Staff Concern 1: Provide a specific ACTION & increased CT for an inoperable battery charger

The proposed change addresses the condition where one [or two] battery charger[s on one train/division] is inoperable. Incorporating TSTF-360 into the plant TSs would allow increasing the battery charger allowed outage time (AOT) from 2 hours to 7 days provided that the licensee is able to restore battery terminal voltage to greater than or equal to the minimum established float voltage within 2 hours, and are able to verify that battery float current is less than or equal to 2 amps once per 12 hours.

The proposed TS Bases for this REQUIRED ACTION states the following:

> REQUIRED ACTION A.3 limits the restoration time for the inoperable battery charger to 7 days. This action is applicable if an alternate means of restoring battery terminal voltage to greater than or equal to the minimum established float voltage has been used (e.g., balance of plant non-Class 1E battery charger). The 7-day CT reflects a reasonable time to effect restoration of the qualified battery charger to OPERABLE status.

Per GDC 17, the battery charger has two primary safety functions (1) maintaining the Class 1E battery in a fully charged condition while supplying required dc loads (charged sufficiently to supply the loads required during the Design Basis Accident) and (2) supply the post-accident loads while recharging the battery. The battery charger is needed to stabilize the discharge of the battery at the completion of the duty cycle. The stabilization ensures that sufficient reserves are present in the battery to provide for loads in excess of the battery charger capability. In addition to the above, the battery charger provides dc control power (and thus ac power) on recovery of ac power following events such as loss of offsite power or station blackout.

EEEB’s concern is that without an 'alternate means' that is capable of automatically being supplied by a Class 1E or non-Class 1E back-up power source, the affected train would not be capable of providing dc control power (and thus ac power) on recovery of ac power following events such as loss of offsite power or station blackout or recharging the battery. It is also possible that the battery capacity could discharge to the point where the battery may not have sufficient remaining capacity to operate the supply breakers to restore power to the safety related buses.

Therefore, EEEB needs to be assured that the 'alternate means' that is being credited for restoring battery terminal voltage to greater than or equal to the minimum established float voltage is supported by a back-up Class 1E or non-Class 1E power source that is independent of the offsite power supply (e.g., Class 1E or non-Class 1E diesel generator). Furthermore, and if not already described in the plant’s UFSAR, the licensee will need to update the UFSAR to address the aforementioned 'alternate means' since it would be credited for the 7-day AOT allowance.

TSTF Response Summary:

This scenario assumes a charger failure followed by a LOOP/SBO event. Only one of the redundant trains is involved. In addition, there are manual means available (breaker closing springs charged and manual charging possible) that can reestablish ac power.

For the 7-day period (after completing the immediate actions of establishing minimum charge voltage and assuring the battery is adequate charged), the battery remains capable of performing its required duty cycle. The condition is limited to a single division/train, where all required functions to protect public health and safety are assured (provided no additional single failures) even if the battery division/train were to be completely non-functional, as could be postulated during the initial 12-hour allowance to reestablish battery capacity. It is accepted that while in the allowed limited durations of a Tech Spec Action, additional single failures need not be considered when evaluating the ability of the plant to respond to an event. The added assurance of this division/train's battery to supply at least one complete duty cycle (assuming the charger was NOT available post event) is added protection above the minimum necessary to cope and provides an adequate basis for the 7-day outage time and does not necessitate that there be any capability for the 'alternate means' to be backed up by an onsite AC power source (e.g., diesel generator).

The NRC has reiterated the position that a single failure need not be considered when not meeting an LCO and being in an action statement. The GDC and Tech Specs differ in that the GDC specify for design where as the Tech Specs specify the requirements for the operation of nuclear reactors.

TSTF Response Detailed Analysis:

The emphasis in TSTF-360 was to take a tiered and focused approach to the actions and completion times, keeping the unit in a safe and stable condition at all times. Conceptually, if a charger is lost, the battery begins discharging due to the house loads. Therefore, the first priority should be to stop the discharge and determine the battery condition. If possible, the inoperable charger will be restored within the 2-hour period. However, if this is not possible, it is preferable to use an "alternate means" to stop the discharge and determine the battery condition before going into a shutdown condition. This alternate means consists of a balance of plant non-Class 1E charger with sufficient capacity to carry the house loads plus the normal float current of the battery. The three action statements provide a focused sequence of actions upon loss of a charger.

It is preferred to know the condition of the battery prior to initiating a shutdown. By using an alternate charger to stop the discharge and measuring float current to determine the state of charge, a quick assessment of the battery state of charge can be made. This is not possible when using specific gravity readings, due to the inherent time lag in the readings. However, immediately after connecting a charger to the battery, the combination of battery voltage and float current provides sufficient information to determine if the battery is stable and sufficiently charged to continue down that path. If either battery voltage or float current is out of limits, then the DC system is considered inoperable.

With an inoperable charger under the existing TS, shutdown of the unit would be initiated within 2 hours, and the charger would still have to be repaired before the battery could be recharged and ac power restored after any subsequent loss of ac power event. With no charger connected, the battery will continue to discharge throughout the event, even after ac power is restored. With an alternate charger connected, the discharge can be stopped and the battery stabilized.

The position that the alternate charger must be powered from a diesel generator was not a limitation imposed in the TSTF. We are not aware of any NRC analysis or documentation to support the current position requiring diesel backup. Diesel backup is not required based on the following:

- The actual change in incremental conditional core damage probability (ICCDP) caused by not having a backup source versus a non-safety-related backup source is extremely small. This is demonstrated by the fact multiple plants have LCO times for class 1E diesel generators ranging from 7 to 14 days.
- All the springs in the ac breakers store sufficient energy to allow a single manual operation.
- Breaker springs can be manually recharged if necessary.
- To meet the action statement the alternate charger must be capable of restoring the battery terminal voltage to the minimum required. In order for this to occur, the battery must be significantly recharged.
- With a charged battery and postulating no other failures, in the event of a LOOP the following would occur:
    - The diesel generator would start and load, restoring power to the class 1E AC bus and all critical loads.
    - The static inverters would transfer from DC to AC power automatically
    - With the static inverters transferred to AC power, the major load on the batteries is removed.
    - The significant load reduction on the batteries significantly extends battery life beyond the 4 or 8 hour LOOP requirement.
    - The extended run time would be sufficient to bring the plant to cold shutdown and make plans to go to single train operation or manual control of the AC system.
    - The extended run time would allow sufficient time to restore charging, there is a high probability that either the temporary charger would be restored or the failed charger restored, which would halt the discharge and eliminate the need for single train AC operation.
    - Most LOOP events do not exceed the 4 or 8 hour design criteria which makes it probable that power to the temporary charger would be restored prior to the battery becoming fully discharged.

Based on the preceding, there was no expectation that the charger have emergency power backup when this provision was proposed and adopted in the NUREG STS.

If not already described in the UFSAR, when used, the 'alternate means' will be controlled by configuration management processes.

Regulatory Issue Summary 2005-20, "Operability Determination Process,"

Appendix C.1, "Relationship Between the GDC and the Technical Specifications," states, "Required actions and completion times of the TSs illustrate the relationship between the GDC and the TSs. The GDC require redundancy of function for safety systems. This is normally accomplished by incorporating at least two redundant trains into the design of each safety system. The TSs typically allow a facility to continue to operate for a specified time with only one train of a two-train safety system operable. In that case, the GDC are met because the system design provides the necessary redundancy. The TSs permit the operation of the system with only a single train based on an evaluation of the protection provided by the unique system lineup for the specified period."

Staff Concern 2: Replace battery specific gravity monitoring with float current monitoring

The proposed change removes specific gravity monitoring from the TSs and replaces it with float current monitoring.

Specific gravity monitoring is used to measure the strength of a battery cell's electrolyte, which is an important component of the battery's chemical reaction, and provides an indication of the battery's state-of-charge. Whereas, float current monitoring may or may not provide an accurate indication of the battery's state-of-charge. Float current monitoring is based on the following equation that is dependent on several variables.

I = (E-Eb)/R

Where:

I = Charging Current
E = Charging Voltage
Eb = Internal Cell Voltage
R = Cell Resistance

EEEB has a concern with two variables of this equation: the charging voltage (E) and cell resistance (R). A change in either of these variables may provide a false indication of the battery's state-of-charge. A proper understanding of the battery's state-of-charge is necessary to provide assurance that the battery has sufficient capacity to perform its design function as prescribed by GDC 17. It is important to note that the battery manufacturer manuals provide recommendations for taking specific gravity readings and do not mention the use of float current monitoring to determine the battery's state-of-charge.

EEEB believes that float current monitoring provides an adequate initial indication of a battery's state-of-charge following a discharge of provided that the applied charging voltage is controlled. However, based on the uncertainty identified above concerning cell resistance, EEEB does not believe that float current monitoring provides adequate assurance of the state-of-charge during steady-state operations. Therefore, EEEB recommends using a combination of both methods in the TSs. Float current monitoring could be allowed to provide reasonable assurance that the battery is fully charged following a discharge and specific gravity monitoring could be allowed for verifying the state-of-charge of the battery during routine surveillances.

TSTF Response Summary:

Float current monitoring is the preferred method of determine battery state of charge for the following reasons:

1. With the proper float voltage applied, float current monitoring accurately indicates battery state of charge after a discharge as well as during steady-state operation.
2. Float current monitoring is a more meaningful indicator of state of charge because current is the primary means of discharging and charging the battery.
3. Specific gravity readings have an inherent time lag on both charge and discharge.
4. Existing Tech Specs for Susquehanna, South Texas Project and other plants which were based on the old standards, allow the un-restricted use of float current in lieu of specific gravity to verify battery state of charge.

Note that the state of charge is only one of many parameters used to determine battery condition in TSTF-360.

***TSTF Response Detailed Analysis*:**

This concern deals with the fundamental question of which state-of-charge indicator is best for surveillance purposes. The basic charge-discharge reactions for lead-acid batteries are associated with electric current flow internal and external to the battery/cells and lead-sulfate conversion internal to the cells. (See Reference 2 below for further discussion of float behavior.)

One of the first indications of a possible discharge is a charger failure alarm followed by a DC Bus under-voltage alarm. Once an unintended discharge is indicated, then battery condition including state of charge must be determined. Measuring the specific gravity in one cell or even several cells at one level in the bulk electrolyte does not give a timely indication of state of charge due to the inherent time lag associated with specific gravity readings. Verifying adequate float voltage and then measuring float current provides a very quick indication of state of charge. For example, if a discharge has occurred, there will be an immediate spike in the current entering the battery once the voltage is applied. Depending upon the degree of discharge, the subsequent recharge current may remain higher than the normal float current level for several minutes before it begins an exponential decay to normal. Therefore, float current monitoring provides a more timely indication of state of charge than specific gravity.

The equation given in the NRC concern is only one of two given in the 1994 INTELEC paper (Ref. 1) to illustrate the cell voltage and current variations associated with the charge-discharge reactions of a lead-acid battery. However, in answer to the concerns, the charging voltage (E) is fixed by the battery charger float/equalize control setting. The internal cell resistance (R) is a very small value and varies inversely with the state of charge, from a maximum when fully discharged to a minimum when fully charged. The dominant factor in the equation is the internal cell voltage (E_b), which is dependent upon the presence of lead sulfate ions within the cell. The quantity of lead sulfate ions is associated with the state of charge. Even a small amount of lead sulfate reduces the internal cell voltage significantly, thus increasing the driving voltage given as ($E- E_b$) in the equation above. (This is why the current demand of a fully discharged battery can be thousands of Amperes even with the internal cell resistance is at its maximum value.) The charge reaction (conversion of lead sulfate) is the preferred reaction electrochemically. Therefore, this reversible reaction proceeds to completion once adequate voltage is applied to the battery.

If there is no lead sulfate to be converted, the battery is fully charged and true float behavior takes place as described in the Paul C. Milner article published in the Bell System Technical Journal (Ref. 2). Tafel line graphs are made by the battery manufacturer to document this behavior. These graphs depict the logarithm of the average expected float current versus the applied cell voltage for a given model series. Float current is made up of components associated with the electrolysis of water, grid corrosion at the positive plates, and oxygen recombination at the negative plates. In order for float current to flow, the voltage applied to the battery must be greater than its open circuit value. This is referred to as over-potential or sometimes an overcharge condition. This is not to be confused with the reversible charge-discharge reaction associated with battery capacity. The over-potential, measured in millivolts per cell, polarizes the plates in order to minimize grid corrosion and self-discharge.

The level of float current measured with the proper float voltage provides a clear indication of battery state of charge at any time. If the current is higher than the established float current limit, then a recent discharge is indicated. The level and time response of the current indicates some characteristics of the discharge as described in the TSTF-360 Bases. If the current is at or below the established limit, there is reasonable assurance the battery is charged. This has been confirmed in technical papers, by consultation with the battery manufacturers, and by over 20 years of experience at one nuclear plant. (Even partial discharges in the order of 0.1% of rated Ah have been captured with continuous float current monitoring.)

The use of float current monitoring to determine the state of charge after a discharge has been included since the earliest STS's as well as the 1975 and later editions of IEEE 450. Some manufacturer manuals contain discussions about charging current in the midst of the sections on specific gravity readings. In a recent poll of class 1E battery suppliers all supported the use of float current for state of charge monitoring in lieu of specific gravity. They still require specific gravity readings as only a maintenance and warranty requirement, which remains a part of the licensee maintenance programs.

Battery manufacturer manuals recommend specific gravity readings and not float current monitoring because most of the flooded battery users don't maintain batteries to the stringent standards required at nuclear plants. We represent a very small percentage of the flooded battery user market. An occasional voltage and perhaps a specific gravity reading is all that's required by many users. The larger telecom users simply use a flashlight to check for lead sulfate crystals to check the state of charge. However, this flashlight technique is not described in the manuals either, because the telecom industry provides this kind of information and trains to their own standards. Also, the battery manufacturers are on the industry standard committees and have in fact supported these practices through their representation on the IEEE Stationary Battery Committee and other industry consensus groups. In addition, at least one safety-related battery manufacturer offers a float current monitoring device on their web page. Finally, the instruction manuals are for general use and cannot be expected to include user-specific recommendations.

Float current monitoring during steady-state operations accurately indicates the battery state of charge as described above. Electric current is the primary means of charging and discharging the battery. Specific gravity readings are taken in the bulk electrolyte away from the active materials and are thus secondary indications. This is why specific gravity readings have an inherent time lag and hence are less accurate in assessing the present state of charge during steady-state operations. There are also limitations to the use of specific gravity readings as described in Section 7 of C&D Installation and Operating Manual (12-800) or Section 11 of the GNB manual (Section 8-05).

References:

[1] K. D. Floyd, "Assessment of Lead-Acid Battery State of Charge by Monitoring Float Charging Current," INTELEC'94, Vancouver, October 30-November 3, 1994.
[2] P. C. Milner, "Float Behavior of the Lead-Acid Battery System," Bell System Technical Journal, pages 1321 through 1334, September 1970.

Staff Concern 3: Provide specific ACTIONS and increased CTs for out-of-limits conditions for battery cell voltage, electrolyte level, and electrolyte temperature

1) The proposed change reduces the voltage limit for the pilot cell from 2.13 volts to 2.07 volts.

   TSTF Response: TSTF-360 does relocate some maintenance limits to a licensee-controlled program, but the voltage limits have not changed. What has changed is how tech specs deal with voltages between 2.13 and 2.07. The voltage limits apply to all connected cells not just the pilot cells. If any cell is found with a voltage less than 2.13 volts, then the maintenance and monitoring program requires that actions be taken to restore the voltage to at least 2.13 volts. TSTF-360 maintains the 2.07 volts as the ultimate operability limit (albeit with marginally extended restoration times) and monitors to assure actions are taken when below 2.13 volts (see TS 5.5.[14] Admin Control Program).

   The battery pilot cell is typically selected to represent the average battery cell in the battery. If the battery pilot cell represents the average, a battery pilot cell voltage measurement of 2.07 volts or slightly greater would provide an indication that several battery cells of the battery have a voltage less than 2.07 volts. With several battery cells below 2.07 volts there is not sufficient assurance that the battery can still perform its safety function as prescribed by GDC 17. This could potentially result in a loss of function and from a TS point of view could potentially render the battery inoperable without requiring entry into a LCO.

   TSTF Response: SR 3.8.4.1 requires battery terminal voltage to be maintained at greater than or equal to the minimum established float voltage (defined as the number of cells times the manufacturer's minimum float voltage per cell). As for the entire battery being floated at 2.13 or 2.07, that is not possible. The lowest minimum float allowed by any manufacturer of a class 1E lead-calcium battery is 2.17 vdc/cell. For the pilot cell to be average it would have to float at 2.17 if that was the applied voltage. If the applied voltage was less than 2.17 volts/cell then the battery could not pass the weekly surveillance for minimum terminal voltage. This provides reasonable assurance that multiple cells would not be below 2.07 or even 2.13 volts. It is possible for a pilot cell (or any cell for that matter) to develop a problem between surveillance tests that would cause its individual cell voltage to drop below 2.13 or 2.07 volts. If this condition is found then the appropriate Tech Spec and Battery Monitoring Program Actions would be entered which requires all cells to be verified greater than 2.07 volts.

   It should be noted that neither the battery manufacturers nor the licensees perform any discharge test from a minimum average cell voltage of 2.13 let alone a minimum average cell voltage of 2.07. Discharge tests, which are performed to demonstrate a battery's capability or available capacity, are typically initiated with an average battery cell voltage in the range of 2.20 to 2.25 volts.

   TSTF Response: Discharge test conditions comply with the requirements of IEEE 450-1975 which was endorsed by the NRC under Reg. Guide 1.129. These requirements have remained unchanged to the 1995 and current 2002 revision. Discharge tests are initiated with the charger disconnected from the battery. However, the string and individual cell voltages may be above the open circuit value at the start of the test, which would also be expected during an actual loss-of-power event. These elevated voltages are due to the residual capacitive charge on the surface of the plates. Therefore they will have the same impact on an actual discharge as on a test and as such can be disregarded. In addition, the IEEE 946 working group commissioned short circuit testing in 1991, which demonstrated that no additional discharge capability occurs with respect to previous float or equalize voltages (i.e. capacitive charge effect).

References:
[1] IEEE 450-1975, IEEE Recommended Practice for Maintenance, Testing and Replacement of Large Lead Storage Batteries for Generating Stations and Substations
[2] U.S. Nuclear Regulatory Commission Regulatory Guide 1.129 Maintenance, Testing, and Replacement of Large Lead Storage Batteries for Nuclear Power Plants
[3] IEEE 946-2004, IEEE Recommended Practice for the Design of DC Auxiliary Power Systems for Generating Stations, Annex C (informative) Batteries, Available Short Circuit Current – Sample Calculations

A voltage limit of 2.13 volts was originally provided for most plant TSs. The 2.13 volt limit is consistent with battery manufacturer manuals and IEEE Standard 450 (As a corrective action, the battery manufacturers and IEEE Standard 450 recommend providing an equalize charge to the affected battery or battery cell in an effort to raise the voltage above 2.13 volts). The 2.13 volt limit provided a measure of margin necessary for relying on a measurement uncertainty obtained from only the pilot cell. Thus, providing reasonable assurance that the battery had sufficient capacity to perform its intended safety function. The 2.07 volt limit for the pilot cell does not provide a measure of margin necessary for relying on a measurement uncertainty obtained from only the pilot cell. Therefore, a measurement of 2.07 volts at the pilot cell does not provide reasonable assurance that the battery has sufficient capacity to perform its intended safety function.

TSTF Response: The past TS for nearly all power reactors allowed temporary reductions from 2.13 volts (i.e., the "Category B Limit") and only considered the battery inoperable when below 2.07 volts in any cell (i.e, the "Category C Allowable"). Pilot cell voltage has no relationship to the capacity of the battery or any cell. See the papers referenced below. The 2.13 volt limit is a maintenance limit for taking corrective action. TSTF-360 continues to require actions to be taken when below 2.13 volts (see TS 5.5.[14] Admin Control Program), in accordance with IEEE 450 or the battery manufacturer. This maintenance limit is considered important and continues to be addressed by TSTF-360.

References:
[1] D. O. Feder & G. Carosella, "The Never Ending Pursuit of Float Voltage Uniformity in Stationary Reserve Battery Plants", Proceedings INTELEC 1994, p. 609-617.
[2] E. Davis, D. Funk, W. Johnson, "Internal Ohmic Measurements and Their Relationship to Battery Capacity" Proceedings of Battcon 98 pages 2-1 to 2-9

Based on the above, EEEB proposes revising TSTF-360 and the STS to require licensees to establish an acceptance criteria for the pilot cell based on the standard deviation of individual cell voltages to provide sufficient confidence that no battery cell is below [2.07] volts (the brackets around 2.07 designate that the acceptance criteria is plant specific and should be based on the battery manufacturer's cell type and cell size that are installed in safety related applications). The acceptance criteria for the pilot cell (2.13 volts or any other selected voltage) should be related to the average cell voltage during a performance discharge test such that the ampere-hours removed from the battery between the acceptance criteria and the minimum voltage would be sufficient for the battery to perform its designed safety function. Otherwise, the current SR should remain unchanged to ensure that the licensee verifies that the battery pilot cell is above 2.13 volts.

TSTF Response: As previously discussed there is no impact on the tested capacity due to the residual capacitive charge. See previous discussions and references above.

The bracketed 2.07 volts is the open circuit voltage of the cell. For a lead-acid battery it is dependent on the electrolyte specific gravity. It is independent of the size of the cell (G. W. Vinal, Storage Batteries, Copyright 1955, Page 192 Table 39). The 2.07 value is a nominal value for a battery with a nominal electrolyte specific gravity of 1.215. The 2.07 value envelopes the expected open circuit voltage range for a battery with a nominal specific gravity 1.215.

There is no relationship between the average voltage during discharge and the open circuit voltage. The average voltage will be below the open circuit value for entire duration of the discharge. This can be seen in any manufacturers discharge fan curve for any battery. This is due to the fact that as soon as a discharge starts, the batteries internal resistance creates a voltage drop proportional to the rate of discharge (Voltage Drop = Discharge Rate Times the Battery Internal Resistance). Since the nominal open circuit voltage of a fully charged 1.215 specific gravity cell is 2.07 VDC, then it follows that the cell voltage during discharge is less than this value.

There is no justification to assume that any ampere hours are removed from a cell between voltages of 2.13 and 2.07. The previously cited studies have demonstrated that there is no correlation between cell float voltage and cell capacity.

2) The proposed change replaces electrolyte temperature measurement of representative battery cells with electrolyte temperature measurement of each battery pilot cell.

A low electrolyte temperature limits the current and power available. The 12-hour CT proposed by TSTF-360 only addresses the pilot cell. No ACTION has been stated for the remaining cells. As mentioned previously, the battery pilot cell is typically selected to represent the average battery cell in the battery. If the battery pilot cell represents the average, a battery pilot cell with a temperature at or slightly greater than the minimum established design limit would provide an indication that several battery cells of the battery are below the minimum established design limit. With several battery cells with an electrolyte temperature below the minimum design limit there is not sufficient assurance that the battery can still perform its safety function as prescribed by GDC 17.

This could potentially result in a loss of function and from a TS point of view could potentially render the battery inoperable without requiring entry into a LCO.

TSTF-360 provides the following justification for only measuring the battery pilot cell's electrolyte temperature:

> Since the battery is sized with margin, while battery capacity is degraded, sufficient capacity exists to perform the intended function. Therefore, the affected battery is not required to be considered inoperable solely as a result of the pilot cell temperature not being met, and the 12-hour CT provides a reasonable time to restore the electrolyte temperature within established limits.

While EEEB understands that batteries are typically designed with margin, this statement is too broad. In order to justify this change, EEEB would need a description of the extent of each nuclear power plant's battery capacity margin available at the end of the batteries' expected life [IEEE Standard 485, "IEEE Recommended Practice for Sizing Lead-Acid Batteries for Stationary Applications," sizing criteria (design, aging, and temperature margins)] and an explanation as to why (or how it is known) that this capacity margin is sufficient to allow the battery to perform its intended safety function. Furthermore, the results of an evaluation/analysis demonstrating that the batteries have been sized with sufficient capacity (including margin for a degraded battery) should be incorporated into the respective plant's UFSAR. EEEB also recommends establishing a minimum acceptable margin and require licensees to ensure that the minimum allowed margin would be maintained. Otherwise, the SR should remain to ensure that the licensee measures a representative sample of battery cells to verify that no battery cells are below minimum established design limit.

***TSTF Response Summary*:**

While battery capacity is degraded by a low temperature, the change is small even in a worst case scenario. Because the change is small, the other margins used in sizing normally ensure sufficient capacity exists to perform the intended function. Even if all margins were used up, the resulting loss in battery capacity for a single train is too small to have a significant impact on the incremental conditional core damage probability (ICCDP). Plant Design and Operating Practices make the possibility of a battery actually reaching this limit very small. The 12-hour CT provides a reasonable time to restore the electrolyte temperature within established limits and is a reasonable trade off in risk with a plant shutdown. This position is supported by the following analysis.

TSTF Response Detailed Analysis:

Worst Case Scenario Analysis:

Assumptions for worst case:

- Pilot cell is warmest cell in the battery
- Pilot cell is at minimum temperature of 45 degrees F
- Battery is at IEEE limit of 5 degrees F differential temperature
- Average cell temperature is 5 degrees less than pilot cell temperature

Based on the above assumptions the temperature correction factor used in the sizing calculations would be 1.25 according to IEEE 485-2003. However, the required factor for 40°F is 1.30. Therefore, the deviation in correction factor is 0.05 (1.30 - 1.25), resulting in an apparent capacity margin deficit of 3.8% (100 x 0.05/1.30). However, due to the sizing methodology in IEEE 485, there is a cumulative effect due to the multiplication rather than addition of margins. For example, including an aging correction factor of 1.25 with the temperature correction factor of 1.25, the combined sizing correction factor would be 1.56 (1.25 x 1.25) or 156% capacity while the required capacity would be only 150% (100 + 25 + 25), thus resulting in a net capacity margin gain of 6%. Even if the aging factor is reduced to 1.16, the excess in sizing margin of 4% (1.45 minus 1.41 = 0.04; 1.16 x 1.25 = 1.45, 1.00 + 0.16 + 0.25 = 1.41) would compensate for the 3.8% deficit due to the temperature differential. Therefore, the sizing excess margin compensates for this worst-case temperature deviation of 5°F. If a battery is found outside of the 5°F bounding analysis then it will be addressed on a site specific basis. In a similar fashion, it can be shown that other cases with less extreme minimum temperatures would also be covered by this excess sizing margin.

Justification for using Pilot Cell Temperature:

The impact of a single cell temperature being above or below the average does not in itself affect the battery's ability to perform its design function. Just as a cell below the average is reduced in its output ability, those above the average temperature are increased. That is why the average temperature is used for sizing and not the lowest individual cell temperature.

First, it should be acknowledged that the minimum established design limit for electrolyte temperature is based upon known temperature data and documented in design calculations. Therefore, we would not expect to reach this minimum limit. Second, the battery is sized with margins for temperature, aging and load growth.

In risk space, a loss of 5% capacity for a single cold battery train is not significant. The uncertainties in the incremental conditional core damage probability (ICCDP) calculation more than bound this slight reduction in battery capacity.

If the pilot cell electrolyte temperature (using the worst case assumptions) should reach the minimum design limit, some time is needed to establish the cause and take corrective actions. In addition to the excess sizing margin described above, the margins used for aging and design would not expect to be depleted at the same time. The fact that the battery is otherwise considered operable indicates that the sizing and aging margins must still exist at the time that a pilot cell temperature may be discovered below its limit. Furthermore, there is some increased plant risk associated with an unplanned Tech Spec required shutdown transient. Therefore, these other margins and the limited time to restore the limit without subjecting the plant to a shutdown transient, provide a sufficient qualitative basis for the presentation related to electrolyte temperature.

It should also be remembered that as the battery discharges, heat is generated which increases the cell temperature. This effect offsets some of the capacity loss due to starting at a lower temperature. During sizing, credit is not taken for this effect and as such it constitutes an additional margin.

Battery room temperatures are monitored and the first indication of a problem would be the temperature going low out of tolerance. Since batteries have very large thermal inertia, it is highly probable that the room temperature excursion would be corrected prior to the battery reaching minimum temperature.

Staff Concern 4: Create a licensee-controlled program based on the Institute of Electrical and Electronics Engineers (IEEE) Standard 450-1995 or 2002, "IEEE Recommended Practice for Maintenance, Testing, and Replacement of Vented Lead-Acid Batteries for Stationary Applications," and/or the improved Technical Specification Bases to reference actions for cell voltage and electrolyte level.

Consistency with IEEE Standard 450-1995 was used throughout TSTF-360 as the justification for approval, however, the NRC has yet to endorse this version of IEEE Standard 450. The most recent version of IEEE Standard 450 that has been endorsed by the NRC through Regulatory Guides (RGs) is IEEE Standard 450-1975. The RGs of mention are: RG 1.128, "Installation, Design, and Installation of Large Lead Storage Batteries for Nuclear Power Plants," and RG 1.129, "Maintenance, Testing, and Replacement of Large Lead Storage Batteries for Nuclear Power Plants."

TSTF Response: Justifications in TSTF-360 were provided without reliance on IEEE 450. All references to IEEE 450 were either informational ("also consistent with" type of after thought) or were directed at the commitments to the non-TS monitoring program that would be required when adopting this change. Amendment requests have included noted exceptions to various RGs to be reflected in the plant's licensing bases (FSAR). Since RGs are guidance and alternatives are always open for NRC review and approval, the path taken in TSTF-360 to justify these exceptions and alternatives does not depend on a formal NRC endorsement of IEEE 450-1995 (2002) in a RG.

We agree that all submittals must include adequate justification for the changes and it is not adequate justification only to state the changes are in accordance with IEEE 450-1995 or 2002 or TSTF-360.

For the most part, EEEB agrees with the majority of the recommended practices in the latest revisions to IEEE Standard 450. However, and similar to Staff Concern 2 above, EEEB disagrees with the IEEE Standard 450 recommendation allowing the use of float current monitoring in lieu of measuring specific gravity.

TSTF Response: This concern has been previously addressed under Staff Concern 2.

EEEB is currently working with the Office of Nuclear Regulatory Research and the new reactor licensing branch to initiate a revision to the aforementioned RGs to address the latest revision of IEEE Standard 450. In the meantime, IEEE Standard 450-1995 (or IEEE Standard 450-2002) should not be used as an acceptable bases for approval until it has been fully or partially endorsed by a revised RG.

TSTF Response: As stated above, IEEE 450-1995 or 2002 is not the basis for approval, the technical rationale presented is. Stating conformance to or commitment to practices of the latest version is presented for site-by-site approval. Proposed and justified alternatives are commonly approved by the NRC on a site-specific basis. Guidance will be provided to licensees to relocate references to IEEE 450-1995 or 2002 to the Tech Spec Bases.

EEEB therefore believes that all references to the consistency with IEEE Standard 450-1995 should be removed from TSTF-360 and replaced by a reference to the plant procedure for the battery monitoring and maintenance program.

TSTF Response: TSTF-360 presumes a licensee commitment to develop site programs/procedures/processes to assure monitoring per IEEE 450-1995 specifically because plant programs/procedures/processes that only followed 1975 version were deemed to be inadequate. This was part of the negotiated approval of TSTF-360. Guidance will be provided to licensees to relocate references to IEEE 450-1995 or 2002 to the Tech Spec Bases.

As mentioned below, the licensee will have to submit this procedure to assure the staff that the relocated parameters have been incorporated into the battery monitoring and maintenance program.

TSTF Response: Guidance will be provided to licensees to include a statement in the submittal letter that the maintenance and monitoring program is a regulatory commitment.

Staff Concern 5: Miscellaneous

Licensees need to address following list of items:

1. Licensees seeking to create a new battery monitoring and maintenance program need to provide assurance that the relocated battery parameter values will continue to be controlled at their current level and actions will be implemented in accordance with the licensee's corrective action program. Furthermore, the licensee will have to submit a copy of this program to assure the staff that the relocated parameters have been incorporated into the battery monitoring and maintenance program.

   TSTF Response: As previously stated, guidance will be provided to licensees to include a statement in the submittal letter that the maintenance and monitoring program is a regulatory commitment.

2. The values represented by the phrases 'minimum established design limits' and 'minimum established float voltage' must be consistent with the battery manufacturer recommendations.

   TSTF Response**:** The 'minimum established float voltage" is currently tied to the manufacturer's recommendations in the Bases for SR 3.8.4.1. The minimum established design limit for temperature is based on the battery sizing calculations and is site specific.

3. The minimum established float voltage needs to be identified in the TS Bases.

   TSTF Response**:** We agree this bracketed value must be completed by the licensee in the Bases. The bracketed value is really a "per-cell" value and a "string" value as indicated in Bases for SR 3.8.4.1 and 3.8.6 Background. The per-cell value is multiplied by the number of connected cells to determine the string "minimum established float voltage."

4. Licensees that propose adding the following alternate acceptance criteria to the plant TSs for the battery chargers need to ensure that the time to return the battery to the fully charged state accurately reflects the battery charger design capacity as it is detailed in the plant's UFSAR:

   Verify each battery charger can recharge the battery to the fully charged state within [24] hours while supplying the largest combined demands of the various continuous steady state loads, after a battery discharge to the bounding design basis event discharge state.

   TSTF Response**:** We agree this bracketed value must be completed by the licensee to agree with the plant's design bases.

5. Each change that is requested by the licensee, including those changes identified in TSTF-360, needs to be supported by site specific data.

   TSTF Response**:** We agree that any bracketed values as well as any other site-specific changes requested should be adequately supported in the submittal.