

Station Blackout

GE BWR/4 Technology Course

R-504B – 4.5

Objectives

1. Define the term “station blackout” (SBO).
2. Recognize the expected plant response and potential consequences of a SBO event.
3. Recognize the regulatory requirements contained in 10CFR50.63, to reduce the risk from a SBO event.
4. Identify the primary methods available to mitigate the consequences of a station blackout.

Station Blackout (10CFR50.2):

- Complete loss of AC electric power to the:
 - essential switchgear buses
 - nonessential switchgear buses

IN OTHER WORDS

- Loss of Offsite Power concurrent with:
 - Turbine / generator trip
 - unavailability of the onsite emergency ac power system

Station Blackout (10CFR50.2):

- Does not include the loss of available AC power to buses fed by station batteries through inverters or by alternate AC sources.
- Not required to assume:
 - Single failure of remaining systems, or
 - Concurrent Design Basis Accident
- Do not need to assume concurrent SBO on multiple units at multi-unit site if total AC sources exceed minimum redundancy for non-DBA safe shutdown (e.g. at a two unit site with 4 diesels, one unit in SBO and one unit in LOOP).

How would a SBO Event Occur?

Starts with a LOOP:

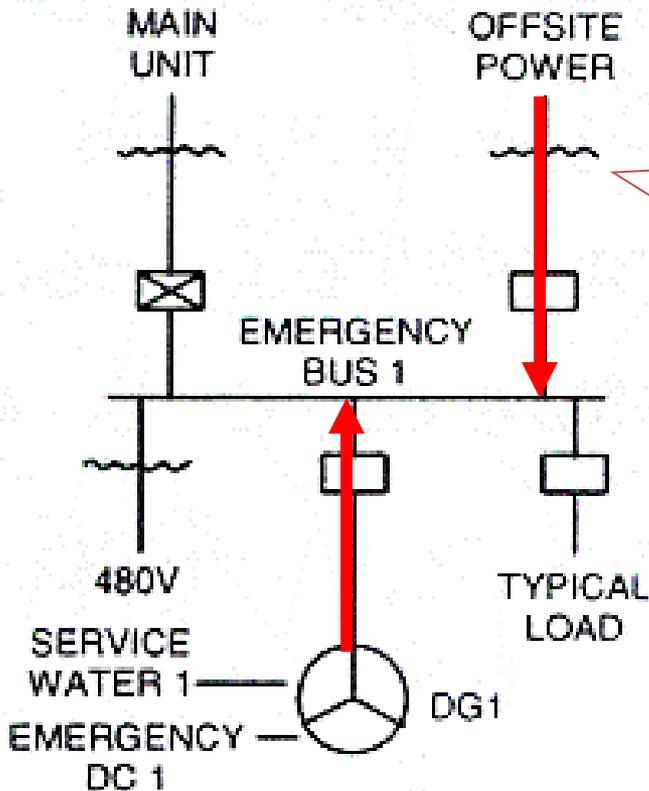
- Turbine trips on load reject, Reactor trips on TCV fast closure
- Emergency buses de-energize, diesels should start/load

Then Diesels fail to start and/or load

- Lose all AC powered loads (recirc pumps, etc...)
- Lose RPS MG Sets
- Group 1 Isolation

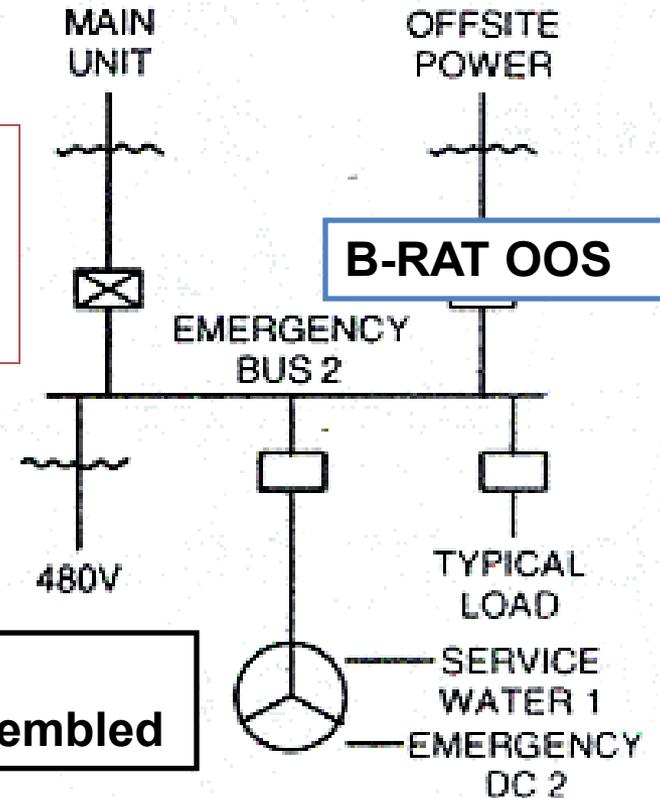
Can SBO Occur?

Vogtle Unit 1
Mode 6, Midloop
1990



Truck hits a tower in switchyard. Tower damages A-RAT.

4.16KV



B-EDG
Disassembled

A EDG starts, but does not continue to run.

- SBO for 36 minutes.
- RCS temperature increase 46 deg. F.

LEGEND

-  - CLOSED BREAKER
-  - OPEN BREAKER
-  - TRANSFORMER

Original Design

- An electrical distribution system in conformance with GDC 17 was once considered sufficient to protect health and safety of the public.
- GDC 17: independent onsite and offsite electrical sources where no single failure would prevent fulfillment of safety function
- The simultaneous loss of both the offsite and onsite sources of AC power (station blackout) was considered incredible and therefore was not considered in plant design or accident analysis.

Evolution of Issue

- **1975 Reactor Safety Study (WASH 1400)**
 - PRA showed SBO contribution to CDF was significant
- **1979 Commission Issued USI A-44 SBO**
 - Developed task action plan to evaluate likelihood and consequences of SBO events
- **1980 ASLB** changed construction permit for St. Lucie U-2:
 - SBO added to design bases.
 - Operator training.
 - Backfit for St. Lucie U-1

Evolution of Issue

- **GL 81-04** - Emergency Procedures and Training for Station Blackout Events:
 - Required licensees to verify the adequacy of or develop emergency procedures & operator training to better enable plants to cope with an SBO.
- **1988 NUREG-1032 Study of SBO**
 - 50.63 SBO Rule (more detail later)
 - REG Guide 1.155: Implementation of SBO rule including EDG reliability programs with target values.

SBO Rule –10 CFR 50.63

In addition to requiring reliability programs for on-site power sources and procedures for restoring on-site and offsite power, it required licensee's to:

- Perform a coping analysis and perform modifications (if needed) to ensure the plant could “cope” with a station blackout for a specific time duration.

OR

- No coping analysis required if Alternate AC source available within 10 minutes.

Alternate AC Source (10CFR50.2):

- Connectable but not normally connected to offsite or onsite emergency power systems.
- Minimum potential for common mode failure with offsite or onsite emergency power sources.
- Available in timely manner.
- Sufficient capacity and reliability for operation of all systems required for coping with SBO for time required to bring and maintain plant in safe shutdown (non-DBA).

SBO Rule –10 CFR 50.63

Coping time:

The time duration that a given facility must be capable of maintaining core cooling & containment integrity without AC power

Determined from the following factors:

- Emergency AC power configuration
- Independence of offsite power sources
- Frequency of severe weather
- Time to restore power following severe weather
- Diesel reliability

BWR Compliance w/ SBO Rule

Two major classifications of BWRs in terms of SBO strategy

1. BWR-2 and BWR-3 use isolation condensers for decay heat removal. Do **not** have makeup capability independent of AC power.
2. BWR-4, BWR-5 and BWR-6 use RCIC system and either:
 - HPCI system, or
 - High pressure core spray (HPCS) system with a dedicated diesel.

Either RCIC or HPCI/HPCS is adequate to remove decay heat from the core **and** control water inventory in the reactor vessel independent of ac power.

BWR Compliance w/ SBO Rule

- Most plants have 4 hour coping time
 - 8 hrs @ Peach Bottom, Pilgrim and Vermont Yankee
- Some plants made significant physical mods:
 - Dresden and Quad Cities added two new diesels
 - New batteries at LaSalle and Nine Mile Point
 - New battery chargers at Hatch
- Many plants made procedure changes for DC Load Shedding

Actions Following a SBO

EOPs

- Control level with RCIC (and HPCI)
- Control pressure with SRVs
- Cooldown at $< 100^{\circ}\text{F/hr}$

SBO AOP

- Attempt to restore diesels
- Contact system operator to restore offsite power
- Minimize DC loads to extend battery life

Other factors

- Lose AC lights, significant number of indicators, and card readers on security doors

Mitigating strategy during SBO

Without AC power:

- Major mitigating strategy is to cooldown in EOPs
- Will eventually lead to
 - battery depletion,
 - loss of decay heat removal (no DC to HPCI/RCIC)
 - Core uncover (SRVs to suppression pool)
 - Core melt
 - Containment breach (overpressure or electrical penetrations)
- Design basis accidents in conjunction with a SBO reduce time to core damage, containment failure and radioactive releases.

New Developments

- Maintenance Rule
 - Monitor all equipment important to safety, including EDGs
 - Assess risk, including severe weather
- MSPI
 - Compare Diesel Unavailability (UA) and Unreliability (UR) assumed in PRA with actual performance
 - Diesel UA and UR can result in greater than green PIs
- August 2003, Grid Events
 - 9 US & 8 Canadian units tripped.
- GL 2006-02
 - Procedures and protocols with TSOs concerning grid
 - Inspected annually by RIs (IP 71111.01)

New Developments

- March 2011 – Earthquake and tsunami led to major nuclear catastrophe at the Fukushima Dai-ichi power plants in Japan
 - Order Issued to mitigate an extended loss of AC power (beyond coping time)
 - Rule Making in progress which will codify the order.

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