RESPONSE TO REQUEST FOR ADDITIONAL INFORMATION

APR1400 Design Certification

Korea Electric Power Corporation / Korea Hydro & Nuclear Power Co., LTD

Docket No. 52-046

RAI No.:	**16-7915**
SRP Section:	**08.01 – Electrical Power – Introduction**
Application Section:	**08.01**
Date of RAI Issued:	**05/22/2015**

Question No. 08.01-1

In DCD Tier 2 Section 8.1, the applicant described briefly the offsite and onsite power distribution system of the plant and referenced the Single Line Diagram Figure 8.1-1 (2 pages). These descriptions are further provided in DCD Sections 8.2 and 8.3.

The staff noted in the above descriptions and drawings that the medium voltage ac distribution system will be designed to supply power to the safety loads from the normal power source. i.e., unit auxiliary transformers (UAT), and in case of loss of power from the UAT, the safety loads will be automatically transferred to the station auxiliary transformers (SAT). The primary voltage windings of the two UATs are connected to the main generator (MG) Isophase Bus (IPB) between the generator circuit breaker (GCB) and the main transformer (MT), for obtaining auxiliary power for plant loads during normal operation. Each UAT and SAT has two secondary voltage windings, rated 13.8 kV and 4.16 kV. From Figure 8.1-1 it is noted that the 13.8 kV winding of each UAT and SAT is connected to non-Class 1E buses. The 4.16 kV winding is connected to 4.16 kV safety-related Class 1E buses, as well as permanent non-safety buses. In accordance with SECY-91-078, “EPRI’s Requirements Document and Additional Evolutionary LWR Certification Issues,” (NRC,1991, ADAMS ML072150592), offsite power shall be directly supplied to the Class 1E emergency power supply safety-related buses without any intervening non-Class 1E buses. SECY 91-078 states that the design should include:

• at least one offsite circuit to each redundant safety division (that) should be supplied directly from one of the offsite power sources with no intervening non-safety buses in such a manner that the offsite source can power the safety buses if any non-safety bus should fail.

• an alternate power source to non-safety loads, unless it can be demonstrated that existing design margins will ensure that transients for loss of non-safety power events are no more

severe than those associated with the turbine-trip-only event specified in current plant designs.

The staff noted that both Class 1E and non-class 1E buses are connected to the same UAT, and similarly for the SAT, rendering the emergency Class 1E buses/switchgear vulnerable to potential failure due to a failure of the non-Class 1E bus/switchgear. In addition, the safety loads could be subjected to transients caused by the non-safety loads, and adds additional failure points between the offsite power sources and the safety loads. Therefore, the staff finds that the proposed design does not meet the SECY-91-078 requirements.

Furthermore, 10 CFR Part 50, GDC 17 requires, in part, that the onsite electrical distribution system shall have sufficient independence, redundancy, and testability to perform their safety functions assuming a single failure. The proposed design does not provide capability to minimize the probability of losing electric power at the safety bus, since there is potential that the Class 1E buses are vulnerable to potential failures as a result of failures of the non-Class 1E buses. Therefore, the staff finds that the proposed design does not meet the GDC 17 requirement. Furthermore, Standard Review Plan (SRP) Chapter 8.2, Acceptance Criterion 4, and Chapter 8.3, Acceptance Criteria 4J, discuss this requirement.

Since this configuration of the power distribution system does not meet the requirement of the SECY-91-078 and GDC 17, the staff finds this power distribution arrangement unacceptable because connecting both non-safety and safety system to common transformer windings compromises the safety system reliability with no electrical separation. According to the above SECY and per GDC 17, the staff's position is that at least one offsite circuit to each redundant safety division should be supplied directly from one of the offsite power sources (UAT or SAT), with no intervening non-safety buses, in such a manner that the offsite source can power the safety buses upon a failure of any non-safety bus.

Based on the above discussion, please provide:

a) A power distribution configuration that meets the requirement of SECY-91-078, and GDC 17, such that the failure of the non-safety bus/switchgear does not adversely impact the Class 1E Emergency Power Bus/Switchgear.
b) Revised single line diagrams and descriptions in DCD chapters that reflect any changes in the power distribution systems.

Response

KHNP considers the current design configuration of the electrical power distribution system to the Class 1E buses complies with GDC 17 and SECY-91-078 with the following observation and design enhancements for the concerns that the staff identified in the RAI question.

The APR1400 offsite power system is designed in accordance with IEEE Std. 765, which provides detail design guidance and design criteria to properly meet GDC 17. In particular, the APR1400 adopts the enhanced preferred power supply (PPS) design mentioned in Subsection 4.5.c) of IEEE Std. 765.

Two physically independent PPS circuits are directly connected to Class 1E medium-voltage (MV) buses: one through the main transformer (MT) and unit auxiliary transformers (UATs) and the other through standby auxiliary transformers (SATs). During normal operation, the Class 1E and non-Class 1E MV buses are supplied from UATs, connected to the MT. In case of a loss of power from the UATs, the Class 1E and non-Class 1E MV buses are automatically transferred to the SATs.

Each UAT and SAT has a 13.8 kV and a 4.16 kV winding on the secondary side. The 13.8 kV winding is connected to two non-Class 1E 13.8 kV buses and the 4.16 kV winding is connected to two Class 1E 4.16 kV buses, one non-Class 1E 4.16 kV bus and one permanent non safety 4.16 kV bus.

Since each PPS circuit connects directly to redundant 4.16 kV Class 1E buses, failure of a non-Class 1E bus does not prevent the PPS circuit from supplying the offsite power to the Class 1E buses, provided the failure is properly isolated by the protective devices.

Therefore, the Class 1E buses are not subject to potential failure due to a failure of the non-Class 1E buses since the non-Class 1E electrical equipment is designed to preclude adverse effects on Class 1E electrical equipment due to its failure during normal, accident, or post-accident modes of plant operation and each Class 1E and non-Class 1E buses are protected by properly coordinated Class 1E and non-Class 1E protection devices as described in DCD Tier 2 Chapter 8, Subsection 8.1.3.2.j and Subsection 8.3.1.3.4.

KHNP also recognizes that in case of a specific failure, e.g. fail-to-open of the bus incoming breaker upon the fault at a non-Class 1E MV bus, the fault effect could propagate to the Class 1E buses which are fed from the same SAT or UAT as the faulted non-Class 1E bus.

In order to preclude this potential risk, KHNP is implementing the following design enhancement to the incoming breakers at the non-Class 1E MV buses:

a) Two independent circuit breakers (thus, doubling the incoming breakers), connected in series, are used as a set of incoming breakers for all non-Class 1E 13.8 kV and 4.16 kV switchgears. This design enhancement significantly reduces the probability of failure of the non-Class 1E incoming breakers in case of a bus fault.
b) Of the two independent circuit breakers, only one circuit breaker will be used for switching operation as well as protection while the other only for protection.

c) To avoid a common cause failure of the two circuit breakers, each circuit breaker will be independent from the other, both physically and functionally, and will have its own protective relaying provisions.

The design configuration of APR1400 electrical power distribution system with the above enhancements meets the requirements of availability of the offsite power supply to Class 1E buses as specified in GDC 17 and properly addresses the staff's position in accordance with SECY-91-078.

The enhanced electric power distribution configuration and descriptions in the APR1400 DCD are provided as an attachment.

Impact on DCD

DCD Tier 1 Figure 2.6-1 and relevant sections of Tier 2 Chapter 8 will be revised as shown in the attachment.

Impact on PRA

There is an impact on the PRA. However, it is minor and will not impact risk insights. This impact will be reflected in the next revision of the PRA.

Impact on Technical/Topical/Environmental Reports

There is no impact on any Technical, Topical and Environmental Reports.

Impact on Technical Specifications

There is no impact on the Technical Specifications.

APR1400 DCD TIER 1

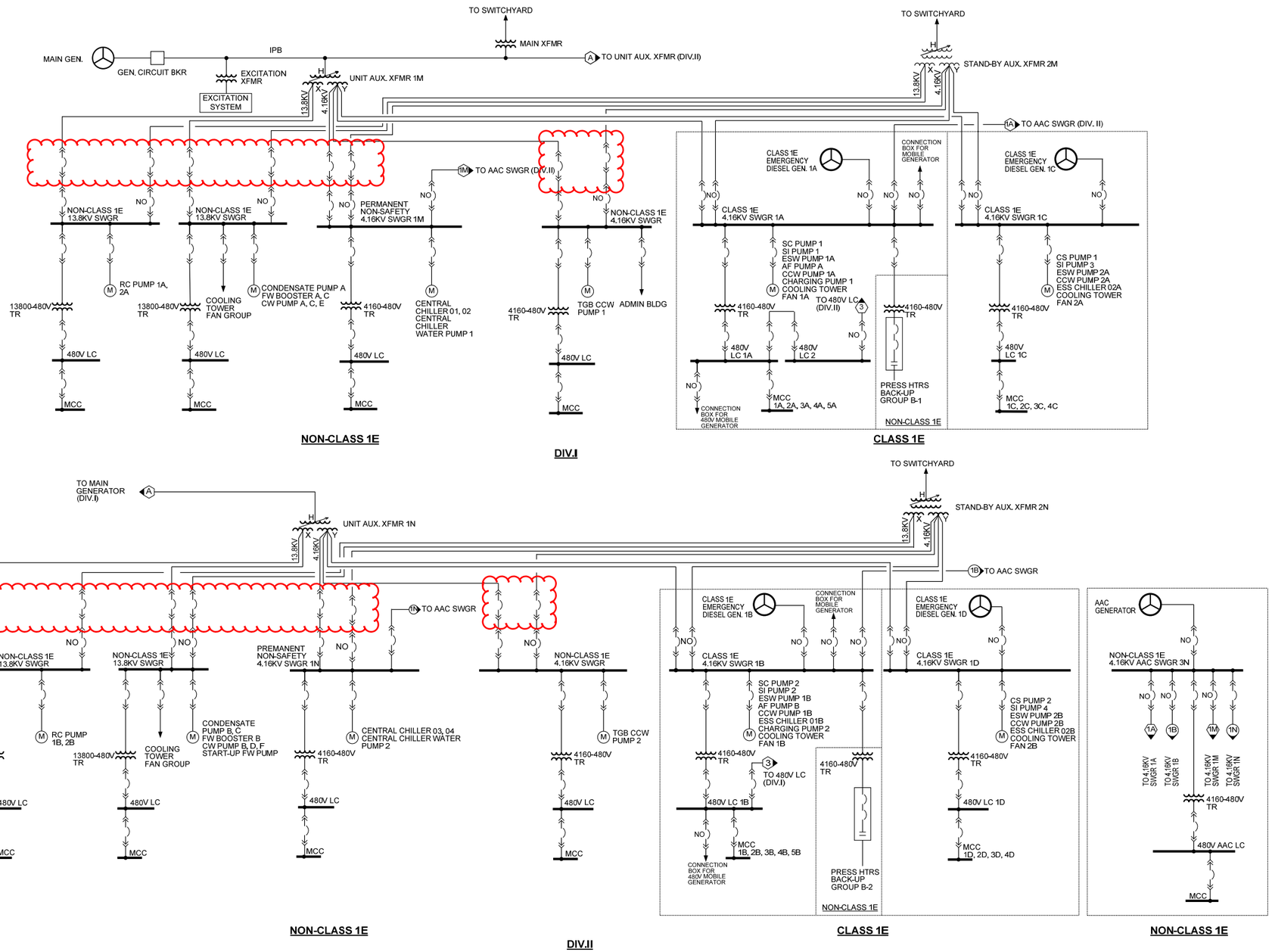
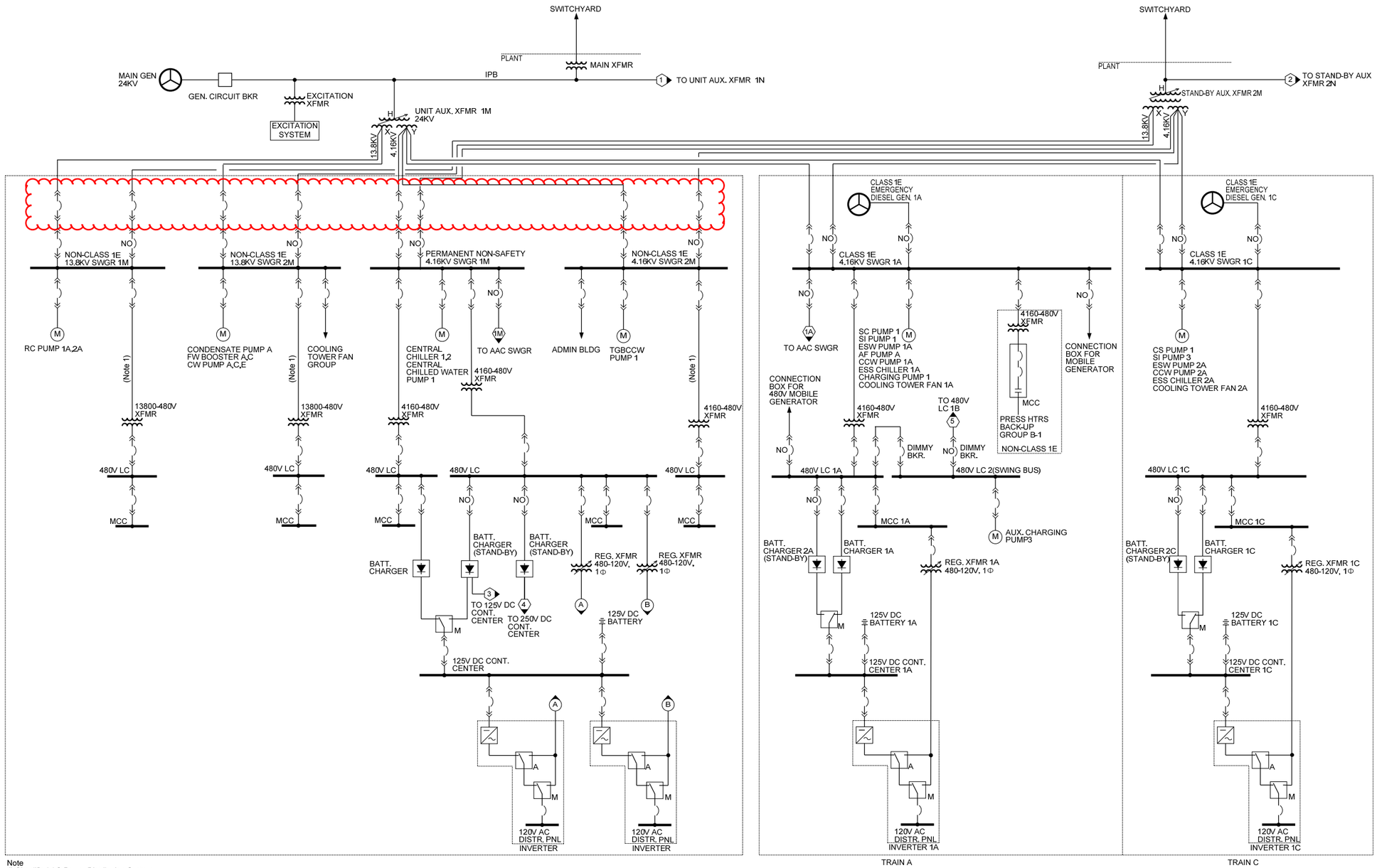


Figure 2.6.1-1 AC Electrical Power Distribution System

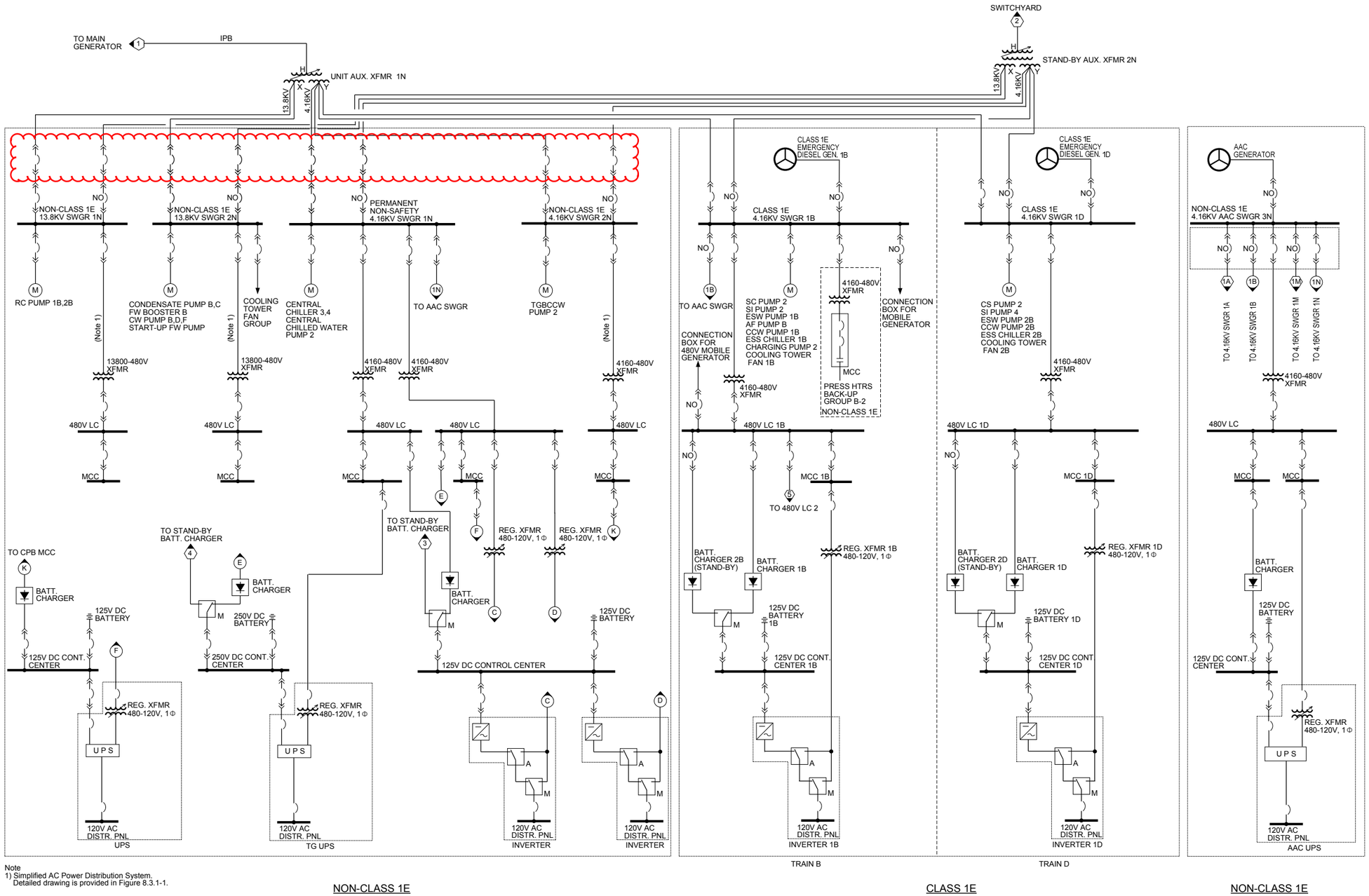
APR1400 DCD TIER 2



Note
1) Simplified AC Power Distribution System.
Detailed drawing is provided in Figure 8.3.1-1.

Figure 8.1-1 Electric Power System Single Line Diagram (Division I) (1 of 2)

APR1400 DCD TIER 2



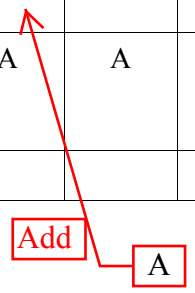
Note
1) Simplified AC Power Distribution System.
Detailed drawing is provided in Figure 8.3.1-1.

Figure 8.1-1 Electric Power System Single Line Diagram (Division II) (2 of 2)

Table 8.1-2 (7 of 8)

Criteria		DCD Section				Remarks
		8.2	8.3.1	8.3.2	8.4	
6. Commission Papers (SECY)		Requirements				
SECY-90-016	Evolutionary Light Water Reactor Certification Issues and Their Relationships to Current Regulatory Requirements, 1990	A	A		A	
SECY-94-084	Policy and Technical Issues Associated with the Regulatory Treatment of Non-Safety Systems in Passive Plant Designs, 1994					Not applicable
SECY-95-132	Policy and Technical Issues Associated with the Regulatory Treatment of Non-Safety Systems (RTNSS) in Passive Plant Designs, 1995					Not applicable
SECY-91-078	EPRI's Requirements Document and Additional Evolutionary LWR Certification Issues, 1991	A				
SECY-12-0025	Proposed Orders and Requests for Information in Response to Lessons Learned from Japan's March 11, 2011, Great Tohoku Earthquake and Tsunami		A	A		
SECY-05-0227	Final Rule –AP1000 Design Certification, 2005					Not applicable

(A) Requirements and criteria provided in the subject document are applied to the noted section.



8.3.1.1.1 Non-Class 1E Onsite AC Power System

There are two 3-winding UATs and two 3-winding SATs in the APR1400, and each transformer provides 13.8 kV and 4.16 kV power. During normal plant operation, two non-Class 1E 13.8 kV switchgears, one non-Class 1E 4.16 kV switchgear, and one PNS 4.16 kV switchgear are powered from a UAT in each division. One non-Class 1E AAC 4.16 kV switchgear can be aligned to either of PNS 4.16 kV switchgears.

The AAC GTG is automatically started by a starting signal from an undervoltage relay and supplies power to two PNS buses (division I and division II) manually during a LOOP. The loads that are not safety-related, but require operation during a LOOP, are connected to these buses manually. The AAC source is provided with diverse starting mechanisms compared to the Class 1E EDG. The AAC source is selected to minimize common-mode failures with the Class 1E EDG. The AAC source rating is adequate to meet the load requirements shown in Tables 8.3.1-4 and 8.3.1-5 during an SBO or LOOP conditions.

Add double

The incoming circuit breakers to the non-Class 1E 13.8 kV and 4.16 kV buses are provided with undervoltage and timed overcurrent protections. The feeders on 13.8 kV and 4.16 kV buses are provided with instantaneous and timed overcurrent protection.

Load center transformers are connected to 13.8 kV or 4.16 kV switchgears and provide power to 480V load center buses. The non-Class 1E MCC buses are connected to the non-Class 1E load center buses.

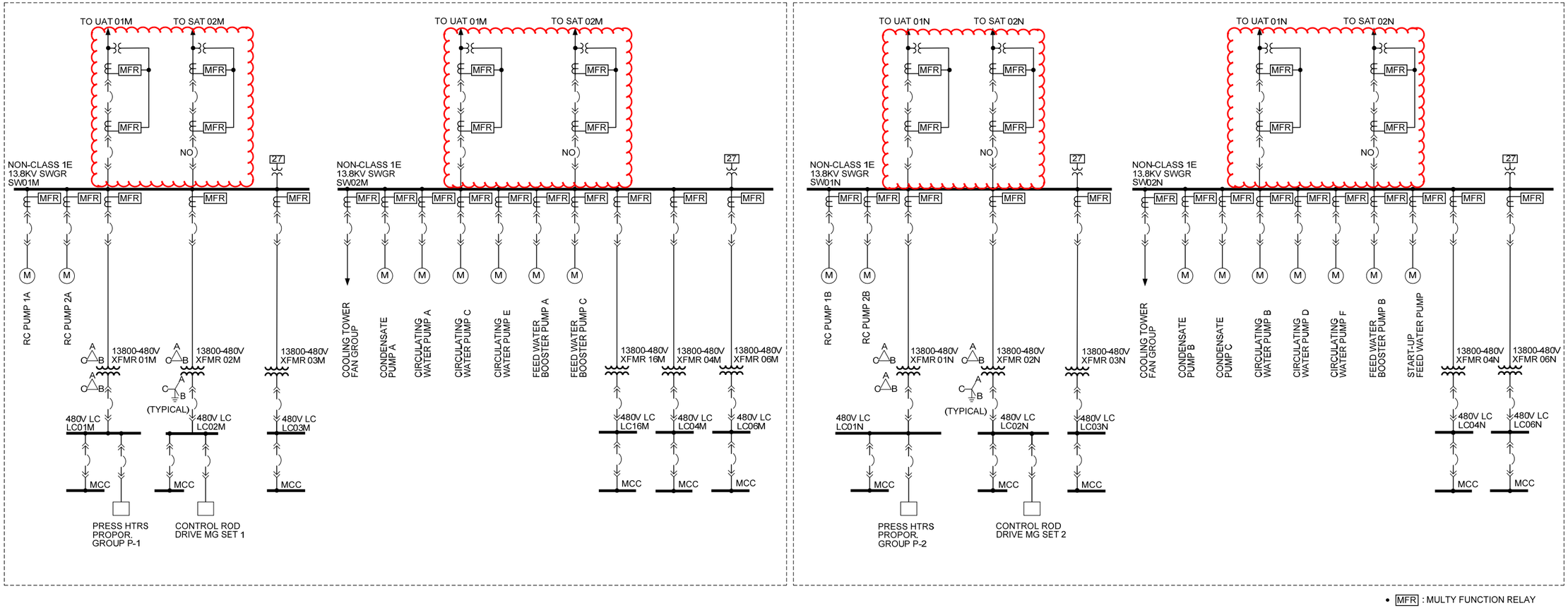
8.3.1.1.1.1 13.8 kV Onsite AC Power System

The 13.8 kV onsite ac power system consists of four non-Class 1E switchgears and supplies power to large motors such as the reactor coolant pump motors, condensate pump motors, feedwater booster pump motors, circulating water pump motors, startup feedwater pump motor, and associated 480V load centers.

Preliminary fault studies under bounding conditions are performed using IEEE Std. 141 (Reference 1) to determine the fault levels.

Add

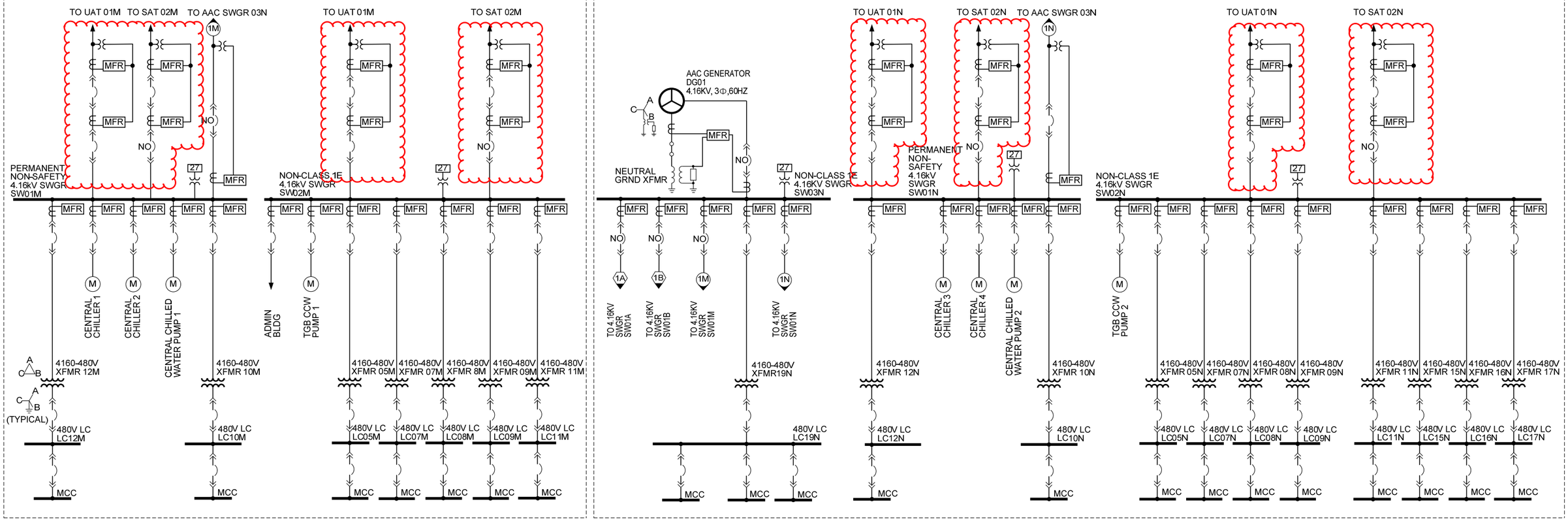
Two independent circuit breakers (referred to as double incoming circuit breakers), connected in series, are used as a set of incoming breakers for all non-Class 1E 13.8 kV and 4.16 kV switchgear incomers, thereby significantly reducing the probability of failure of the non-Class 1E incoming breakers in case of bus fault. Of the two independent circuit breakers, only one breaker is used for switching operation and protection and the other only for protection as shown in Figure 8.3.1-1.



Non-Class 1E 13.8kV AC Power System

Figure 8.3.1-1 Onsite AC Electrical Power System (1 of 3)

APR1400 DCD TIER 2



Non-Class 1E 4.16 kV AC Power System

Figure 8.3.1-1 Onsite AC Electrical Power System (2 of 3)