

PROPOSED TECHNICAL SPECIFICATION CHANGES

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### 3.7 Auxiliary Electrical Systems

#### Applicability

Applies to the auxiliary electrical power systems.

#### Objectives

To specify conditions of operation for plant station power necessary to ensure safe reactor operation and combined availability of the engineered safety features.

#### Specifications

- 3.7.1 The reactor shall not be heated or maintained above 200°F unless the following conditions are met (except as permitted by Paragraph 3.7.2):
- A. Any one of the following combinations of power sources operable:
    - 1. Startup Transformer No. 1 and Startup Transformer No. 2.
    - 2. Startup Transformer No. 2 and Unit Auxiliary Transformer provided that the latter one is connected to the 22KV line from the switchyard rather than to the generator bus.
  - B. All 4160 V switchgear, 480 V load centers, 480 V motor control centers and 120 V AC distribution panels in both of the ESAS distribution systems are operable and are being powered from either one of the two startup transformers or the unit auxiliary transformer.
  - C. Both diesel generator sets are operable each with:
    - 1. a separate day tank containing a minimum of 160 gallons of fuel,
    - 2. a separate emergency storage tank containing a minimum of 138 inches (20,000 gallons) of fuel,
    - 3. a separate fuel transfer pump, and
    - 4. a separate starting air compressor.
  - D. DELETED
  - E. DELETED
  - F. The off-site power undervoltage and protective relaying interlocks associated with required startup transformer power sources shall be operable per Table 3.5.1-1.
  - G. The selective load-shed features associated with Startup Transformer No. 2 shall be operable if selected for auto transfer.

3.7.2

- A. The specifications in 3.7.1 may be modified to allow one of the following conditions to exist after the reactor has been heated above 200F. Except as indicated in the following conditions, if any of these conditions are not met, a hot shutdown shall be initiated within 12 hours. If the condition is not cleared within 24 hours, the reactor shall be brought to cold shutdown within an additional 24 hours.
- B. In the event that one of the offsite power sources specified in 3.7.1.A (1 or 2) is inoperable, reactor operation may continue for up to 24 hours if the availability of the diesel generators is immediately verified.
- C. Either one of the two diesel generators may be inoperable for up to 7 days in any month provided that during such 7 days the operability of the remaining diesel generator is demonstrated immediately and daily thereafter, there are no inoperable ESF components associated with the operable diesel generator, and provided that the two sources of off-site power specified in 3.7.1.A(1) or 3.7.1.A(2) are available.
- D. Any 4160V, 480V, or 120V switchgear, load center, motor control center, or distribution panel in one of the two ESF distribution systems may be inoperable for up to 8 hours, provided that the operability of the diesel generator associated with the operable ESF distribution system is demonstrated immediately and all of the components of the operable distribution system are operable. If the ESF distribution system is not returned to service at the end of the 8 hour period, Specification 3.7.2.A shall apply.
- E. DELETED
- F. DELETED
- G. DELETED
- H. If the requirements of Specification 3.7.1.G cannot be met, either:
  - (1) place all Startup Transformer No. 2 feeder breakers in "pull-to-lock" within 1 hour, restore the inoperable interlocks to operable status within 30 days, or submit within 30 days a Special Report pursuant to Specification 6.12.5 outlining the cause of the failure, proposed corrective action and schedule for implementation; or
  - (2) apply the action requirements of Table 3.5.1-1, Note 14.

- 3.7.3 Both 125 VDC electrical power subsystems shall be operable when the unit is above the cold shutdown condition.
- A. With one 125 VDC electrical power subsystem inoperable:
1. verify that there are no inoperable safety related components associated with the operable 125 VDC electrical subsystem which are redundant to the inoperable 125 VDC electrical power subsystem,
  2. verify the operability of the diesel generator associated with the operable 125 VDC electrical subsystem immediately, and
  3. restore the 125 VDC electrical subsystem to operable status within 8 hours.
- B. With one 125 VDC electrical power subsystem inoperable, and unable to satisfy the requirements or allowable outage times of 3.7.3.A.1, 3.7.3.A.2, or 3.7.3.A.3, the unit shall be placed in hot shutdown within 12 hours and in cold shutdown within an additional 24 hours.

- 3.7.4 Battery cell parameters shall be within limits when the associated 125 VDC electrical power subsystems are required to be operable.
- A. With one or more batteries with one or more battery cell parameters not within Table 4.6-1 Category A or B limits:
1. Within 1 hour, verify pilot cell electrolyte level and float voltage meet Table 4.6-1 Category C limits,
  2. Within 24 hours and once per 7 days thereafter, verify battery cell parameters meet Table 4.6-1 Category C limits, and
  3. Within 31 days, restore battery cell parameters to Table 4.6-1 Category A and B limits.
- B. With one or more batteries with one or more battery cell parameters not within Table 4.6-1 Category A or B limits and unable to satisfy the requirements or allowable outage times of 3.7.4.A.1, 3.7.4.A.2, or 3.7.4.A.3, declare the associated battery inoperable immediately and perform the required actions of 3.7.3.A.
- C. With one or more batteries with electrolyte temperature of the pilot cell not within the limits of Specification 4.6.2.8, electrolyte temperature of representative cells not within the limits of Specification 4.6.2.6 or with one or more batteries with one or more battery cell parameters not within Table 4.6-1 Category C limits, declare the associated battery inoperable immediately and perform the required actions of 3.7.3.A.

#### Bases

The electrical system is designed to be electrically self-sufficient and provide adequate, reliable power sources for all electrical equipment during startup, normal operation, safe shutdown and handling of all emergency situations. To prevent the concurrent loss of all auxiliary power, the various sources of power are independent of and isolated from each other.

In the event that the offsite power sources specified in 3.7.1.A (1 or 2) are inoperable, the required capacity of one emergency storage tank plus one day tank (20,160 gallons) will be sufficient for not less than three and one-half days operation for one diesel generator loaded to full capacity. (ANO-1 FSAR 8.2.2.3) The underground emergency storage tanks are gravity fed from the bulk storage tank and are normally full, while the day tanks are fed from transfer pumps which are capable of being cross connected at their suction and discharges and automatically receive fuel oil when their inventory is less than 180 gallons. Thus, at least a seven day total diesel oil inventory is available onsite for emergency diesel generator operation during complete loss of electric power conditions.

Technical Specification 3.7.2 allows for the temporary modification of the specifications in 3.7.1 provided that backup system(s) are operable with safe reactor operation and combined availability of the engineered safety features ensured.

Technical Specification 3.7.1.F and 3.7.1.G provide assurance that the Startup Transformer No. 2 loads will not contribute to a sustained degraded grid voltage situation. This will protect ESF equipment from damage caused by sustained undervoltage.

The 125 VDC electrical power system consists of two independent and redundant safety related class 1E DC electrical subsystems. Each subsystem consists of one 100% capacity 125 VDC battery, an associated battery charger, and its distribution network. Additionally, there is one spare battery charger per subsystem, which provides backup service in the event that the preferred battery charger is out of service.

If one of the required DC electrical power subsystems is inoperable (e.g., inoperable battery, no operable battery charger, or inoperable battery and no operable associated battery charger), the remaining DC electrical power subsystem has the capacity to support a safe shutdown and to mitigate an accident condition. Since a subsequent worst-case single failure would, however, result in the complete loss of the remaining 125 VDC electrical power subsystems with attendant loss of ES functions, continued power operation should not exceed 8 hours.

Battery cell parameters must remain within acceptable limits to ensure availability of the required DC power to shut down the reactor and maintain it in a safe condition after an anticipated operational event or a postulated design basis accident. Cell parameter limits are conservatively established, allowing continued DC electrical system function even with Table 4.6-1 Category A and B limits not met.

With one or more cells in one or more batteries not within limits (i.e., Table 4.6-1 Category A limits not met, or Category B limits not met, or Category A and B limits not met) but within the Table 4.6-1 Category C limits, the battery is degraded but has sufficient capacity to perform its intended function. Therefore, the battery is not required to be considered inoperable solely as a result of Category A or B limits not met, and continued operation is permitted for a limited period of time. The pilot cell electrolyte level and float voltage are required to be verified to meet the Table 4.6-1 Category C limits within 1 hour (TS 3.7.4.A.1). These checks will provide a quick representative status of the remainder of the battery cells. Verification that the Table 4.6-1 Category C limits are met (TS 3.7.4.A.2) provides assurance that during the time needed to restore the parameters to within the Category A and B limits, the battery will still be capable of performing its intended function. This verification is repeated at 7 day intervals until the parameters are restored to within Category A and B limits. This periodic verification is consistent with the increased potential to exceed these battery parameter limits during these conditions.

With one or more batteries with one or more battery cell parameters outside the Table 4.6-1 Category C limit for any connected cell, sufficient capacity to supply the maximum expected load requirement is not assured. Therefore, the battery must be immediately declared inoperable and the corresponding DC electrical power subsystem must be declared inoperable.

Additionally, other potentially extreme conditions, such as electrolyte temperature of the pilot cell falling below 60°F, average electrolyte temperature of representative cells falling below 60°F or battery terminal voltage below the limit are also cause for immediately declaring the associated DC electrical power subsystem inoperable.

e. Diesel fuel from the emergency storage tank shall be sampled and found to be within acceptable limits specified in Table 1 of ASTM D975-68 when checked for viscosity, water, and sediment.

5. Once every 31 days the pressure in the required starting air receiver tanks shall be verified to be  $\geq 175$  psig.

Once every 18 months, the capacity of each diesel oil transfer pump shall be verified to be at least 10 gpm.

#### 4.6.2 DC Sources and Battery Cell Parameters

1. Verify battery terminal voltage is  $\geq 124.7$  V on float charge once each 7 days.
2. Verify battery capacity is adequate to supply, and maintain in operable status, the required emergency loads for the design duty cycle when subjected to either a battery service test or a modified performance discharge test once every 18 months.
3. Verify battery capacity is  $\geq 80\%$  of the manufacturers rating when subjected to a performance discharge test or a modified performance discharge test once every 60 months, once every 24 months when battery has reached 85% of the service life with capacity  $\geq 100\%$  of the manufacturers rating and showing no degradation, and once every 12 months when battery shows degradation or has reached 85% of the service life and capacity is  $< 100\%$  of the manufacturer's rating.
4. Any battery charger which has not been loaded while connected to its 125V d-c distribution system for at least 30 minutes during every quarter shall be tested and loaded while connected to its bus for 30 minutes.
5. Verify battery pilot cell parameters meet Table 4.6-1 Category A limits once per 7 days.
6. Verify average electrolyte temperature of representative cells is  $\geq 60^{\circ}\text{F}$  once per 92 days.
7. Verify battery cell parameters meet Table 4.6-1 Category B limits once per 92 days and once within 24 hours after a battery discharge to  $< 110$  V and once within 24 hours after a battery overcharge to  $> 145$  V.
8. Verify electrolyte temperature of pilot cell is  $\geq 60^{\circ}\text{F}$  once per 31 days.

#### 4.6.3 Emergency Lighting

The correct functioning of the emergency lighting system shall be verified once every 18 months.

Table 4.6-1 (page 1 of 1)  
Battery Cell Surveillance Requirements

| PARAMETER                           | CATEGORY A:<br>LIMITS FOR EACH<br>DESIGNATED<br>PILOT CELL  | CATEGORY B:<br>LIMITS FOR EACH<br>CONNECTED CELL  | CATEGORY C:<br>ALLOWABLE LIMITS<br>FOR EACH<br>CONNECTED CELL  |
|-------------------------------------|---|---|--|
| Electrolyte Level                   | > Minimum level indication mark, and $\leq$ 1/4 inch above maximum level indication mark <sup>(a)</sup> | > Minimum level indication mark, and $\leq$ 1/4 inch above maximum level indication mark <sup>(a)</sup> | Above top of plates, and not overflowing   |
| Float Voltage                       | $\geq$ 2.13 V   | $\geq$ 2.13 V   | $>$ 2.07 V   |
| Specific Gravity <sup>(b) (c)</sup> | $\geq$ 1.195  | $\geq$ 1.190<br><u>AND</u><br>Average of all connected cells $>$ 1.195                                  | Not more than 0.020 below average connected cells<br><u>AND</u><br>Average of all connected cells $\geq$ 1.190 |

- (a) It is acceptable for the electrolyte level to temporarily increase above the specified maximum during equalizing charges provided it is not overflowing.
- (b) Corrected for electrolyte temperature.
- (c) A battery charging current of  $<$  2 amps when on float charge is acceptable for meeting specific gravity limits following a battery recharge, for a maximum of 7 days. When charging current is used to satisfy specific gravity requirements, specific gravity of each connected cell shall be measured prior to expiration of the 7 day allowance.

## Bases

The emergency power system provides power requirements for the engineered safety features in the event of a DBA. Each of the two diesel generators is capable of supplying minimum required engineered safety features from independent buses. This redundancy is a factor in establishing testing intervals. The monthly tests specified above will demonstrate operability and load capacity of the diesel generator. The fuel supply and diesel starter motor air pressure are continuously monitored and alarmed for abnormal conditions. Starting on complete loss of off-site power will be verified by simulated loss-of-power tests once every 18 months.

The SR 4.6.2.1 verification of battery terminal voltage while on float charge helps to ensure the effectiveness of the charging system and the ability of the batteries to perform their intended function. Float charge is the condition in which the battery charger is supplying the continuous charge required to overcome the internal losses of a battery and maintain the battery in a fully charged state. The voltage requirements are based on the nominal design voltage of the battery (2.15 V per cell average) and are consistent with the battery vendor allowable minimum volts per cell limits. The inability to meet this requirement constitutes an inoperable battery.

The SR 4.6.2.2 battery service test is a special test of the battery capability, as found, to satisfy the design requirements (battery duty cycle) of the DC electrical power system. The discharge rate and test length should correspond to the design duty cycle requirements. A modified performance discharge test may be performed in lieu of a service test. The inability to meet this requirement constitutes an inoperable battery.

The modified performance discharge test is a simulated duty cycle consisting of just two rates; the one minute rate published for the battery or the largest current load of the duty cycle, followed by the test rate employed for the performance test, both of which envelope the duty cycle of the battery. Since the ampere-hours removed by a rated one minute discharge represents a very small portion of the battery capacity, the test rate can be changed to that for the performance test without compromising the results of the performance discharge test. The battery terminal voltage for the modified performance discharge test should remain above the minimum battery voltage specified in the battery service test for the duration of time equal to that of the service test.

A modified performance discharge test is a test of the battery capacity and its ability to provide a high rate, short duration load (usually the highest rate of the duty cycle). This will often confirm the battery's ability to meet the critical period of the load duty cycle, in addition to determining its percentage of rated capacity. Initial conditions for the modified performance discharge test should be identical to those specified for a service test and the test discharge rate must envelope the duty cycle of the service test if the modified performance discharge test is performed in lieu of a service test.

The SR 4.6.2.3 battery performance discharge test is a test of constant current capacity of a battery after having been in service, to detect any change in the capacity determined by the acceptance test. The test is intended to determine overall battery degradation due to age and usage. The inability to meet this requirement constitutes an inoperable battery.

Either the battery performance discharge test or the modified performance discharge test, described above, is acceptable for satisfying SR 4.6.2.3; however, only the modified performance discharge test may be used to satisfy SR 4.6.2.3 while satisfying the requirements of SR 4.6.2.2 at the same time.

The acceptance criteria for this surveillance are consistent with IEEE-450. This reference recommends that the battery be replaced if its capacity is below 80% of the manufacturer's rating. A capacity of 80% shows that the battery rate of deterioration is increasing, even if there is ample capacity to meet the load requirements.

The frequency for this test is normally 60 months. If the battery shows signs of degradation, or if the battery has reached 85% of its service life and capacity is < 100% of the manufacturer's rating, the frequency is reduced to 12 months. However, if the battery shows no degradation but has reached 85% of its service life, the frequency is only reduced to 24 months for batteries that retain  $\geq 100\%$  of the manufacturer's ratings. Degradation is indicated, according to IEEE-450, when the battery capacity drops by more than 10% relative to its capacity on the previous performance test or when it is  $\geq 10\%$  below the manufacturer's rating.

SR 4.6.2.4 requires that each required battery charger be capable of supplying the connected loads while maintaining the battery fully charged. This is based on the assumption that the batteries are fully charged at the beginning of a design basis accident, and on the safety function of providing adequate power for the design basis accident loads.

SR 4.6.2.5 verifies that the Table 4.6-1 Category A battery cell parameters are consistent with vendor recommendations and IEEE-450, which recommend regular battery inspections (at least once per month) including voltage, specific gravity, and electrolyte level of pilot cells.

The SR 4.6.2.6 verification that the average temperature of representative cells is  $\geq 60^{\circ}\text{F}$  is consistent with a recommendation of IEEE-450, which states that the temperature of electrolytes in representative cells (~10% of all connected cells) should be determined on a quarterly basis. Lower than normal temperatures act to inhibit or reduce battery capacity. This surveillance ensures that the operating temperatures remain within an acceptable operating range. This limit is based on manufacturer recommendations.

SR 4.6.2.7 verifies that the Table 4.6-1 Category B battery cell parameters are consistent with vendor recommendations and IEEE-450, which recommend regular battery inspections (at least once per quarter) including voltage, specific gravity, and electrolyte level of each connected cell. In addition, within 24 hours after a battery discharge to < 110 V or a battery overcharge to > 145 V, the battery must be demonstrated to meet Category B limits. Transients, such as motor starting transients, which may momentarily cause battery voltage to drop to  $\leq 110$  V, do not constitute a battery discharge provided battery terminal voltage and float current return to pre-transient values. This inspection is also consistent with IEEE-450, which recommends special inspections following a severe discharge or overcharge, to ensure that no significant degradation of the battery occurs as a consequence of such discharge or overcharge.

The SR 4.6.2.8 verification that the temperature of the pilot cell is  $\geq 60^{\circ}\text{F}$  is consistent with a recommendation of IEEE-450, which states that the temperature of electrolytes in pilot cells should be determined on a monthly basis. Lower than normal temperatures act to inhibit or reduce battery capacity. This surveillance ensures that the operating temperatures remain within an acceptable operating range. This limit is based on manufacturer recommendations.

Table 4.6-1 delineates the limits on electrolyte level, cell float voltage, and specific gravity for three different categories. The meaning of each category is discussed below.

Category A defines the normal parameter limit for each designated pilot cell in each battery. The cells selected as pilot cells are those whose temperature, voltage and electrolyte specific gravity approximate the state of charge of the entire battery.

The Category A limits specified for electrolyte level are based on manufacturer recommendations and are consistent with the guidance in IEEE-450, with the extra 1/4 inch allowance above the high water level indication for operating margin to account for temperatures and charge effects. In addition to this allowance, footnote (a) to Table 4.6-1 permits the electrolyte level to be above the specified maximum level during equalizing charge, provided it is not overflowing. These limits ensure that the plates suffer no physical damage and that adequate electron transfer capability is maintained in the event of transient conditions. IEEE-450 recommends that electrolyte level readings should be made only after the battery has been at float charge for at least 72 hours.

The Category A limit specified for float voltage is  $\geq 2.13$  V per cell. This value is based on the battery vendor allowable minimum cell voltage and on a recommendation of IEEE-450, which states that prolonged operation of cells  $< 2.13$  V can reduce the life expectancy of cells.

The Category A limit specified for specific gravity for each pilot cell is  $\geq 1.195$ . This value is characteristic of a charged cell with adequate capacity. According to IEEE-450, the specific gravity readings are based on a temperature of 77°F (25°C).

The specific gravity readings are corrected for actual electrolyte temperature. For each 3°F (1.67°C) above 77°F (25°C), 1 point (0.001) is added to the reading; 1 point is subtracted for each 3°F below 77°F. The specific gravity of the electrolyte in a cell increases with a loss of water due to electrolysis or evaporation.

Category B defines the normal parameter limits for each connected cell. The term "connected cell" excludes any battery cell that is jumpered out.

The Category B limits specified for electrolyte level and float voltage are the same as those specified for Category A and have been discussed above. The Category B limit specified for specific gravity for each connected cell is  $\geq 1.190$  with the average of all connected cells  $> 1.195$ . These values are based on manufacturer's recommendations. The minimum specific gravity value required for each cell ensures that the effects of a highly charged or newly installed cell will not mask overall degradation of the battery.

Category C defines the limits for each connected cell. These values, although reduced, provide assurance that sufficient capacity exists to perform the intended function and maintain a margin of safety. When any battery parameter is outside the Category C limits, the assurance of sufficient capacity described above no longer exists and the battery must be declared inoperable.

The Category C limits specified for electrolyte level (above the top of the plates and not overflowing) ensure that the plates suffer no physical damage and maintain adequate electron transfer capability. The Category C limit for float voltage is consistent with IEEE-450, which states that a cell voltage of 2.07 V or below, under float conditions and not caused by elevated temperature of the cell, indicates internal cell problems and may require cell replacement.

The Category C limit of average specific gravity  $\geq 1.190$  is based on manufacturer recommendations. In addition to that limit, it is required that the specific gravity for each connected cell must be no less than 0.020 below the average of all connected cells. This limit ensures that the effect of a highly charged or new cell does not mask overall degradation of the battery.

Footnotes (b) and (c) to Table 4.6-1 are applicable to Category A, B, and C specific gravity. Footnote (b) to Table 4.6-1 requires the above mentioned correction for electrolyte temperature. The value of 2 amps used in footnote (c) is the nominal value for float current established by the battery vendor as representing a fully charged battery with an allowance for overall battery condition. This current provides, in general, an indication of overall battery condition.

Because of specific gravity gradients that are produced during the recharging process, delays of several days may occur while waiting for the specific gravity to stabilize. A stabilized charger current is an acceptable alternative to specific gravity measurement for determining the state of charge. This phenomenon is discussed in IEEE-450. Footnote (c) to Table 4.6-1 allows the float charge current to be used as an alternate to specific gravity for up to 7 days following a battery recharge. Within 7 days each connected cell's specific gravity must be measured to confirm the state of charge. Following a minor battery recharge (such as equalizing charge that does not follow a deep discharge) specific gravity gradients are not significant, and confirming measurements may be made in less than 7 days.

The SR 4.6.3 testing of the emergency lighting is scheduled every 18 months and is subject to review and modification if experience demonstrates a more effective test schedule.

#### REFERENCE

FSAR, Section 8

MARKUP OF CURRENT ANO-1 TECHNICAL SPECIFICATIONS

(FOR INFO ONLY)

### 3.7 Auxiliary Electrical Systems

#### Applicability

Applies to the auxiliary electrical power systems.

#### Objectives

To specify conditions of operation for plant station power necessary to ensure safe reactor operation and combined availability of the engineered safety features.

#### Specifications

- 3.7.1 The reactor shall not be heated or maintained above 200°F unless the following conditions are met (except as permitted by Paragraph 3.7.2):
- A. Any one of the following combinations of power sources operable:
    - 1. Startup Transformer No. 1 and Startup Transformer No. 2.
    - 2. Startup Transformer No. 2 and Unit Auxiliary Transformer provided that the latter one is connected to the 22KV line from the switchyard rather than to the generator bus.
  - B. All 4160 V switchgear, 480 V load centers, 480 V motor control centers and 120 V AC distribution panels in both of the ESAS distribution systems are operable and are being powered from either one of the two startup transformers or the unit auxiliary transformer.
  - C. Both diesel generator sets are operable each with:
    - 1. a separate day tank containing a minimum of 160 gallons of fuel,
    - 2. a separate emergency storage tank containing a minimum of 138 inches (20,000 gallons) of fuel,
    - 3. a separate fuel transfer pump, and
    - 4. a separate starting air compressor.
  - D. ~~DELETED~~Both station batteries are operable and each is capable of supplying power to the 125V d-c distribution system. At least one battery charger associated with each station battery is operable.
  - E. ~~DELETED~~At least 2 of 3 d-c control power sources to the 125V d-c switchyard distribution system are operable.
  - F. The off-site power undervoltage and protective relaying interlocks associated with required startup transformer power sources shall be operable per Table 3.5.1-1.
  - G. The selective load-shed features associated with Startup Transformer No. 2 shall be operable if selected for auto transfer.

## 3.7.2

- A. The specifications in 3.7.1 may be modified to allow one of the following conditions to exist after the reactor has been heated above 200F. Except as indicated in the following conditions, if any of these conditions are not met, a hot shutdown shall be initiated within 12 hours. If the condition is not cleared within 24 hours, the reactor shall be brought to cold shutdown within an additional 24 hours.
- B. In the event that one of the offsite power sources specified in 3.7.1.A (1 or 2) is inoperable, reactor operation may continue for up to 24 hours if the availability of the diesel generators is immediately verified.
- C. Either one of the two diesel generators may be inoperable for up to 7 days in any month provided that during such 7 days the operability of the remaining diesel generator is demonstrated immediately and daily thereafter, there are no inoperable ESF components associated with the operable diesel generator, and provided that the two sources of off-site power specified in 3.7.1.A(1) or 3.7.1.A(2) are available.
- D. Any 4160V, 480V, or 120V switchgear, load center, motor control center, or distribution panel in one of the two ESF distribution systems may be inoperable for up to 8 hours, provided that the operability of the diesel generator associated with the operable ESF distribution system is demonstrated immediately and all of the components of the operable distribution system are operable. If the ESF distribution system is not returned to service at the end of the 8 hour period, Specification 3.7.2.A shall apply.
- E. ~~DELETED~~~~With no operable battery charger associated with one station battery, operation is allowed to continue for a period of 8 hours provided at least one battery charger is operable on the opposite train, after which Specification 3.7.2.A shall apply.~~
- F. ~~DELETED~~~~One of the two station batteries and the associated distribution system may be inoperable for 8 hours provided that there are no inoperable safety related components associated with the remaining station battery which are redundant to the inoperable station battery and the operability of the diesel generator is verified immediately. If the battery is not returned to service at the end of the 8 hour period, Specification 3.7.2.A shall apply.~~
- G. ~~DELETED~~~~Two control power sources from the plant to the switchyard and the attendant distribution system may be inoperable for 8 hours, after which Specification 3.7.2.A shall apply.~~
- H. If the requirements of Specification 3.7.1.G cannot be met, either:
- (1) place all Startup Transformer No. 2 feeder breakers in "pull-to-lock" within 1 hour, restore the inoperable interlocks to operable status within 30 days, or submit within 30 days a Special Report pursuant to Specification 6.12.5 outlining the cause of the failure, proposed corrective action and schedule for implementation; or
  - (2) apply the action requirements of Table 3.5.1-1, Note 14.

- 3.7.3 Deleted Both 125 VDC electrical power subsystems shall be operable when the unit is above the cold shutdown condition.
- A. With one 125 VDC electrical power subsystem inoperable:
1. verify that there are no inoperable safety related components associated with the operable 125 VDC electrical subsystem which are redundant to the inoperable 125 VDC electrical power subsystem,
  2. verify the operability of the diesel generator associated with the operable 125 VDC electrical subsystem immediately, and
  3. restore the 125 VDC electrical subsystem to operable status within 8 hours.
- B. With one 125 VDC electrical power subsystem inoperable, and unable to satisfy the requirements or allowable outage times of 3.7.3.A.1, 3.7.3.A.2, or 3.7.3.A.3, the unit shall be placed in hot shutdown within 12 hours and in cold shutdown within an additional 24 hours.
- 3.7.4 Battery cell parameters shall be within limits when the associated 125 VDC electrical power subsystems are required to be operable.
- A. With one or more batteries with one or more battery cell parameters not within Table 4.6-1 Category A or B limits:
1. Within 1 hour, verify pilot cell electrolyte level and float voltage meet Table 4.6-1 Category C limits,
  2. Within 24 hours and once per 7 days thereafter, verify battery cell parameters meet Table 4.6-1 Category C limits, and
  3. Within 31 days, restore battery cell parameters to Table 4.6-1 Category A and B limits.
- B. With one or more batteries with one or more battery cell parameters not within Table 4.6-1 Category A or B limits and unable to satisfy the requirements or allowable outage times of 3.7.4.A.1, 3.7.4.A.2, or 3.7.4.A.3, declare the associated battery inoperable immediately and perform the required actions of 3.7.3.A.
- C. With one or more batteries with electrolyte temperature of the pilot cell not within the limits of Specification 4.6.2.8, electrolyte temperature of representative cells not within the limits of Specification 4.6.2.6 or with one or more batteries with one or more battery cell parameters not within Table 4.6-1 Category C limits, declare the associated battery inoperable immediately and perform the required actions of 3.7.3.A.

#### Bases

The electrical system is designed to be electrically self-sufficient and provide adequate, reliable power sources for all electrical equipment during startup, normal operation, safe shutdown and handling of all emergency situations. To prevent the concurrent loss of all auxiliary power, the various sources of power are independent of and isolated from each other.

In the event that the offsite power sources specified in 3.7.1.A (1 or 2) are inoperable, the required capacity of one emergency storage tank plus one day tank (20,160 gallons) will be sufficient for not less than three and

one-half days operation for one diesel generator loaded to full capacity. (ANO-1 FSAR 8.2.2.3) The underground emergency storage tanks are gravity fed from the bulk storage tank and are normally full, while the day tanks are fed from transfer pumps which are capable of being cross connected at their suction and discharges and automatically receive fuel oil when their inventory is less than 180 gallons. Thus, at least a seven day total diesel oil inventory is available onsite for emergency diesel generator operation during complete loss of electric power conditions.

Technical Specification 3.7.2 allows for the temporary modification of the specifications in 3.7.1 provided that backup system(s) are operable with safe reactor operation and combined availability of the engineered safety features ensured.

Technical Specifications 3.7.1.F and 3.7.1.G provide assurance that the Startup Transformer No. 2 loads will not contribute to a sustained degraded grid voltage situation. This will protect ESF equipment from damage caused by sustained undervoltage.

The 125 VDC electrical power system consists of two independent and redundant safety related class 1E DC electrical subsystems. Each subsystem consists of one 100% capacity 125 VDC battery, an associated battery charger, and its distribution network. Additionally, there is one spare battery charger per subsystem, which provides backup service in the event that the preferred battery charger is out of service.

If one of the required DC electrical power subsystems is inoperable (e.g., inoperable battery, no operable battery charger, or inoperable battery and no operable associated battery charger), the remaining DC electrical power subsystem has the capacity to support a safe shutdown and to mitigate an accident condition. Since a subsequent worst-case single failure would, however, result in the complete loss of the remaining 125 VDC electrical power subsystems with attendant loss of ES functions, continued power operation should not exceed 8 hours.

Battery cell parameters must remain within acceptable limits to ensure availability of the required DC power to shut down the reactor and maintain it in a safe condition after an anticipated operational event or a postulated design basis accident. Cell parameter limits are conservatively established, allowing continued DC electrical system function even with Table 4.6-1 Category A and B limits not met.

With one or more cells in one or more batteries not within limits (i.e., Table 4.6-1 Category A limits not met, or Category B limits not met, or Category A and B limits not met) but within the Table 4.6-1 Category C limits, the battery is degraded but still has sufficient capacity to perform its intended function. Therefore, the battery is not required to be considered inoperable solely as a result of Category A or B limits not met, and continued operation is permitted for a limited period of time. The pilot cell electrolyte level and float voltage are required to be verified to meet the Table 4.6-1 Category C limits within 1 hour (TS 3.7.4.A.1). These checks will provide a quick representative status of the remainder of the battery cells. Verification that the Table 4.6-1 Category C limits are met (TS 3.7.4.A.2) provides assurance that during the time needed to restore the parameters to within the Category A and B limits, the battery will still be capable of performing its intended function. This verification is repeated at 7 day intervals until the parameters are restored to within Category A and B limits. This periodic verification is consistent with the increased potential to exceed these battery parameter limits during these conditions.

With one or more batteries with one or more battery cell parameters outside the Table 4.6-1 Category C limit for any connected cell, sufficient capacity to supply the maximum expected load requirement is not assured. Therefore, the

battery must be immediately declared inoperable and the corresponding DC electrical power subsystem must be declared inoperable.

Additionally, other potentially extreme conditions, such as electrolyte temperature of the pilot cell falling below 60°F, average electrolyte temperature of representative cells falling below 60°F or battery terminal voltage below the limit are also cause for immediately declaring the associated DC electrical power subsystem inoperable.

- e. Diesel fuel from the emergency storage tank shall be sampled and found to be within acceptable limits specified in Table 1 of ASTM D975-68 when checked for viscosity, water, and sediment.
5. Once every 31 days the pressure in the required starting air receiver tanks shall be verified to be  $\geq 175$  psig.

Once every 18 months, the capacity of each diesel oil transfer pump shall be verified to be at least 10 gpm.

#### 4.6.2 ~~Station Batteries and Switchyard Batteries~~ DC Sources and Battery Cell Parameters

1. ~~The voltage, temperature and specific gravity of a pilot cell in each bank and the overall battery voltage of each bank shall be measured and recorded daily.~~ Verify battery terminal voltage is  $\geq 124.7$  V on float charge once each 7 days.
2. ~~Measurements shall be made quarterly of voltage of each cell to the nearest 0.01 volt, of the specific gravity of each cell, and of the temperature of every fifth cell in each bank. The level of the electrolyte shall be checked and adjusted as required. All data, including the amount of water added to any cell, shall be recorded.~~ Verify battery capacity is adequate to supply, and maintain in operable status, the required emergency loads for the design duty cycle when subjected to either a battery service test or a modified performance discharge test once every 18 months.
3. ~~Once every 18 months, a performance discharge test shall be conducted in accordance with the manufacturer's instructions, the purpose of determining battery capacity.~~ Verify battery capacity is  $\geq 80\%$  of the manufacturers rating when subjected to a performance discharge test or a modified performance discharge test once every 60 months, once every 24 months when battery has reached 85% of the service life with capacity  $\geq 100\%$  of the manufacturers rating and showing no degradation, and once every 12 months when battery shows degradation or has reached 85% of the service life and capacity is  $< 100\%$  of the manufacturer's rating.
4. Any battery charger which has not been loaded while connected to its 125V d-c distribution system for at least 30 minutes during every quarter shall be tested and loaded while connected to its bus for 30 minutes.
5. Verify battery pilot cell parameters meet Table 4.6-1 Category A limits once per 7 days.
6. Verify average electrolyte temperature of representative cells is  $\geq 60^{\circ}\text{F}$  once per 92 days.
7. Verify battery cell parameters meet Table 4.6-1 Category B limits once per 92 days and once within 24 hours after a battery discharge to  $< 110$  V and once within 24 hours after a battery overcharge to  $> 145$  V.
8. Verify electrolyte temperature of pilot cell is  $\geq 60^{\circ}\text{F}$  once per 31 days.

#### 4.6.3 Emergency Lighting

The correct functioning of the emergency lighting system shall be verified once every 18 months.

Table 4.6-1 (page 1 of 1)  
Battery Cell Surveillance Requirements

| <u>PARAMETER</u>                              | <u>CATEGORY A:<br/>LIMITS FOR EACH<br/>DESIGNATED<br/>PILOT CELL</u>  | <u>CATEGORY B:<br/>LIMITS FOR EACH<br/>CONNECTED CELL</u>   | <u>CATEGORY C:<br/>ALLOWABLE LIMITS<br/>FOR EACH<br/>CONNECTED CELL</u>   |
|---|---|---|---|
| <u>Electrolyte Level</u>                      | <u>&gt; Minimum level<br/>indication mark,<br/>and ≤ 1/4 inch<br/>above maximum<br/>level indication<br/>mark<sup>(a)</sup></u> | <u>&gt; Minimum level<br/>indication mark,<br/>and ≤ 1/4 inch<br/>above maximum<br/>level indication<br/>mark<sup>(a)</sup></u> | <u>Above top of<br/>plates, and not<br/>overflowing</u>   |
| <u>Float Voltage</u>                          | <u>≥ 2.13 V</u>   | <u>≥ 2.13 V</u>   | <u>&gt; 2.07 V</u>  |
| <u>Specific<br/>Gravity<sup>(b) (c)</sup></u> | <u>≥ 1.195</u>  | <u>≥ 1.190</u><br><br><u>AND</u><br><br><u>Average of all<br/>connected cells<br/>&gt; 1.195</u>                                | <u>Not more than<br/>0.020 below<br/>average connected<br/>cells</u><br><br><u>AND</u><br><br><u>Average of all<br/>connected cells<br/>≥ 1.190</u> |

(a) It is acceptable for the electrolyte level to temporarily increase above the specified maximum during equalizing charges provided it is not overflowing.

(b) Corrected for electrolyte temperature.

(c) A battery charging current of < 2 amps when on float charge is acceptable for meeting specific gravity limits following a battery recharge for a maximum of 7 days. When charging current is used to satisfy specific gravity requirements, specific gravity of each connected cell shall be measured prior to expiration of the 7 day allowance.

## Bases

The emergency power system provides power requirements for the engineered safety features in the event of a DBA. Each of the two diesel generators is capable of supplying minimum required engineered safety features from independent buses. This redundancy is a factor in establishing testing intervals. The monthly tests specified above will demonstrate operability and load capacity of the diesel generator. The fuel supply and diesel starter motor air pressure are continuously monitored and alarmed for abnormal conditions. Starting on complete loss of off-site power will be verified by simulated loss-of-power tests once every 18 months.

~~Considering system redundancy, the specified testing intervals for the station batteries should be adequate to detect and correct any malfunction before it can result in system malfunction. Batteries will deteriorate with time, but precipitous failure is extremely unlikely. The surveillance specified is that which has been demonstrated over the years to provide an indication of a cell becoming unserviceable long before it fails.~~

~~Routine battery maintenance specified by the manufacturer includes regularly scheduled equalizing charges in order to retain the capacity of the battery. A test discharge should be conducted to ascertain the capability of the battery to perform its design function under postulated accident condition. An excessive drop of voltage with respect to time is indicative of required battery maintenance or replacement.~~

The SR 4.6.2.1 verification of battery terminal voltage while on float charge helps to ensure the effectiveness of the charging system and the ability of the batteries to perform their intended function. Float charge is the condition in which the battery charger is supplying the continuous charge required to overcome the internal losses of a battery and maintain the battery in a fully charged state. The voltage requirements are based on the nominal design voltage of the battery (2.15 V per cell average) and are consistent with the battery vendor allowable minimum volts per cell limits. The inability to meet this requirement constitutes an inoperable battery.

The SR 4.6.2.2 battery service test is a special test of the battery capability, as found, to satisfy the design requirements (battery duty cycle) of the DC electrical power system. The discharge rate and test length should correspond to the design duty cycle requirements. A modified performance discharge test may be performed in lieu of a service test. The inability to meet this requirement constitutes an inoperable battery.

The modified performance discharge test is a simulated duty cycle consisting of just two rates; the one minute rate published for the battery or the largest current load of the duty cycle, followed by the test rate employed for the performance test, both of which envelope the duty cycle of the battery. Since the ampere-hours removed by a rated one minute discharge represents a very small portion of the battery capacity, the test rate can be changed to that for the performance test without compromising the results of the performance discharge test. The battery terminal voltage for the modified performance discharge test should remain above the minimum battery voltage specified in the battery service test for the duration of time equal to that of the service test.

A modified performance discharge test is a test of the battery capacity and its ability to provide a high rate, short duration load (usually the highest rate of the duty cycle). This will often confirm the battery's ability to meet the critical period of the load duty cycle, in addition to determining its percentage of rated capacity. Initial conditions for the modified performance discharge test should be identical to those specified for a service test and the test discharge rate must envelope the duty cycle of the service test if the modified performance discharge test is performed in lieu of a service test.

The SR 4.6.2.3 battery performance discharge test is a test of constant current capacity of a battery after having been in service, to detect any change in the

capacity determined by the acceptance test. The test is intended to determine overall battery degradation due to age and usage. The inability to meet this requirement constitutes an inoperable battery.

Either the battery performance discharge test or the modified performance discharge test, described above, is acceptable for satisfying SR 4.6.2.3; however, only the modified performance discharge test may be used to satisfy SR 4.6.2.3 while satisfying the requirements of SR 4.6.2.2 at the same time.

The acceptance criteria for this surveillance are consistent with IEEE-450. This reference recommends that the battery be replaced if its capacity is below 80% of the manufacturer's rating. A capacity of 80% shows that the battery rate of deterioration is increasing, even if there is ample capacity to meet the load requirements.

The frequency for this test is normally 60 months. If the battery shows signs of degradation, or if the battery has reached 85% of its service life and capacity is < 100% of the manufacturer's rating, the frequency is reduced to 12 months. However, if the battery shows no degradation but has reached 85% of its service life, the frequency is only reduced to 24 months for batteries that retain  $\geq 100\%$  of the manufacturer's ratings. Degradation is indicated, according to IEEE-450, when the battery capacity drops by more than 10% relative to its capacity on the previous performance test or when it is  $\geq 10\%$  below the manufacturer's rating.

SR 4.6.2.4 requires that each required battery charger be capable of supplying the connected loads while maintaining the battery fully charged. This is based on the assumption that the batteries are fully charged at the beginning of a design basis accident, and on the safety function of providing adequate power for the design basis accident loads.

SR 4.6.2.5 verifies that the Table 4.6-1 Category A battery cell parameters are consistent with vendor recommendations and IEEE-450, which recommend regular battery inspections (at least once per month) including voltage, specific gravity, and electrolyte level of pilot cells.

The SR 4.6.2.6 verification that the average temperature of representative cells is  $\geq 60^{\circ}\text{F}$  is consistent with a recommendation of IEEE-450, which states that the temperature of electrolytes in representative cells (~10% of all connected cells) should be determined on a quarterly basis. Lower than normal temperatures act to inhibit or reduce battery capacity. This surveillance ensures that the operating temperatures remain within an acceptable operating range. This limit is based on manufacturer recommendations.

SR 4.6.2.7 verifies that the Table 4.6-1 Category B battery cell parameters are consistent with vendor recommendations and IEEE-450, which recommend regular battery inspections (at least once per quarter) including voltage, specific gravity, and electrolyte level of each connected cell. In addition, within 24 hours after a battery discharge to < 110 V or a battery overcharge to > 150 V, the battery must be demonstrated to meet Category B limits. Transients, such as motor starting transients, which may momentarily cause battery voltage to drop to  $\leq 110$  V, do not constitute a battery discharge provided battery terminal voltage and float current return to pre-transient values. This inspection is also consistent with IEEE-450, which recommends special inspections following a severe discharge or overcharge, to ensure that no significant degradation of the battery occurs as a consequence of such discharge or overcharge.

The SR 4.6.2.8 verification that the temperature of the pilot cell is  $\geq 60^{\circ}\text{F}$  is consistent with a recommendation of IEEE-450, which states that the temperature of electrolytes in pilot cells should be determined on a monthly basis. Lower than normal temperatures act to inhibit or reduce battery capacity. This surveillance ensures that the operating temperatures remain within an acceptable operating range. This limit is based on manufacturer recommendations.

Table 4.6-1 delineates the limits on electrolyte level, cell float voltage, and specific gravity for three different categories. The meaning of each category is discussed below.

Category A defines the normal parameter limit for each designated pilot cell in each battery. The cells selected as pilot cells are those whose temperature, voltage and electrolyte specific gravity approximate the state of charge of the entire battery.

The Category A limits specified for electrolyte level are based on manufacturer recommendations and are consistent with the guidance in IEEE-450, with the extra 1/4 inch allowance above the high water level indication for operating margin to account for temperatures and charge effects. In addition to this allowance, footnote (a) to Table 4.6-1 permits the electrolyte level to be above the specified maximum level during equalizing charge, provided it is not overflowing. These limits ensure that the plates suffer no physical damage and that adequate electron transfer capability is maintained in the event of transient conditions. IEEE-450 recommends that electrolyte level readings should be made only after the battery has been at float charge for at least 72 hours.

The Category A limit specified for float voltage is  $\geq 2.13$  V per cell. This value is based on the battery vendor allowable minimum cell voltage and on a recommendation of IEEE-450, which states that prolonged operation of cells  $< 2.13$  V can reduce the life expectancy of cells.

The Category A limit specified for specific gravity for each pilot cell is  $\geq 1.195$ . This value is characteristic of a charged cell with adequate capacity. According to IEEE-450, the specific gravity readings are based on a temperature of 77°F (25°C).

The specific gravity readings are corrected for actual electrolyte temperature. For each 3°F (1.67°C) above 77°F (25°C), 1 point (0.001) is added to the reading; 1 point is subtracted for each 3°F below 77°F. The specific gravity of the electrolyte in a cell increases with a loss of water due to electrolysis or evaporation.

Category B defines the normal parameter limits for each connected cell. The term "connected cell" excludes any battery cell that is jumpered out.

The Category B limits specified for electrolyte level and float voltage are the same as those specified for Category A and have been discussed above. The Category B limit specified for specific gravity for each connected cell is  $\geq 1.190$  with the average of all connected cells  $> 1.195$ . These values are based on manufacturer's recommendations. The minimum specific gravity value required for each cell ensures that the effects of a highly charged or newly installed cell will not mask overall degradation of the battery.

Category C defines the limits for each connected cell. These values, although reduced, provide assurance that sufficient capacity exists to perform the intended function and maintain a margin of safety. When any battery parameter is outside the Category C limits, the assurance of sufficient capacity described above no longer exists and the battery must be declared inoperable.

The Category C limits specified for electrolyte level (above the top of the plates and not overflowing) ensure that the plates suffer no physical damage and maintain adequate electron transfer capability. The Category C limit for float voltage is consistent with IEEE-450, which states that a cell voltage of 2.07 V or below, under float conditions and not caused by elevated temperature of the cell, indicates internal cell problems and may require cell replacement.

The Category C limit of average specific gravity  $\geq 1.190$  is based on manufacturer recommendations. In addition to that limit, it is required that the specific gravity for each connected cell must be no less than 0.020 below the average of

all connected cells. This limit ensures that the effect of a highly charged or new cell does not mask overall degradation of the battery.

Footnotes (b) and (c) to Table 4.6-1 are applicable to Category A, B, and C specific gravity. Footnote (b) to Table 4.6-1 requires the above mentioned correction for electrolyte temperature. The value of 2 amps used in footnote (c) is the nominal value for float current established by the battery vendor as representing a fully charged battery with an allowance for overall battery condition. This current provides, in general, an indication of overall battery condition.

Because of specific gravity gradients that are produced during the recharging process, delays of several days may occur while waiting for the specific gravity to stabilize. A stabilized charger current is an acceptable alternative to specific gravity measurement for determining the state of charge. This phenomenon is discussed in IEEE-450. Footnote (c) to Table 4.6-1 allows the float charge current to be used as an alternate to specific gravity for up to 7 days following a battery recharge. Within 7 days each connected cell's specific gravity must be measured to confirm the state of charge. Following a minor battery recharge (such as equalizing charge that does not follow a deep discharge) specific gravity gradients are not significant, and confirming measurements may be made in less than 7 days.

The SR 4.6.3 testing of the emergency lighting is scheduled every 18 months and is subject to review and modification if experience demonstrates a more effective test schedule.

#### REFERENCE

FSAR, Section 8

**Proposed Technical Requirement Manual Pages**

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### LIMITING CONDITIONS FOR OPERATION

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## 3.7 AUXILIARY ELECTRICAL SYSTEMS

### LIMITING CONDITION FOR OPERATION

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#### 3.7.1 Switchyard DC Sources

##### Applicability

Applies to the auxiliary electrical power system.

##### Objectives

To specify conditions of operation for the 125 VDC Switchyard Distribution System.

##### Requirements

- 3.7.1.1 At least 2 of 3 DC control power sources to the 125VDC switchyard distribution system shall be operable when the unit is above the cold shutdown condition.
- 3.7.1.2 With two control power sources from the plant to the switchyard inoperable, restore one control power source to operable status within 8 hours.
- 3.7.1.3 With two control power sources from the plant to the switchyard inoperable and unable to satisfy the requirement of TRM 3.7.1.2, or with three control power sources from the plant to the switchyard inoperable, initiate a condition report to document the inoperability and determine any limitations for continued operation of the plant.

### BASES

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The ANO switchyard consists of a 500 kV yard and a 161 kV yard connected by a 600 MVA autotransformer bank with a 22 kV tertiary winding. The control power for the 500 kV and 161 kV switchyard breakers can be supplied from three sources: 1) the 125 volt DC battery located in the switchyard control building; 2) the battery charger located in the switchyard control building; and 3) the ANO-1 DC bus "D41." The battery and battery charger operate in parallel continuously. The ANO-1 DC bus may be connected to the switchyard DC bus by a manual throwover switch. The switchyard DC bus is a non-1E power supply and is described in the ANO-1 Safety Analysis Report (SAR) Section 8.2.1.3.

##### References

SAR, Section 8.2.1.3

## 3.7 AUXILIARY ELECTRICAL SYSTEMS

### LIMITING CONDITION FOR OPERATION

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#### 3.7.2 Switchyard Battery Cell Parameters

##### Applicability

Applies to the auxiliary electrical power system.

##### Objectives

To specify conditions of operation for the 125VDC Switchyard Battery.

##### Requirements

- 3.7.2.1 Battery cell parameters shall be within limits when the DC control power sources to the 125VDC switchyard distribution system are required to be operable.
- 3.7.2.2 With one or more battery cell parameters not within TRM Table 4.6.1-1 Category A or B limits:
- A. Within 1 hour, verify pilot cell electrolyte level and float voltage meet TRM Table 4.6.1-1 Category C limits,
  - B. Within 24 hours and once per 7 days thereafter, verify battery cell parameters meet TRM Table 4.6.1-1 Category C limits, and
  - C. Within 31 days, restore battery cell parameters to TRM Table 4.6.1-1 Category A and B limits.
- 3.7.2.3 With one or more battery cell parameters not within TRM Table 4.6.1-1 Category A or B limits and unable to satisfy the actions or allowable times of TRM 3.7.2.2.A, 3.7.2.2.B, or 3.7.2.2.C, declare the battery inoperable and perform the required action of TRM 3.7.1.2 or TRM 3.7.1.3, as appropriate.
- 3.7.2.4 With one or more batteries with electrolyte temperature of representative cells not within the limits of TRM 4.6.1.6 or with one or more batteries with one or more battery cell parameters not within TRM Table 4.6.1-1 Category C limits, declare the battery inoperable and perform the required action of TRM 3.7.1.2 or TRM 3.7.1.3, as appropriate.

### BASES

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Battery cell parameters must remain within acceptable limits to ensure availability of the required DC power. Cell parameter limits are conservatively established, allowing continued DC electrical system function even with TRM Table 4.6.1-1 Category A and B limits not met.

With one or more cells not within limits (i.e., TRM Table 4.6.1-1 Category A limits not met, or Category B limits not met, or Category A and B limits not met) but within the TRM Table 4.6.1-1 Category C limits, the battery is degraded but still has sufficient capacity to perform its

intended function. Therefore, the battery is not required to be considered inoperable solely as a result of Category A or B limits not met. The pilot cell electrolyte level and float voltage are required to be verified to meet the TRM Table 4.6.1-1 Category C limits within 1 hour (TRM 3.7.2.2.A). These checks will provide a quick representative status of the remainder of the battery cells. Verification that the TRM Table 4.6.1-1 Category C limits are met (TRM 3.7.2.2.B) provides assurance that during the time needed to restore the parameters to within the Category A and B limits, the battery will still be capable of performing its intended function. This verification is repeated at 7 day intervals until the parameters are restored to within Category A and B limits. This periodic verification is consistent with the increased potential to exceed these battery parameter limits during these conditions.

With one or more battery cell parameters outside the TRM Table 4.6.1-1 Category C limit for any connected cell, sufficient capacity to supply the maximum expected load requirement is not assured. Therefore, the battery must be immediately declared inoperable and the corresponding DC control power source to the 125VDC switchyard distribution system must be declared inoperable.

Additionally, other potentially extreme conditions, such as electrolyte temperature of the pilot cell falling below 60°F, average electrolyte temperature of representative cells falling below 60°F or battery terminal voltage below the limit are also cause for immediately declaring the associated DC electrical power subsystem inoperable.

#### References

SAR, Section 8.2.1.3

## 4.1 AUXILIARY ELECTRICAL SYSTEMS

### SURVEILLANCE REQUIREMENTS

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#### 4.6.1 Switchyard DC Sources and Batteries

##### Applicability

Applies to the periodic testing and surveillance requirements of the 125 VDC Switchyard Distribution System to ensure it will respond properly when required.

##### Requirements

- 4.6.1.1 Verify battery terminal voltage is  $\geq 124.7$  V on float charge once each 7 days.
- 4.6.1.2 Verify battery capacity is adequate to supply, and maintain in operable status, the required emergency loads for the design duty cycle when subjected to either a battery service test or a modified performance discharge test once every 18 months.
- 4.6.1.3 Verify battery capacity is  $\geq 80\%$  of the manufacturers rating when subjected to a performance discharge test or a modified performance discharge test once every 60 months, once every 24 months when battery has reached 85% of the service life with capacity  $\geq 100\%$  of the manufacturers rating and showing no degradation, and once every 12 months when battery shows degradation or has reached 85% of the service life and capacity is  $< 100\%$  of the manufacturer's rating.
- 4.6.1.4 Connect and load the battery charger to its 125 VDC distribution system for at least 30 minutes during every quarter.
- 4.6.1.5 Verify battery pilot cell parameters meet TRM Table 4.6.1-1 Category A limits once per 7 days.
- 4.6.1.6 Verify average electrolyte temperature of representative cells is  $\geq 60^{\circ}\text{F}$  once per 92 days.
- 4.6.1.7 Verify battery cell parameters meet TRM Table 4.6.1-1 Category B limits once per 92 days and once within 24 hours after a battery discharge to  $< 110$  V and once within 24 hours after a battery overcharge to  $> 150$  V.

TRM Table 4.6.1-1

Battery Cell Surveillance Requirements

| PARAMETER                          | CATEGORY A:<br>LIMITS FOR EACH<br>DESIGNATED<br>PILOT CELL   | CATEGORY B:<br>LIMITS FOR EACH<br>CONNECTED CELL   | CATEGORY C:<br>ALLOWABLE LIMITS<br>FOR EACH<br>CONNECTED CELL   |
|------------------------------------|--|--|---|
| Electrolyte Level                  | > Minimum level indication mark, and ≤ 1/4 inch above maximum level indication mark <sup>(a)</sup> | > Minimum level indication mark, and ≤ 1/4 inch above maximum level indication mark <sup>(a)</sup> | Above top of plates, and not overflowing  |
| Float Voltage                      | ≥ 2.13 V   | ≥ 2.13 V   | > 2.07 V  |
| Specific Gravity <sup>(b)(c)</sup> | ≥ 1.195  | ≥ 1.190<br><br><u>AND</u><br><br>Average of all connected cells > 1.195                            | Not more than 0.020 below average connected cells<br><br><u>AND</u><br><br>Average of all connected cells ≥ 1.190 |

(a) It is acceptable for the electrolyte level to temporarily increase above the specified maximum during equalizing charges provided it is not overflowing.

(b) Corrected for electrolyte temperature.

(c) A battery charging current of < 2 amps when on float charge is acceptable for meeting specific gravity limits following a battery recharge, for a maximum of 7 days. When charging current is used to satisfy specific gravity requirements, specific gravity of each connected cell shall be measured prior to expiration of the 7 day allowance.

## BASES

The TRM 4.6.1.1 verification of battery terminal voltage while on float charge helps to ensure the effectiveness of the charging system and the ability of the batteries to perform their intended function. Float charge is the condition in which the battery charger is supplying the continuous charge required to overcome the internal losses of a battery and maintain the battery in a fully charged state. The voltage requirements are based on the nominal design voltage of the battery (2.15 V per cell average) and are consistent with the battery vendor allowable minimum volts per cell limits. The inability to meet this requirement constitutes an inoperable battery.

The TRM 4.6.1.2 battery service test is a special test of the battery capability, as found, to satisfy the design requirements (battery duty cycle) of the DC electrical power system. The discharge rate and test length should correspond to the design duty cycle requirements as. A modified performance discharge test may be performed in lieu of a service test. The inability to meet this requirement constitutes an inoperable battery.

The modified performance discharge test is a simulated duty cycle consisting of just two rates; the one minute rate published for the battery or the largest current load of the duty cycle, followed by the test rate employed for the performance test, both of which envelope the duty cycle of the battery. Since the ampere-hours removed by a rated one minute discharge represents a very small portion of the battery capacity, the test rate can be changed to that for the performance test without compromising the results of the performance discharge test. The battery terminal voltage for the modified performance discharge test should remain above the minimum battery voltage specified in the battery service test for the duration of time equal to that of the service test.

A modified performance discharge test is a test of the battery capacity and its ability to provide a high rate, short duration load (usually the highest rate of the duty cycle). This will often confirm the battery's ability to meet the critical period of the load duty cycle, in addition to determining its percentage of rated capacity. Initial conditions for the modified performance discharge test should be identical to those specified for a service test and the test discharge rate must envelope the duty cycle of the service test if the modified performance discharge test is performed in lieu of a service test.

The TRM 4.6.1.3 battery performance discharge test is a test of constant current capacity of a battery after having been in service, to detect any change in the capacity determined by the acceptance test. The test is intended to determine overall battery degradation due to age and usage. The inability to meet this requirement constitutes an inoperable battery.

Either the battery performance discharge test or the modified performance discharge test, described above, is acceptable for satisfying TRM 4.6.1.3; however, only the modified performance discharge test may be used to satisfy TRM 4.6.1.3 while satisfying the requirements of TRM 4.6.1.2 at the same time.

The acceptance criteria for this surveillance are consistent with IEEE-450. This reference recommends that the battery be replaced if its capacity is below 80% of the manufacturer's rating. A capacity of 80% shows that the battery rate of deterioration is increasing, even if there is ample capacity to meet the load requirements.

The frequency for this test is normally 60 months. If the battery shows signs of degradation, or if the battery has reached 85% of its service life and capacity is < 100% of the manufacturer's rating, the frequency is reduced to 12 months. However, if the battery shows no degradation but has reached 85% of its service life, the frequency is only reduced to 24 months for batteries that retain  $\geq 100\%$  of the manufacturer's ratings. Degradation is indicated, according to IEEE-450, when the battery capacity drops by more than 10% relative to its capacity on the previous performance test or when it is  $\geq 10\%$  below the manufacturer's rating.

TRM 4.6.1.4 requires that each required battery charger be capable of supplying the connected loads while maintaining the battery fully charged.

TRM 4.6.1.5 verifies that the TRM Table 4.6.1-1 Category A battery cell parameters are consistent with vendor recommendations and IEEE-450, which recommend regular battery inspections (at least once per month) including voltage, specific gravity, and electrolyte level of pilot cells.

The TRM 4.6.1.6 verification that the average temperature of representative cells is  $\geq 60^\circ\text{F}$  is consistent with a recommendation of IEEE-450, which states that the temperature of electrolytes in representative cells (~10% of all connected cells) should be determined on a quarterly basis. Lower than normal temperatures act to inhibit or reduce battery capacity. This surveillance ensures that the operating temperatures remain within an acceptable operating range. This limit is based on manufacturer recommendations.

TRM 4.6.1.7 verifies that the TRM Table 4.6.1-1 Category B battery cell parameters are consistent with vendor recommendations and IEEE-450, which recommend regular battery inspections (at least once per quarter) including voltage, specific gravity, and electrolyte level of each connected cell. In addition, within 24 hours after a battery discharge to < 110 V or a battery overcharge to > 150 V, the battery must be demonstrated to meet Category B limits. Transients, such as motor starting transients, which may momentarily cause battery voltage to drop to  $\leq 110$  V, do not constitute a battery discharge provided battery terminal voltage and float current return to pre-transient values. This inspection is also consistent with IEEE-450, which recommends special inspections following a severe discharge or overcharge, to ensure that no significant degradation of the battery occurs as a consequence of such discharge or overcharge.

TRM Table 4.6.1-1 delineates the limits on electrolyte level, float voltage, and specific gravity for three different categories. The meaning of each category is discussed below.

Category A defines the normal parameter limit for each designated pilot cell in each battery. The cells selected as pilot cells are those whose temperature, voltage and electrolyte specific gravity approximate the state of charge of the entire battery.

The Category A limits specified for electrolyte level are based on manufacturer recommendations and are consistent with the guidance in IEEE-450, with the extra 1/4 inch allowance above the high water level indication for operating margin to account for temperatures and charge effects. In addition to this allowance, footnote (a) to TRM Table 4.6.1-1 permits the electrolyte level to be above the specified maximum level during equalizing charge, provided it is not overflowing. These limits ensure that the plates suffer no physical damage and that adequate electron transfer capability is maintained in the event of transient conditions. IEEE-450 recommends that electrolyte level readings should be made only after the battery has been at float charge for at least 72 hours.

The Category A limit specified for float voltage is  $\geq 2.13$  V per cell. This value is based on the battery vendor allowable minimum cell voltage and on a recommendation of IEEE-450, which states that prolonged operation of cells  $< 2.13$  V can reduce the life expectancy of cells.

The Category A limit specified for specific gravity for each pilot cell is  $\geq 1.195$ . This value is characteristic of a charged cell with adequate capacity. According to IEEE-450, the specific gravity readings are based on a temperature of 77°F (25°C).

The specific gravity readings are corrected for actual electrolyte temperature. For each 3°F (1.67°C) above 77°F (25°C), 1 point (0.001) is added to the reading; 1 point is subtracted for each 3°F below 77°F. The specific gravity of the electrolyte in a cell increases with a loss of water due to electrolysis or evaporation.

Category B defines the normal parameter limits for each connected cell. The term "connected cell" excludes any battery cell that is jumpered out.

The Category B limits specified for electrolyte level and float voltage are the same as those specified for Category A and have been discussed above. The Category B limit specified for specific gravity for each connected cell is  $\geq 1.190$  with the average of all connected cells  $> 1.195$ . These values are based on manufacturer's recommendations. The minimum specific gravity value required for each cell ensures that the effects of a highly charged or newly installed cell will not mask overall degradation of the battery.

Category C defines the limits for each connected cell. These values, although reduced, provide assurance that sufficient capacity exists to perform the intended function and maintain a margin of safety. When any battery parameter is outside the Category C limits, the assurance of sufficient capacity described above no longer exists and the battery must be declared inoperable.

The Category C limits specified for electrolyte level (above the top of the plates and not overflowing) ensure that the plates suffer no physical damage and maintain adequate electron transfer capability. The Category C limits for float voltage is based on IEEE-450, which states that a cell voltage of 2.07 V or below, under float conditions and not caused by elevated temperature of the cell, indicates internal cell problems and may require cell replacement.

The Category C limits of average specific gravity  $\geq 1.190$  is based on manufacturer recommendations. In addition to that limit, it is required that the specific gravity for each connected cell must be no less than 0.020 below the average of all connected cells. This limit ensures that the effect of a highly charged or new cell does not mask overall degradation of the battery.

Footnotes (b) and (c) to TRM Table 4.6.1-1 are applicable to Category A, B, and C specific gravity. Footnote (b) to TRM Table 4.6.1-1 requires the above mentioned correction for electrolyte temperature. The value of 2 amps used in footnote (c) is the nominal value for float current established by the battery vendor as representing a fully charged battery with an allowance for overall battery condition. This current provides, in general, an indication of overall battery condition.

Because of specific gravity gradients that are produced during the recharging process, delays of several days may occur while waiting for the specific gravity to stabilize. A stabilized charger current is an acceptable alternative to specific gravity measurement for determining the state of charge. This phenomenon is discussed in IEEE-450. Footnote (c) to TRM Table 4.6.1-1 allows the float charge current to be used as an alternate to specific gravity for

up to 7 days following a battery recharge. Within 7 days each connected cell's specific gravity must be measured to confirm the state of charge. Following a minor battery recharge (such as equalizing charge that does not follow a deep discharge) specific gravity gradients are not significant, and confirming measurements may be made in less than 7 days.

#### References

None