POWER SYSTEM DESIGN AND STATION BLACKOUT (SBO) MANAGEMENT IN INDIAN FAST BREEDER REACTORS

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ABSTRACT : In the nuclear new builds and projects in design stage SBO management measures have significant role. Depending on the onsite and offsite power supply configurations, deterministic normal SBO duration is established. Design of systems with adequately sized battery capacities for SBO duration, special SBO Diesel Generator Sets, structured load shedding strategy to conserve battery availability to cope with SBO and to monitor the plant safety beyond SBO duration are considered as part of electrical system design now. This poster discusses the SBO management in Prototype Fast Breeder Reactor (PFBR) under construction and future FBRs under planning.

INTRODUCTION : SBO management measures involve the following major steps. 1) Establishing normal SBO duration , based on the redundancy of the onsite emergency AC power sources such as Diesel Generators (DGs) , the reliability of the onsite emergency ac power sources, the expected frequency of loss of offsite power and the probable time needed to restore offsite power. 2) Designing system with SBO DGs to support the designated loads beyond normal duration 3) Conservatively sizing battery back up duration for no break power systems and 4) Assuring the safety of the plant analyzing major requirements such as decay heat removal capability , spent fuel storage cooling , reactor vault cooling and top shield cooling for the extended SBO duration and ensuring robustness of the overall plant for SBO handling . This poster presents the SBO management measures taken in the 500MWe PFBR under construction and measures considered at the preliminary design stage of 2X600MWe FBRs under planning.

500MWe PFBR SBO MANAGEMENT:

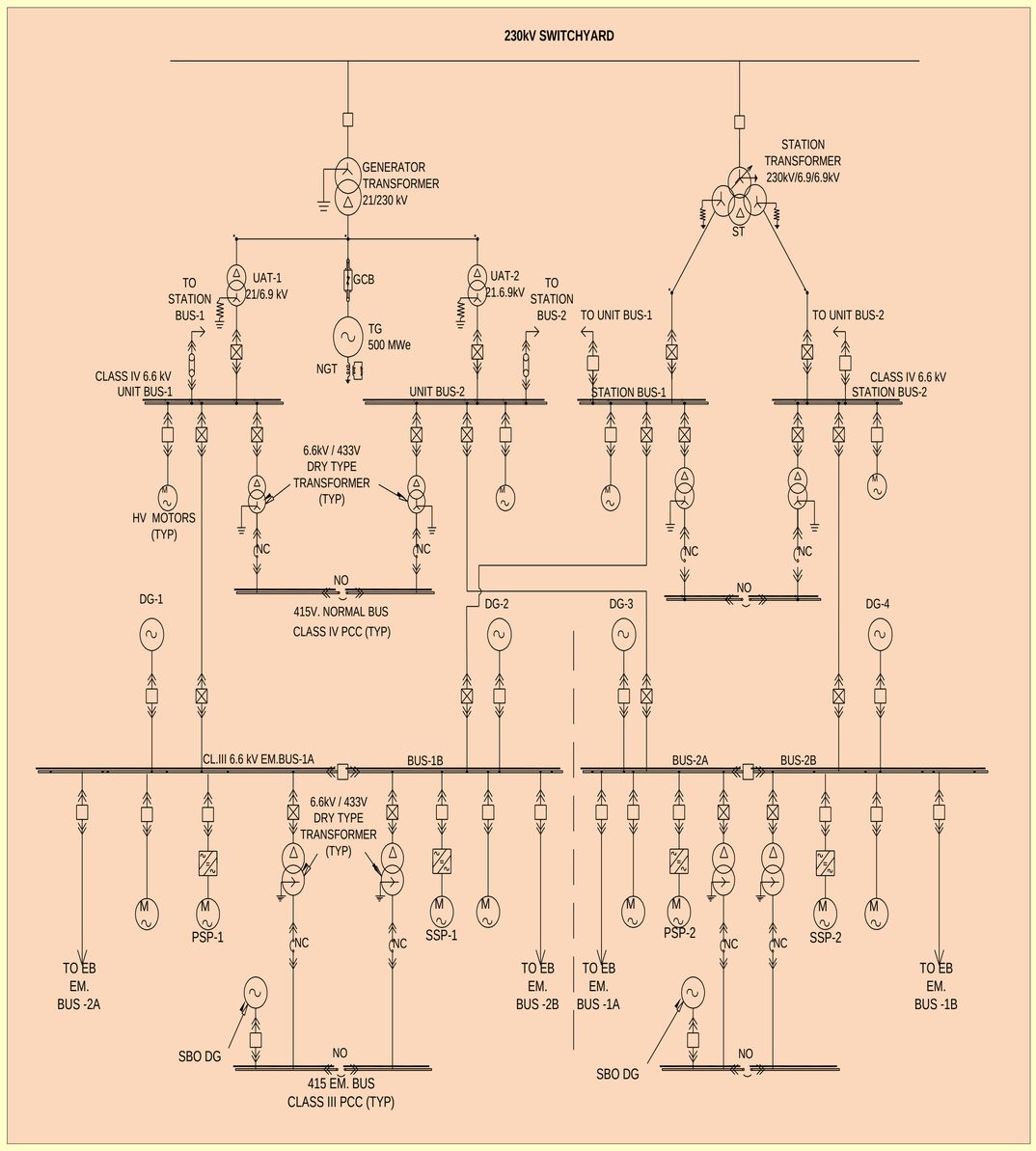
Normal and Emergency Power Supply Configurations: The transmission voltage is 230kV.Normal Class IV supply system derives the power from the grid through a 230/6.9 kV station transformer& from the grid through 230/21 kV generator transformer and two 21/6.9 kV unit auxiliary transformers with the generator circuit breaker in the open position; (or) From the terminals of main generator through two numbers 21/6.9 kV unit auxiliary transformers with the generator circuit breaker in the closed position. Both the offsite supply to the plant are from 230kV system . Class III AC emergency power supply system has two independent 6.6kV divisions in line with the nuclear steam supply systems. Each division arranged in two sections has normal Class IV supply and standby DG for each section . DGs can meet the plant load requirements for 7 days with the design fuel storage capability .

Deterministic SBO Duration: 2 DGs are required only as a third level of defense in depth to operate AC powered decay heat removal systems but 4 DG sets are provided. On detailed fault tree analysis the reliability of one DG is calculated as 0.978 . The PFBR offsite power supply independence and for severe weather group/severe weather recovery/extreme severe weather, data is available for 35 years for the site . Using these inputs in line with USNRC Regulatory Guide 1.155 - Station Blackout, the deterministic SBO duration established is 4h.

System Capabilities: Passive decay heat removal system is used in the plant. The shutdown systems, decay heat removal and containment isolation systems are not dependent on emergency AC power. Under a station blackout situation, the decay heat after reactor trip is not a concern as air is used as the ultimate heat sink and the system functions on natural convection. From the analysis, it found that the decay heat removal operation can be continued for more than 10 days without any risk of sodium freezing. Spent fuel storage cooling and reactor vault temperature and top shield temperature limits are maintained well beyond 10 days .Hence Core cooling and spent fuel bay cooling are preserved for extended worst case SBO duration without challenging the associated systems design limits even for 10 days of SBO.

Battery Capabilities : However , the batteries are sized to meet 1h Instrumentation and Control (I&C) system full loads, 4h designated loads and 24 h to meet very essential loads to monitor the plant safe condition. In addition, the reactor coolant pony motor and auxiliaries are provided with a dedicated battery banks sized for 4h SBO duration to assist further in the initial period of shut down .

SBO DGs: Based on the current trends after Fukushima event two additional small capacity air cooled SBO DGs are provided. They can supply the battery backed systems and other important systems for 3 days.



Normal & Emergency Power Supply Scheme for PFBR

PROPOSED 2X600MWe FBRs SBO MANAGEMENT:

Normal and Emergency Power Supply Configurations: The transmission voltage will be 400kV. The two independent offsite supply to the plant are from independent 400kV and 230kV systems. The plant normal and emergency power supply system configurations will be similar to PFBR.

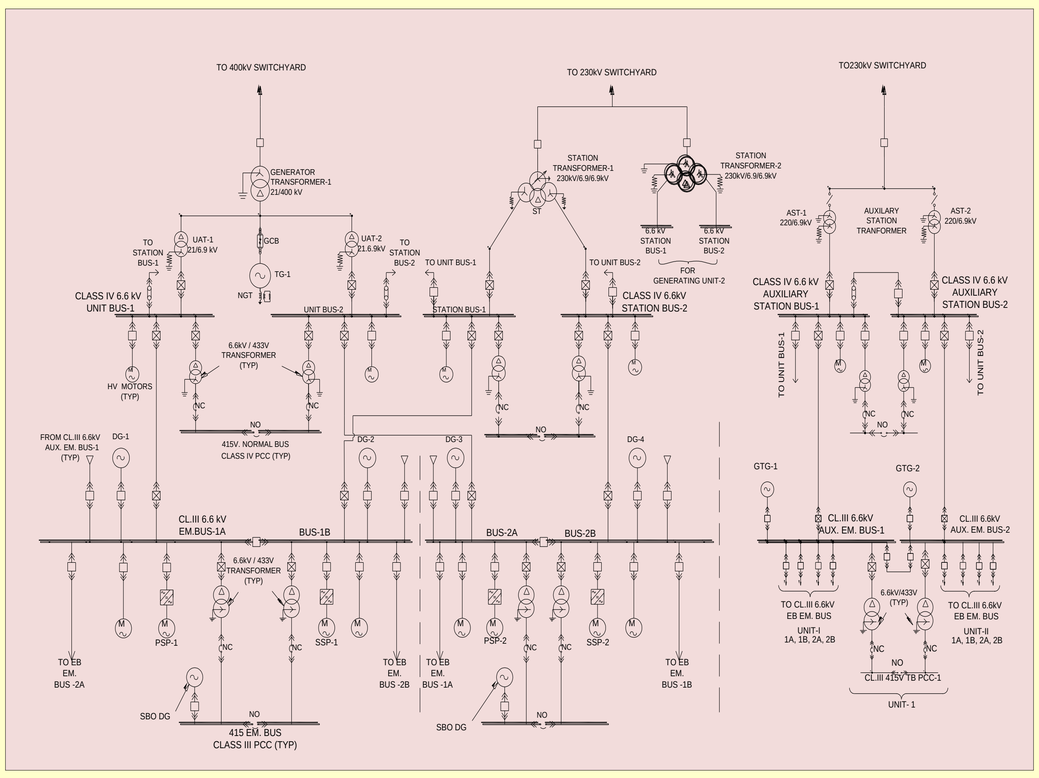
Deterministic SBO Duration: This is similar to PFBR. Using the available site data and proposed normal and emergency power supply system configurations conservatively in line with USNRC Regulatory Guide 1.155 - Station Blackout, the deterministic SBO duration established is 4h

System Capabilities: The shut down systems **,** decay heat removal systems, containment isolation systems, spent fuel storage bays will have enhanced SBO withstand capability compared to PFBR.

Battery Capabilities : However , the batteries are sized to meet 1h Instrumentation and Control system full loads, 4h designated loads and 24 h to meet very essential loads to monitor the plant safe condition . In addition, the reactor coolant pony motor and auxiliaries are provided with a dedicated battery banks sized for 4h SBO duration to assist further in the initial period of shut down . The back up duration enhancements will be done for further system availability during detailed design .

Alternate AC Power Supply System: This will be separate power supply system with offsite connection at 230kV level and with Gas Turbine generator back up source for seven days at Class III 6.6 kV level which can meet one division of Class III emergency power supply system requirement in addition to other designated loads .

SBO DGs: Based on the current trends after Fukushima event two additional small capacity air cooled SBO DGs are provided . They can supply the battery backed systems and other important systems for 3 days.



Normal & Emergency Power Supply Scheme for FBRs

SUMMARY : SBO management is one of the important aspect in assuring safety of nuclear power plants. SBO management is given due importance during design and implementation of FBR systems in India. Deterministic SBO duration is established . Conservative and robust power supply system configurations , different types of standby power sources , adequate battery autonomy time for I&C loads are provided . Nuclear system design and analysis assuring the safety of the plant addressing requirements such as decay heat removal capability , spent fuel storage cooling , reactor vault cooling and top shield cooling etc. are meticulously taken care for extended SBO duration .