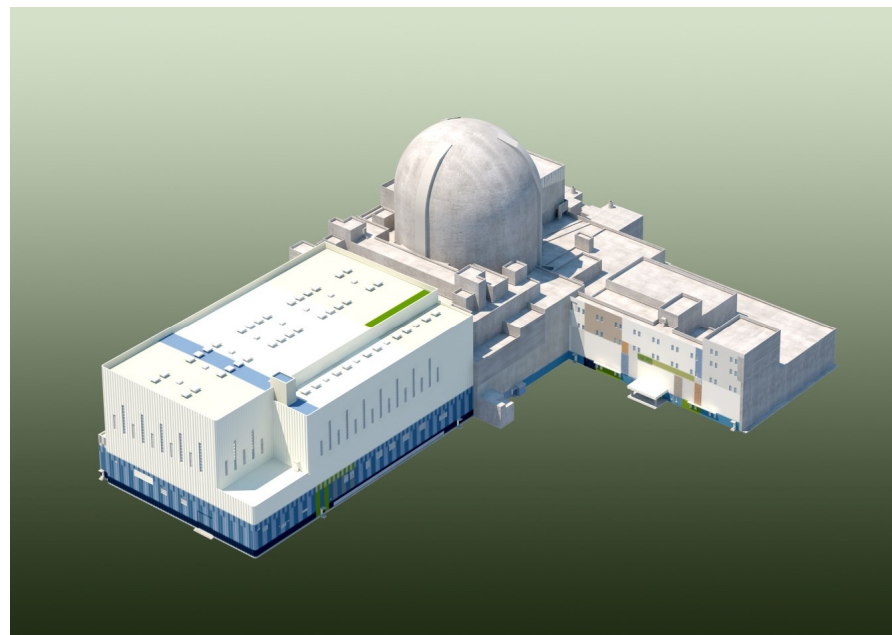


APR 1400 Electrical System Design



KEPCO/KHNP

Apr. 20~21. 2016

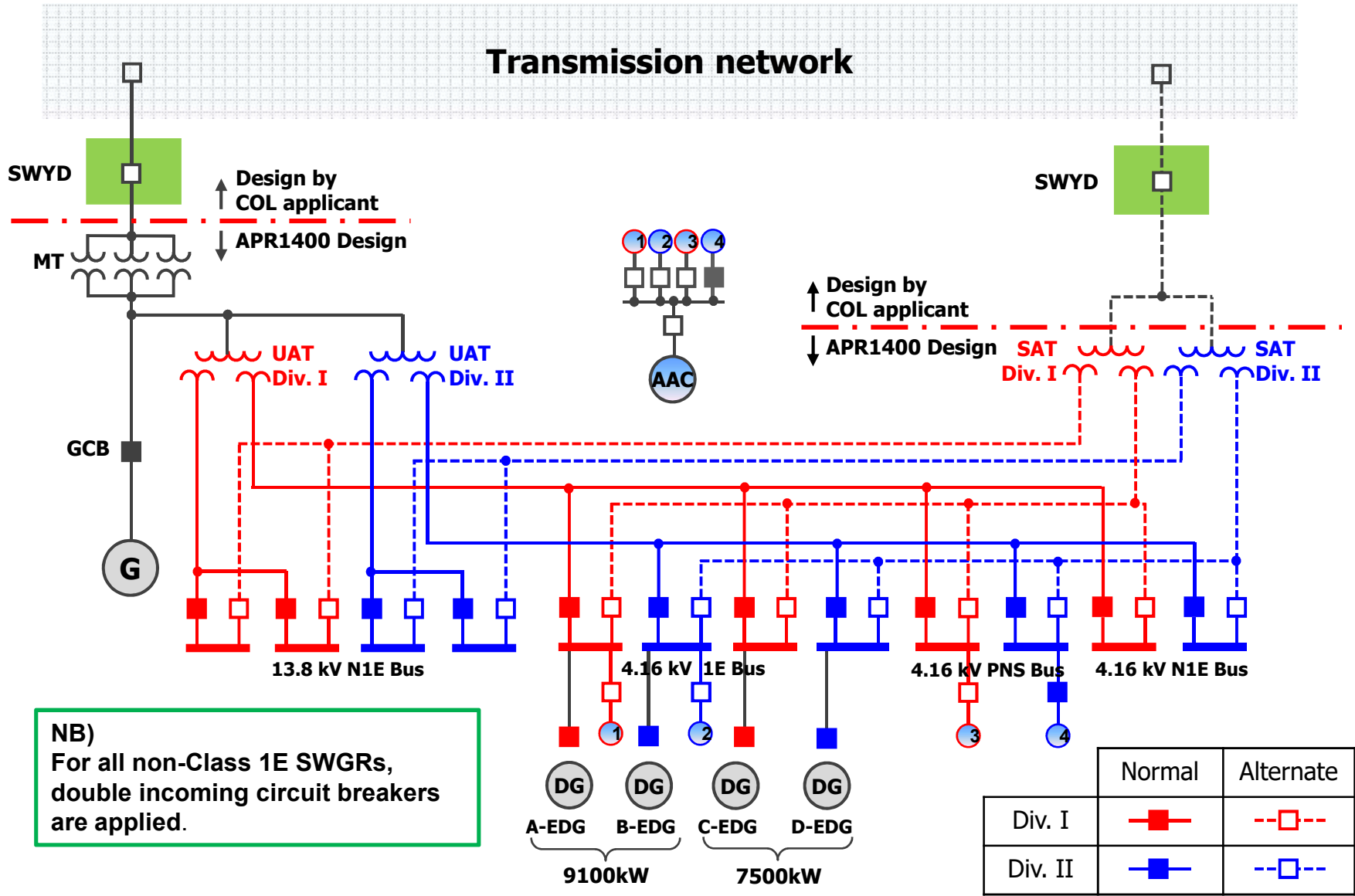
ACRS Meeting (Apr.20-21. 2016)

Contents

- **Introduction**
- **Design Features**
 - **Offsite Power System**
 - **Onsite Power System (AP, EDGs, AAC, DC and IP systems)**
- **Summary**
- **Q&A**



Design Features – Offsite Power System



ACRS Meeting (Apr.20-21. 2016)

Design Features – Offsite Power System

❖ Design Requirements – 10CFR50, Appendix A (GDC) 17

- Sufficient capacity and capability for all safety functions
- Two physically independent circuits
- Available in sufficient time following loss of all other ac power. One circuit shall be available within a few seconds following a loss-of-coolant accident (LOCA).

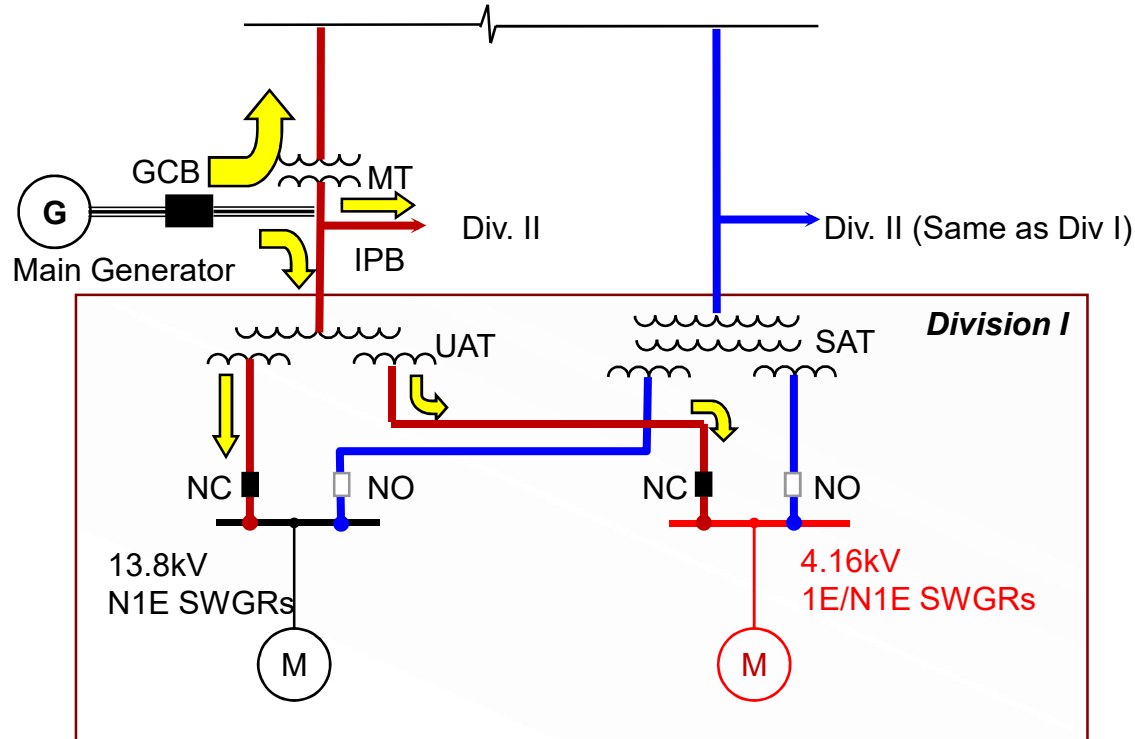
❖ Transmission network and Switchyard

- Not in the scope of the APR 1400 design.
- The transmission network should include **at least two physically independent circuits with sufficient capacity and capability** for the APR 1400. The COL applicant is to identify and provide information on the transmission circuits.
- The plant switchyard design is site-specific and not within the scope of the APR 1400 design. The COL applicant is to address the detailed design and required analyses including FMEA.

Design Features – Offsite Power System

❖ Offsite Power System Components and Circuits

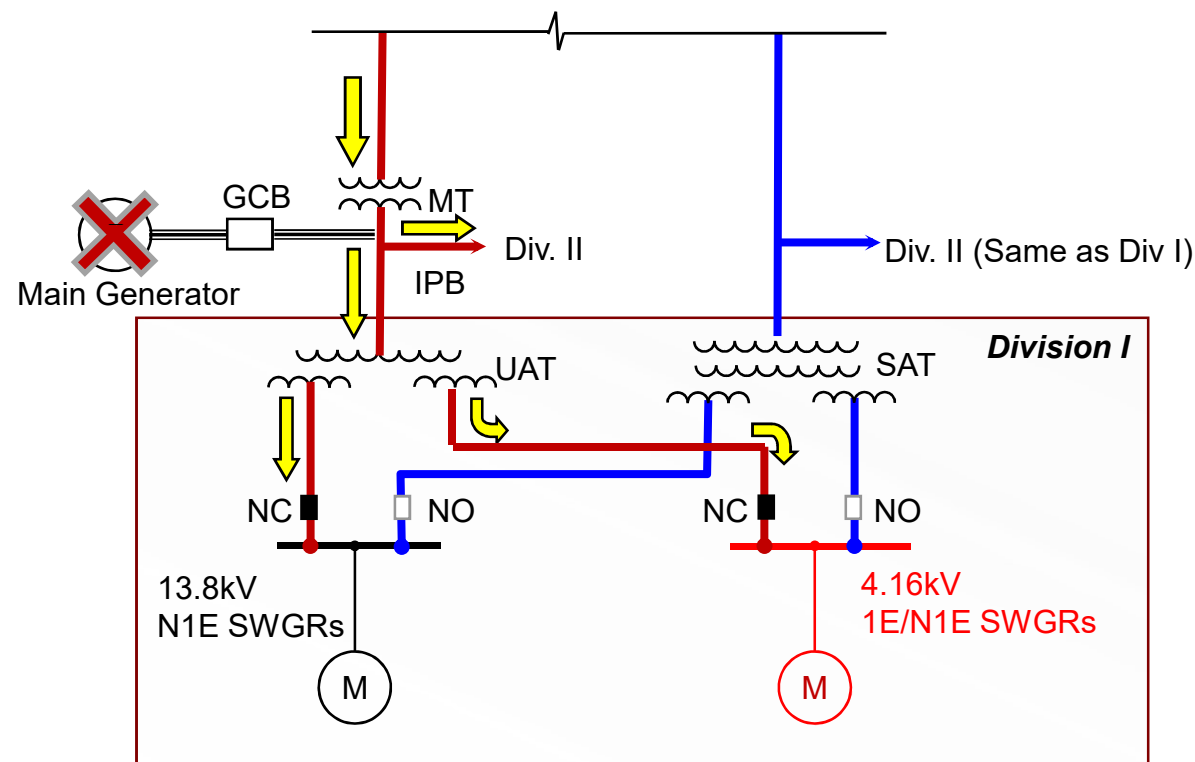
- During **normal operation**, MG generates electric power and delivers the generated output to transmission system and the station auxiliary loads.



Design Features – Offsite Power System

❖ Offsite Power System Components and Circuits (cont.)

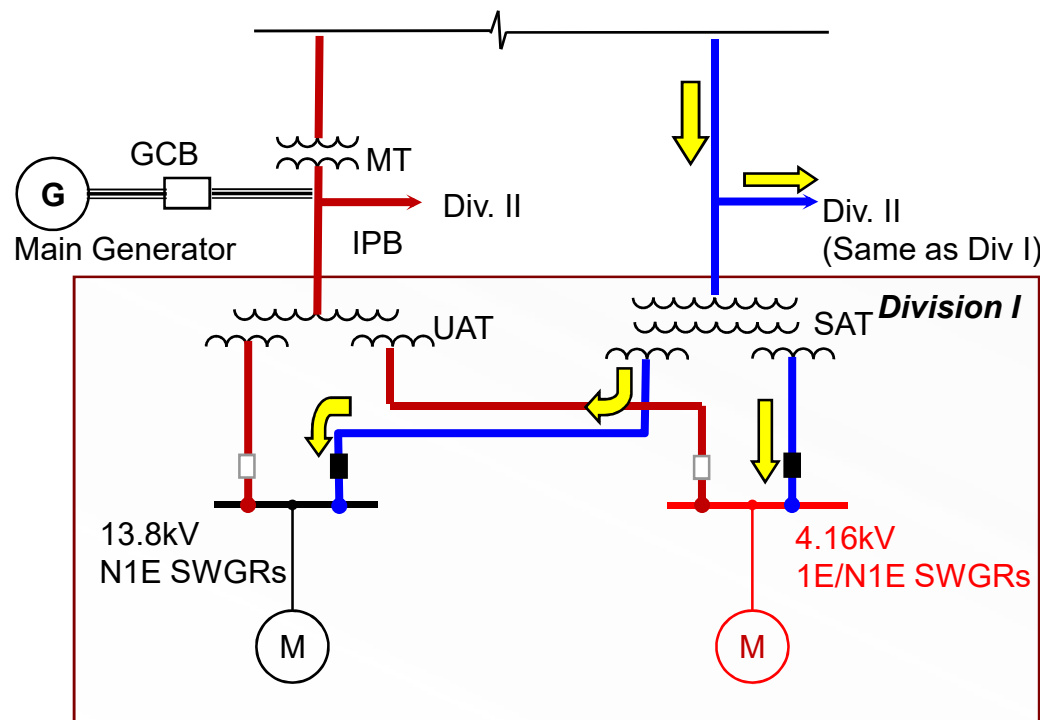
- In case **MG is failed or not in service**, normal path of offsite power supply is secured by tripping/opening GCB (offsite power supply is available without interruption).



Design Features – Offsite Power System

❖ Offsite Power System Components and Circuits (cont.)

- In the event of **fault at normal offsite power circuit**, offsite power supply to plant auxiliaries is switched to alternate path by **automatic bus transfer** (fast or residual voltage bus transfer); alternate path is available, normally, within 1 second.



- ✓ **Fast transfer:** automatic; within 100ms; transfer permitted if the voltage and angle differences between the switchgear bus and alternate PPS source is expected within the acceptable limits (per NEMA C50.41)
- ✓ **Residual voltage transfer:** automatic; back-up transfer to fast transfer.

Design Features – Offsite Power System

- ❖ Separation between normal and alternate PPS's

**Security-Related Information – Withhold
Under 10 CFR 2.390**

Design Features – Onsite Power System

❖ Auxiliary Power System

- Main components: MV SWGR, LV L/Cs, MCCs, EDG and AAC GTG systems, and associated protection system.
- **Sufficient independence, redundancy, and testability** is required to perform their safety functions assuming a single failure ([GDC 17](#)).
- Consists of two divisions (Div. I and Div. II). In particular, the Class 1E AP system consists of four trains (A,B,C, and D) and each two trains (A plus C and B plus D) constitutes Div. I and Div. II, respectively.
- Located in separate rooms and different fire areas with adequate independence to provide reasonable assurance for plant safety assuming a single failure.

Design Features – Onsite Power System

❖ Emergency Diesel Generators (EDGs)

- Four Class 1E EDGs are designed, each corresponding to each train, to cope with a LOOP(loss of offsite power) or a LOOP concurrent with a DBA.
- Each EDG division, Div. I (Train A plus C) or Div. II (Train B plus D) has sufficient capacity and capability to supply emergency loads for safe shutdown during a LOOP concurrent with a DBA.
- Each of EDG Train A and B is capable of supplying sufficient power for decay heat removal and a safe shutdown during a LOOP.
- Each EDG is rated to have a continuous load rating plus margin, and sized to accelerate all of the loads in the loading sequence without exceeding the allowable voltage and frequency limits stated in [RG 1.9](#):
 - ✓ 9,100 kW for Train A and Train B;
 - ✓ 7,500 kW for Train C and Train D.

Design Features – Onsite Power System

❖ Emergency Diesel Generators (EDGs) (cont.)

- Each Class 1E EDG automatically starts independently on a starting signals (e.g. loss of voltage, SIAS, CSAS, AFAS) and accepts loads in sequential manner by independent load sequencing logic.
- EDG design and performance requirements conform to [RG 1.9](#) and [IEEE 387](#).
- Each EDG unit has minimum reliability target, 0.95, in accordance with [RG 1.9](#) and [RG 1.155](#).
- Each EDG is housed in a separate room of seismic Category I buildings that is provided with an independent source of ventilation air and a fire protection system.

Design Features – Onsite Power System

❖ Alternate AC Gas Turbine Generator

- Provides alternate ac power to bring and maintain the plant to safe shutdown condition during an SBO ([10CFR50.63](#)).
- GTG is selected as the AAC source for diversity to EDGs.
- Started and manually aligned to a shutdown bus, Train A or Train B, from MCR/RSR within 10 minutes from the onset of an SBO condition.
- SBO coping duration: **16 hours** according to the methodology of [RG 1.155, Regulatory Position C.3.1](#).
- Physical separation
 - ✓ Connection from the AAC-GTG to the shutdown buses via two normally open circuit breakers (Appendix B of [RG 1.155](#))
 - ✓ Cables from AAC-GTG to the shutdown buses are separate from the cables from the PPS sources.

Design Features – Onsite Power System

❖ Alternate AC Gas Turbine Generator (cont.)

- Supply non-safety essential loads at PNS bus during a LOOP
- Other characteristics
 - ✓ Reliability: 0.95 (per NSAC-108)
 - ✓ Rating: 9,700 kW - for SBO loads (8,689 kW) and PNS loads (6,074 kW)

❖ Connection Provisions for mobile generators



Design Features – Onsite Power System

❖ DC and IP (Instrumentation & Control Power) System

	DC System	IP System
Function	Supplies reliable 125Vdc and 250Vdc* power to various plant non-safety and safety equipment. <i>*Non-Class 1E only</i>	Supplies reliable vital 120V ac power to plant safety and non-safety I&C equipment.
System Components	Battery, Battery Charger and Distribution Panel	Inverter, Regulating Transformer, Automatic/Manual Transfer Switch and Distribution Panel
Division and Train	Class 1E: four trains (Train A,B,C, and D) → <u>Layout of DC/IP system component</u> Non-Class 1E: two divisions (Div. I and II)	
Major loads	Motor operated valves; Solenoid for pneumatic valves; NSSS and BOP control and instrumentation systems; IP inverter; Turbine/generator emergency loads; DC emergency lighting system	Safety Consoles; Plant Protection System (PPS); ESF-CCS and P-CCS; Information Processing System (IPS); Qualified Indication and Alarm System (QIAS).

Design Features – Onsite Power System

❖ DC and IP (Instrumentation & Control Power) System (cont.)

- For each Class 1E train, redundant battery chargers are designed, that is **N+1 design for each train**, thereby allowing for OLM (on-line maintenance) of a battery charger without degraded operation below LCO condition.
- For non-Class 1E, one spare battery charger is commonly used for four different battery chargers.
- Each division of the Class 1E 125Vdc batteries has adequate capacity, without chargers, to provide the necessary dc power to perform the required safety functions.

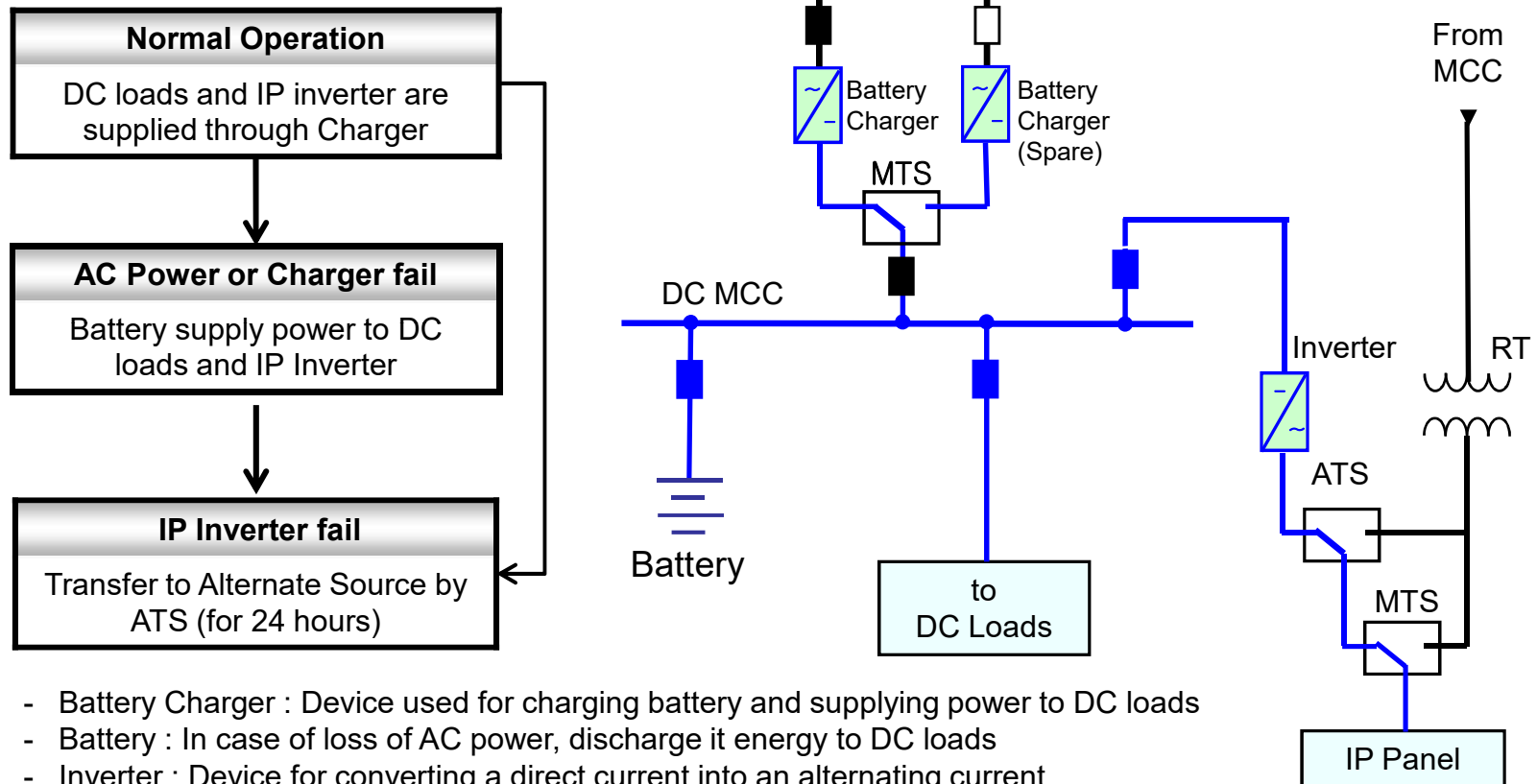
[

TS
)

Design Features – Onsite Power System

❖ DC and IP (Instrumentation & Control Power) System (cont.)

▪ DC and IP Conceptual Diagram



- Battery Charger : Device used for charging battery and supplying power to DC loads
- Battery : In case of loss of AC power, discharge it energy to DC loads
- Inverter : Device for converting a direct current into an alternating current
- ATS/MTS : Automatic/Manual Transfer Switch
- RT(Regulating Transformer) : At any problems in Inverter or DC system, RT supply power to vital loads

Summary

- ❖ **APR 1400 Electrical System** is designed in accordance with US NRC regulatory requirements, properly meets its endorsed codes & standards, and therefore provides reasonable assurance of reliable operation of the plant and safety functions for the plant.