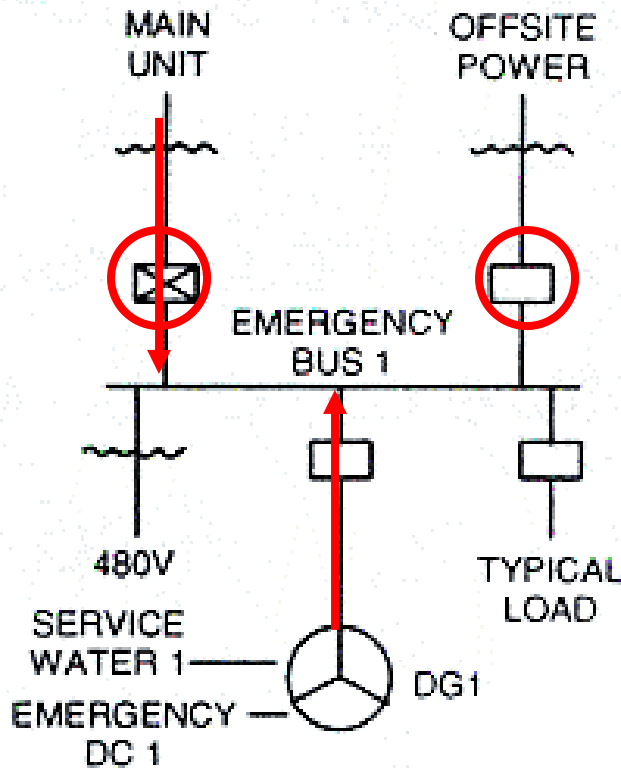
•After a plant trip, the power supply to the onsite Class 1E (ESF) busses is automatically shifted to the offsite grid.



- LEGEND
-  - CLOSED BREAKER
 -  - OPEN BREAKER
 -  - TRANSFORMER

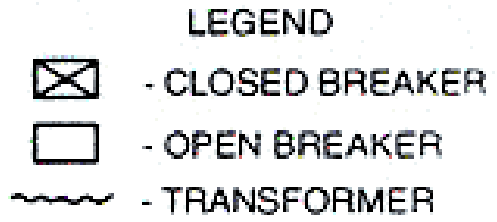
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Fig 4.8-2



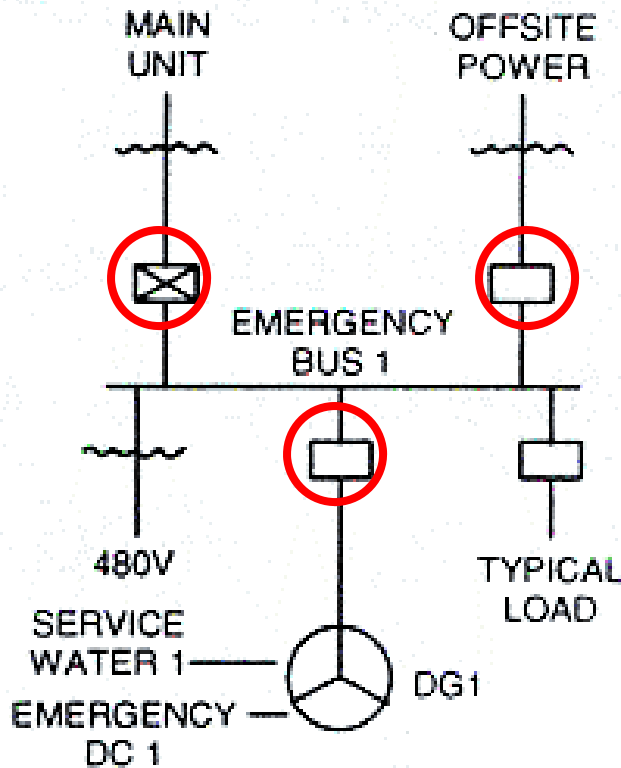
Unit trip with no offsite power.

- If offsite power is not available after a plant trip, the UV condition is sensed on the ESF busses.
- The supply breakers to the ESF busses are opened.
- The loads are stripped from the busses.
- The EDGs are started and develop rated speed & voltage.
- The EDG output breaker auto closes to supply loads needed to maintain the plant in Hot Shutdown & remove decay heat.



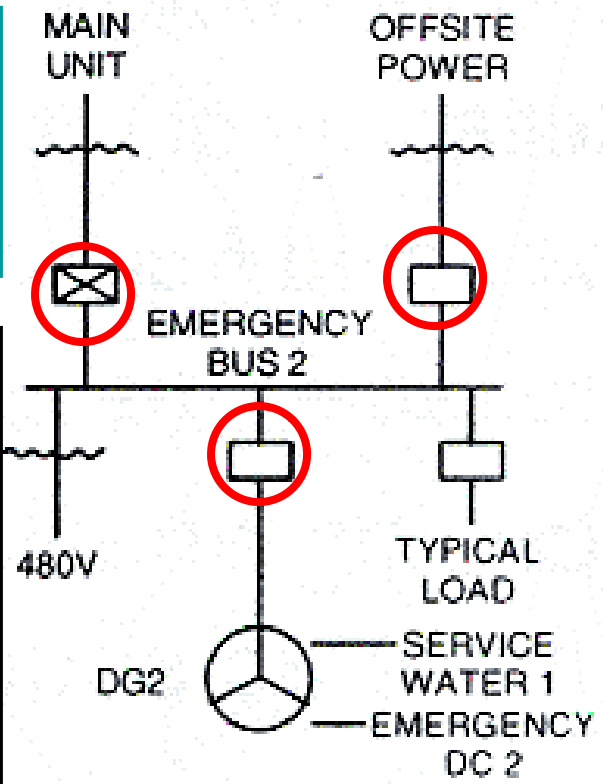
GDC 17 Onsite Power Systems

Fig 4.8-2



If the EDGs are not available, a station blackout (SBO) has occurred.

The simultaneous loss of both offsite & onsite AC power was not considered credible and was not part of the plant design or accident analysis.



- LEGEND
- CLOSED BREAKER
 - OPEN BREAKER
 - TRANSFORMER

GDC 17 Onsite Power Systems

Fig 4.8-2

History (Section 4.8.3)

- 1975 Reactor Safety Study (WASH 1400)
- 1979 Commission Issued USI A-44 SBO
 - (Unresolved Safety Issue)
- NRC's Interim Response
 - Changed construction permit for St. Lucie U-2
 - SBO added to design bases.
 - Operator training.
 - Required improvements is reliability of AFW & EDG.



History (Continued)

- 1988 NUREG-1032 Study of SBO
 - 50.63 SBO Rule (more detail later)
 - REG Guide 1.155: EDG reliability programs with target values.

History (Continued - 1)

1997 NUREG 1560 Individual Plant Exam.

Factors influencing SBO:

- Number of emergency ac power sources
- Battery depletion time
- Modeling of RCP seal failure
- Modifications to RCP seals (high temp O-rings)
- Alternate Seal Cooling

SBO Rule –10 CRF 50.63 (Section 4.8.5)

- Determine capability to cope with loss of all AC power for a specific duration.
- Duration based on:
 - redundancy & reliability of onsite emergency AC power sources.
 - Expected frequency of loss of offsite power.
 - Probable time needed to restore offsite power.
- Ensure plant capable of maintaining core cooling & containment integrity for SBO duration.
- No coping analysis needed for qualified alternate AC source.

Alternate AC Source (10 CFR 50.2)

- Connectable but not normally connected to offsite or onsite emergency power systems.
- Minimum potential for common mode failure.
- Available in timely manner (10 minutes).
- Capacity and reliability for coping with SBO for time required to bring and maintain plant in safe shutdown.

Plant Response to SBO

- Response of RCP seal:
 - No seal injection; leakage up RCP shaft.
 - No CCW; loss of cooling to thermal barrier.
 - High temperature leakage can degrade seal package (300 gpm / RCP).
 - RCP seals leak to containment.
- No AC power to restore inventory loss or remove decay heat.

Severity of SBO

- Duration of power outage.
- Response of RCP seal package.
- Time is core life.
 - More severe at EOL (large negative MTC).

MTC

Consequences of SBO

- Immediate: not severe IF no:
 - Loss of reactor coolant.
 - Steam generator tube rupture.
 - Loss of secondary coolant.
 - And of short duration.
- Potential: If SBO prolonged could result in combination of core damage, over pressurization of containment, and radioactive release.

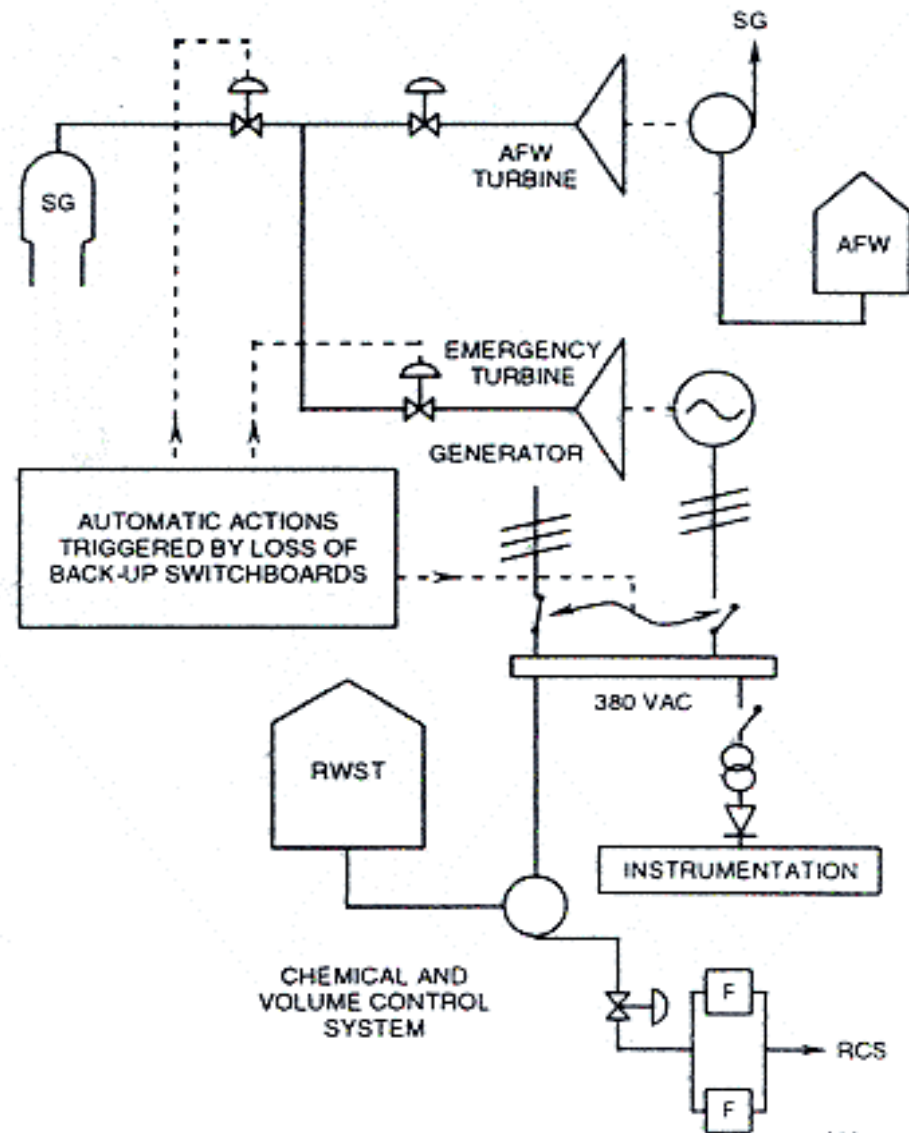
Core Damage

- Initiating event: SBO of prolonged duration.
- Assume no operator action.
- No RCS makeup & no decay heat removal.
- RCP seal failure will eventually occur.
- RCS inventory loss & depressurization due to seal failure.
- RCS becomes saturated & core becomes uncovered.

Mitigation (Section 4.8.2)

- Restore power as soon as possible.
- Minimize loss of RCS inventory.
 - Westinghouse Owners Group developed emergency response guideline ECA 0.0, “Loss of all AC Power.”
 - Basis steps are cooldown and depressurize the RCS using turbine driven AFW & S/G PORVs.

- 1977 Study of SBO Problem
- Designed 1300 MWe Series plants for SBO
- Multiple turbine driven Emer Feedwater Pumps
- Turbine driven electrical generator
 - RCP seal injection pump
 - Instrumentation, controls, lighting for safe shutdown



French Design

(figure 4.8-4)

Can SBO Occur?

- 1990 Vogtle Unit 1.
- Plant Shutdown, mid loop, head de-tensioned.
- A Train RHR in service.
- B DG disassembled for maintenance.
- B RAT tagged out for maintenance.
- Truck toppled tower onto the A RAT, LOOP.
 - A DG started but did not continue to run,
 - SBO 36 minutes,
 - coolant temp increase of 46 degrees.

RAT

Has SBO rule been effective?

- 2000 Final Report, Effectiveness of SBO Rule
- Before SBO Rule 11 of 78 plants had DG reliability prgms, 11 had reliability $<.95$, 2 $<.90$
- All plants have reliability programs (almost all have DG reliability > 95).
- Turkey Point may have lost pwr for 2.5 hours without blackout diesels that were installed prior to hurricane Andrew
- 19 plants added power supplies resulting in significant decrease in CDF for those plants
- Reduction in mean SBO CDF.

Are there future issues?

- April 2003, Grid Events
- Deregulation
- August 2003, Grid Events
 - 9 US & 8 Canadian units tripped.

| | 1968-85 | 1985-96 | 1997-01 |
|---------|---------|---------|---------|
| %>4 hrs | 7 | 17 | 67 |
| Minutes | 36 | 60 | 612 |

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RCP Seals

Fig. 4.8-3

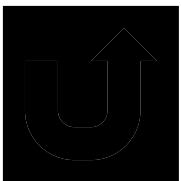
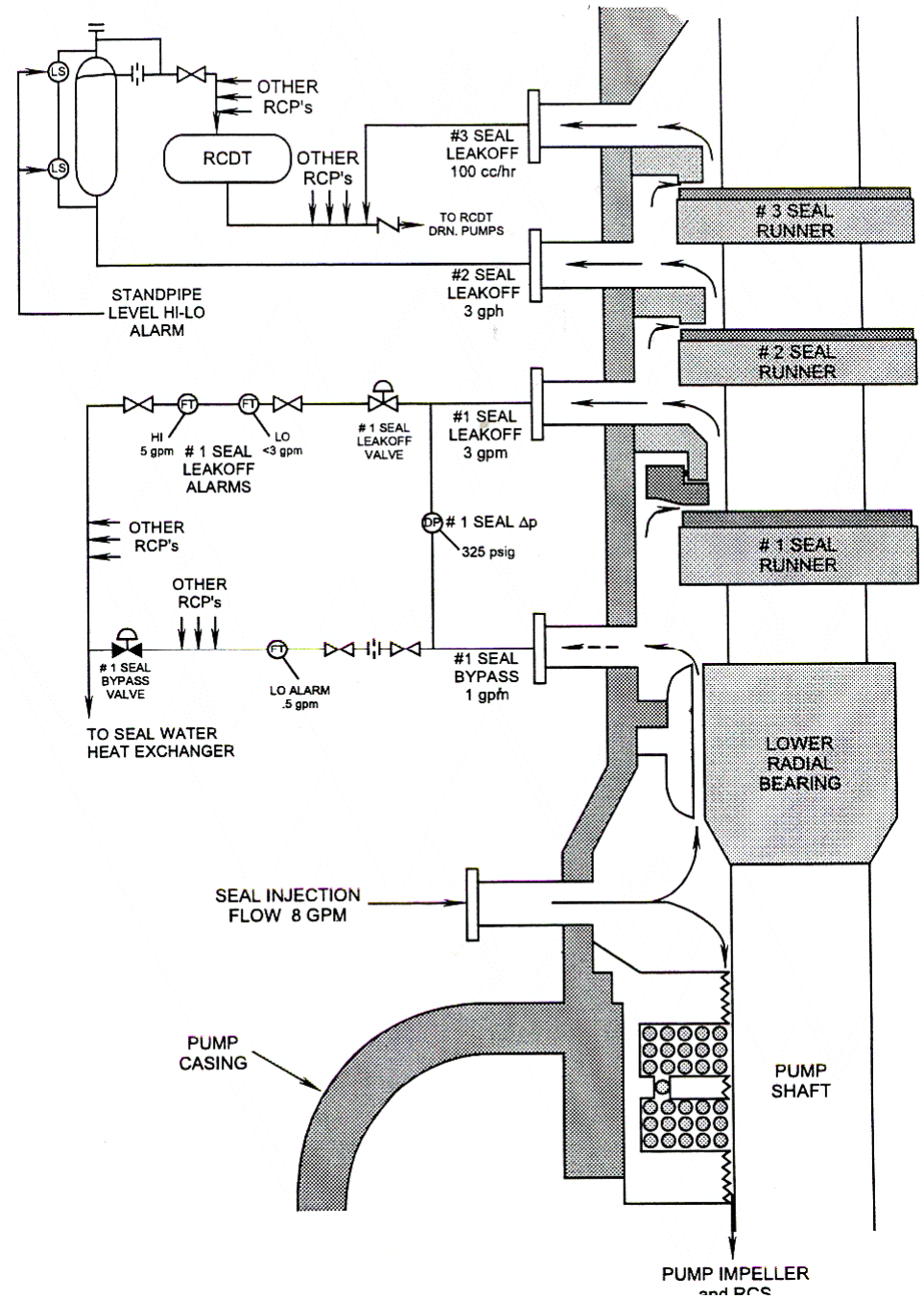
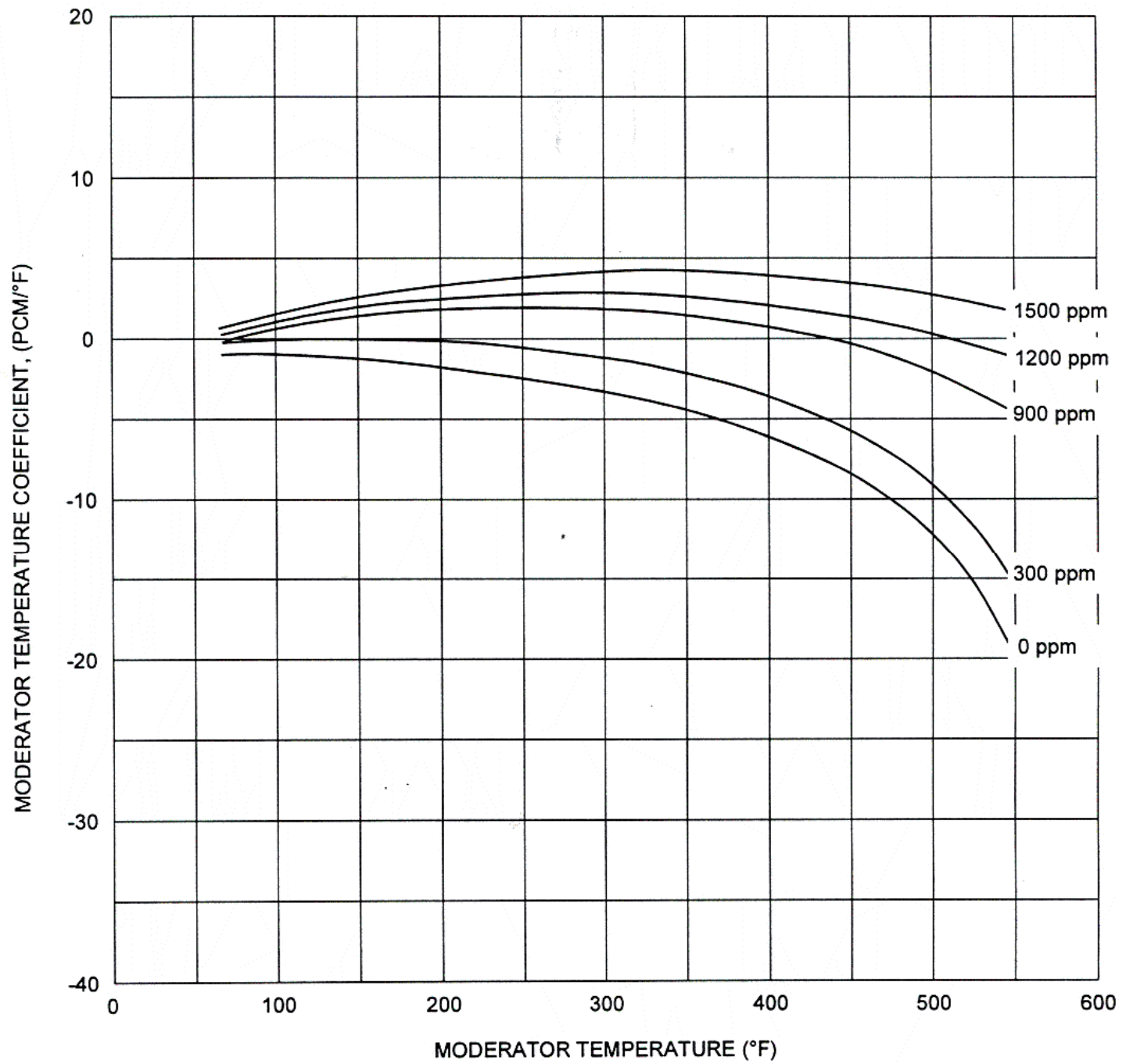
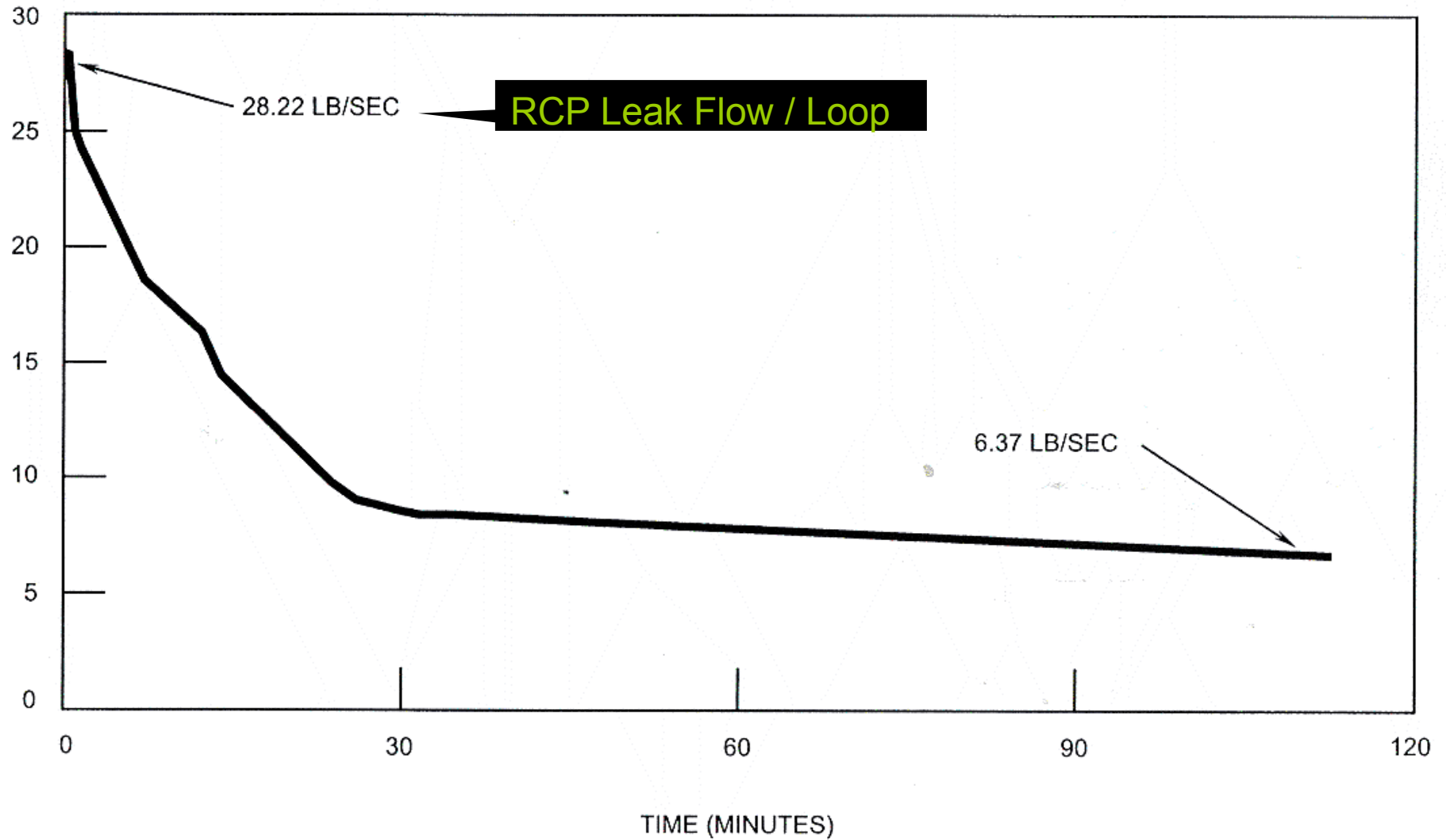


Fig 2.2-6
MTC,Cycle 1
BOL, ARO

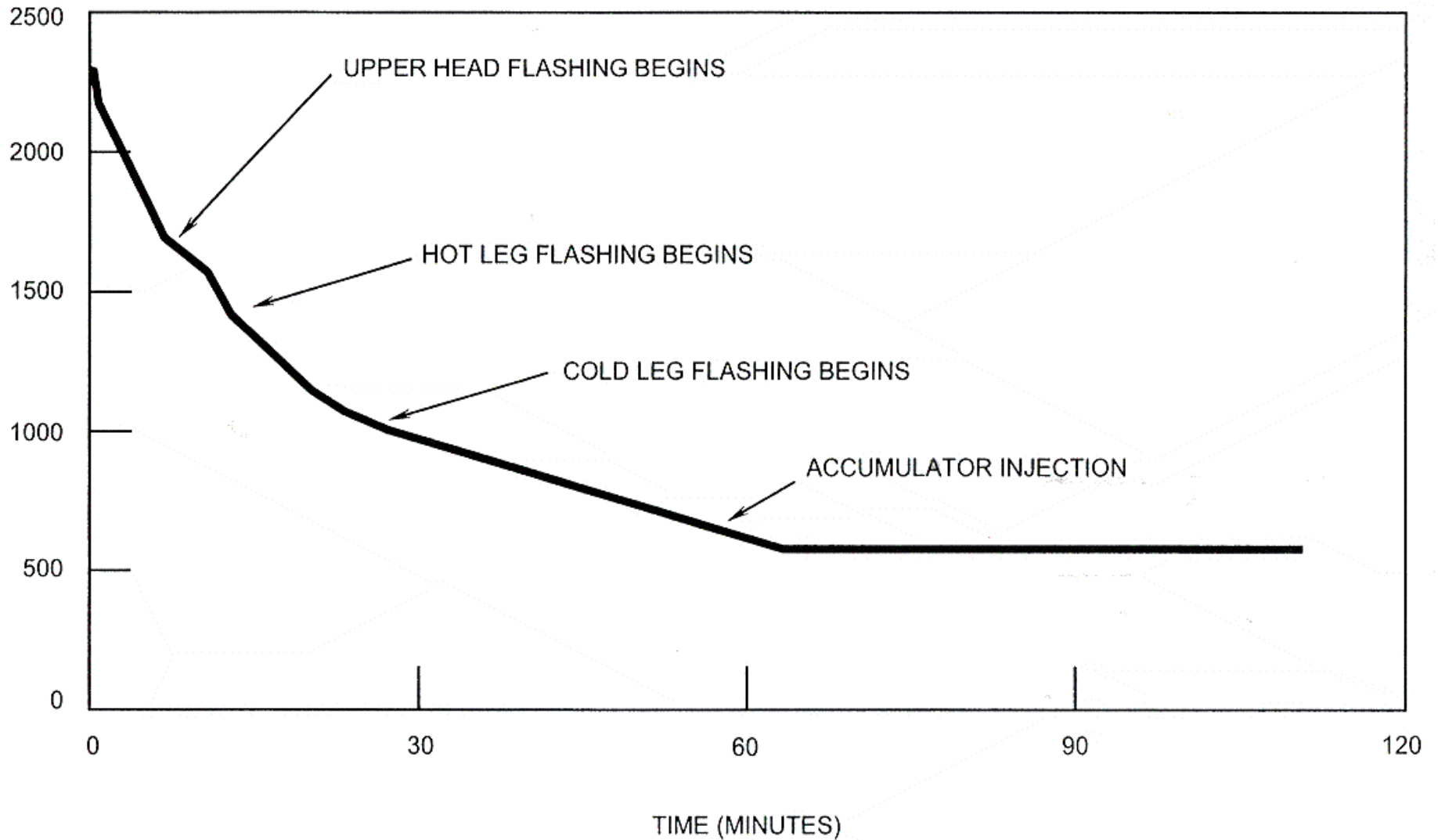


No Depressurization



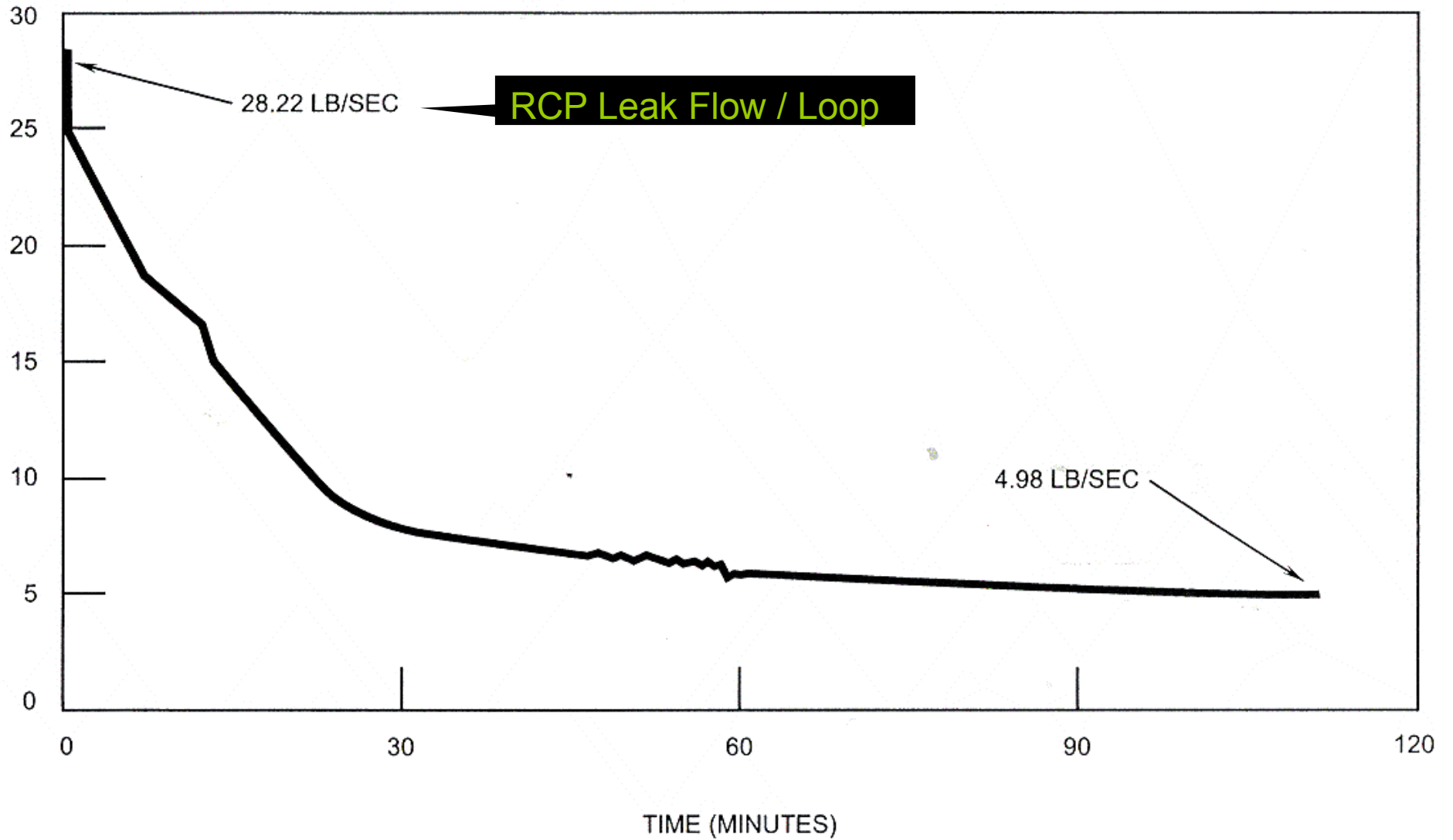
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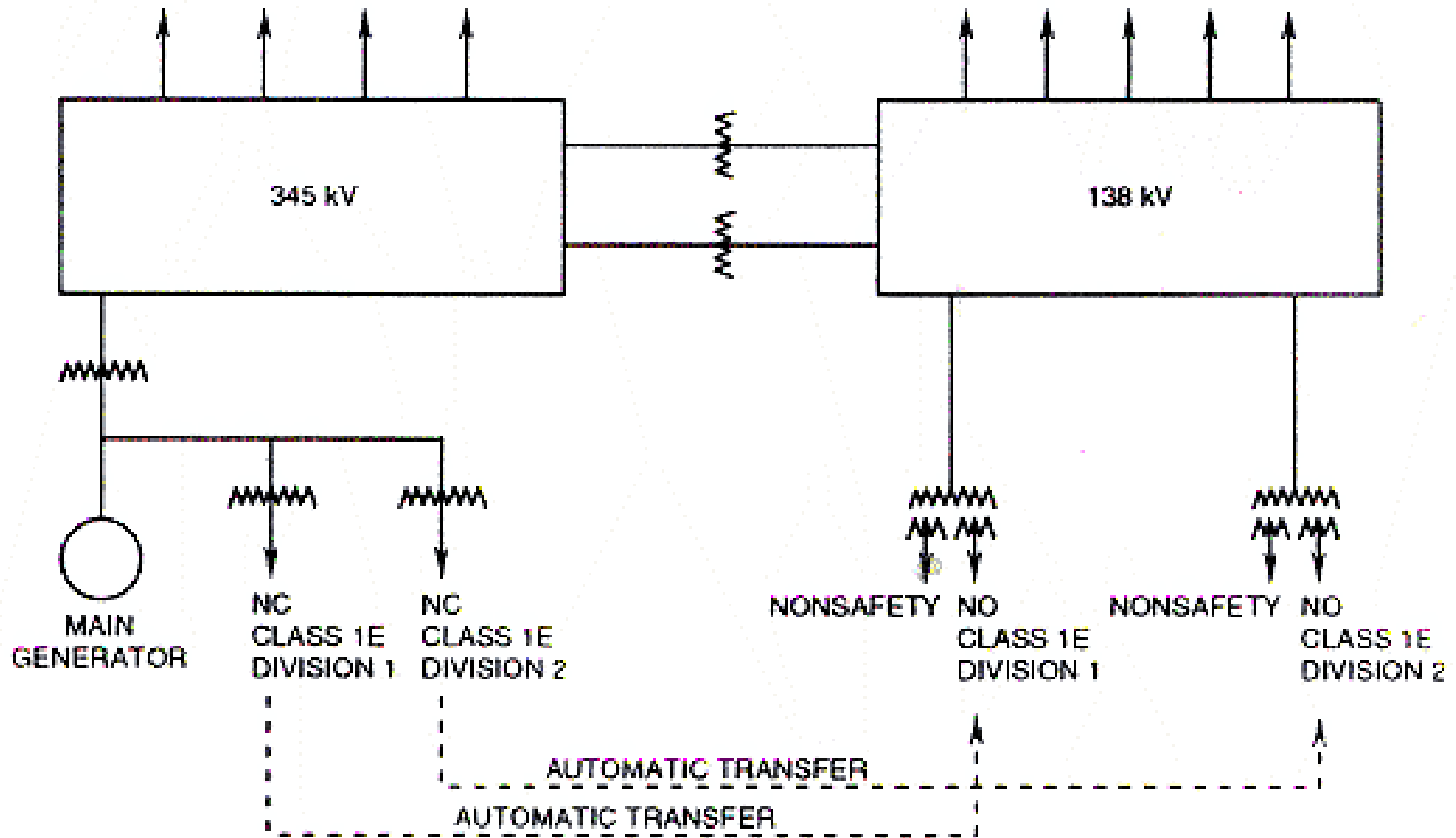
RCS PRESSURE (PSIG)



Depressurization

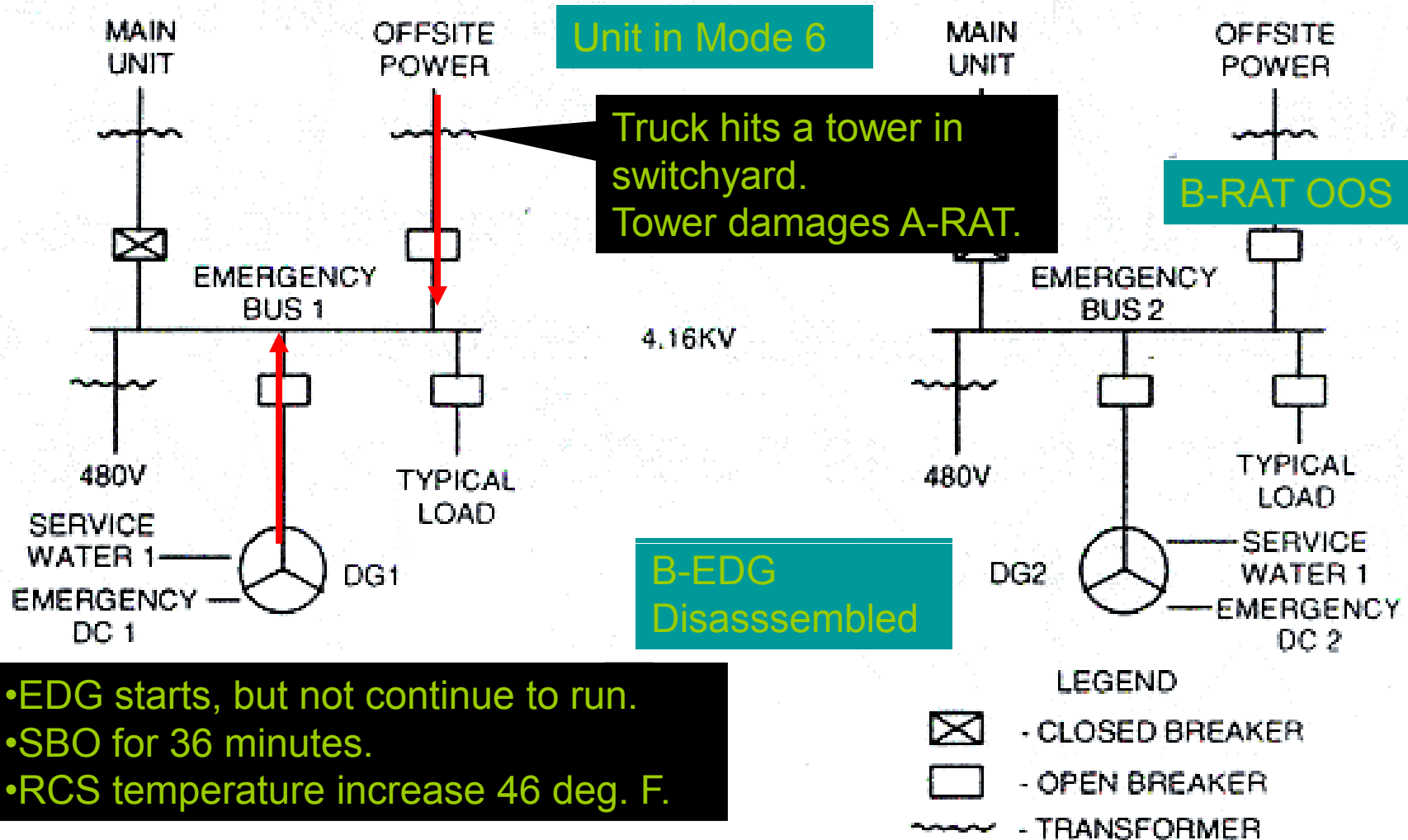
RCP Leak Flow Per Loop (LB/SEC)





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Fig 4.8-1



- EDG starts, but not continue to run.
- SBO for 36 minutes.
- RCS temperature increase 46 deg. F.

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Fig 4.8-2