NRC Staff Response to Industry White Paper
Extended Battery Duty Cycles

Issue

In response to EA-12-049, several licensees have stated that their Class 1E station batteries can last beyond 8 hours as part of their mitigating strategies for beyond design basis events (BDBEs). The NRC staff requires additional information from the industry that shows that the existing Class 1E station batteries can perform their expected function for durations greater than 8 hours throughout the expected service life.

Industry Comment:

1) The industry does not believe IEEE 535 is applicable to beyond design basis events and battery qualification for an extended loss of ac power event is not intended.

NRC Staff Response:

JLD-ISG-2012-01 states that during the initial phase of an extended beyond design basis event an ELAP is assumed and the only source of power are the station batteries. As such, the capability of the batteries needs to be assessed to determine whether or not the batteries will be capable of withstanding an extended duty cycle. One acceptable approach for demonstrating the capability of the battery is to use the guidance in IEEE 535 and satisfying all the clauses contained within. If supplied by industry, the staff would also consider reviewing supporting operational experience with similar vented lead-acid batteries as a means to demonstrate the capability of this technology to support the suggested function over the expected design life. A third option would be to propose mitigating strategies that require alternate means of providing power such as a portable diesel generator to be connected to the battery chargers within 6 hours which would ensure that the batteries could perform their intended function prior to exceeding an 8-hour duty cycle.

Industry Comment:

2) Typically to extend the FLEX mission time of the batteries, stations are relying on timely load shedding of non-essential loads (including non-essential Class 1E loads) from the batteries. Engineering calculations are utilized to provide a reasonable engineering basis to demonstrate that the batteries will have sufficient FLEX mission time to maintain power to key instruments until deployment of on-site portable FLEX equipment. The actual FLEX battery mission time needed at a site is dependent upon the individual station FLEX strategies.

NRC Staff Response:

While we agree that battery mission time needed at a site is dependent upon the individual station FLEX strategies, *calculations should be supplemented by type testing and/or operational experience to show the capability of the batteries to support the proposed duration of a BDBE. Type testing is preferred because failure modes introduced by the extended duty cycles are not clearly understood at this time.*

Industry Comment:

3) Existing station batteries are qualified to meet their design basis function throughout their qualified life. Current Technical Specification surveillance and safety-related maintenance

practices ensure the station's safety-related batteries are maintained ready to perform their function when required.
NRC Staff Response:

The current TS surveillances provide reasonable assurance that the batteries will perform their safety function when called upon for design basis events for a specified duration (duty cycle), typically 1-2 hrs). However, in order to demonstrate that the batteries will perform their design function during a BDBE, a testing program should be established where testing to the most limited and/or extended duty cycle is performed. This will provide reasonable assurance that the batteries will perform their function during a BDBE.

Industry Comment:

4) The existing maintenance and surveillance programs are adequate to trend battery capacity and to ensure age-related or other degradation is addressed for station safety-related batteries before the design basis capacity is challenged. An aging factor is included when sizing lead-acid batteries for design basis loads to allow time for replacement once degradation is detected/confirmed.

***NRC Staff Response**:*

Margins are added to battery qualification testing to ensure that temperature, radiation, cycle aging, instrument calibration errors, manufacturing defects, and other considerations are taken into account during the life of a battery for known failure mechanisms with consideration given to design basis events. These are known factors that have been identified throughout an extensive period of operating experience. Since the existing surveillance and testing program envelops only the duty cycles for design basis events, which is less conservative than a BDBE, a separate testing program or additional tests to the current testing program may have to be performed to provide reasonable assurance that the batteries will perform their function for an extended duty cycle during a BDBE.

Industry Comment:

5) Based on the well-maintained condition of the safety-related batteries (as a result of existing maintenance and surveillance programs), the capacity of the batteries to carry design basis loads is known.

NRC Staff Response:

See the response above. The capacity of the battery to carry design basis loads is known at the qualified discharge rate; however, the capacity and capability of the battery are unknown for BDBE loading at a different discharge rate (i.e., extended durations). Regardless of the existing testing program, the licensee is responsible for showing that the batteries will have sufficient capacity and capability to perform its intended function for the duration assumed during a BDBE.

Industry Comment:

6) Load shedding is an established industry practice to extend battery mission time. Given the known capacity of nuclear plant station batteries, load shedding is a reasonable strategy to extend battery runtime during an ELAP to meet the FLEX battery mission time. Load shedding was explicitly identified in NEI 12-06, "Diverse and Flexible Coping Strategies (FLEX) Implementation Guide", Section 3 as a means to extend battery runtime.

NRC Staff Response*:*

Licensees need to provide load shedding calculations to demonstrate that the batteries are capable of supporting the extended duty cycle regardless of their design capacity to support design basis events. Again, failures modes that might be introduced by the extended duty cycle might reshape a testing program.

Industry Comment:

7) IEEE 485, "Recommended Practice for Sizing Large Lead Storage Batteries for Generating Stations and Substations", methodology is the industry Standard for battery sizing, taking into account correction factors for aging, temperature, and design margin, with the certified manufacturer's discharge data. The IEEE 485 methodology has been proven over time in many nuclear station applications and is widely used by manufacturers, utilities, consultants, and others throughout the battery industry. a. Using the specific FLEX load profiles as design inputs, the effect of load shedding on the battery runtime can be evaluated using IEEE485.
b. The aging correction factor is an integral part of IEEE 485 methodology to adjust the battery sizing for the proper end-of-service life condition (normally 80% of rated capacity).
c. Testing a stationary battery to detect signs of degradation and/or when to replace the battery can be accomplished by testing the battery per IEEE 450. When degradation occurs or capacity approaches 80%, then cell replacement can be planned. This is current industry practice.
d. The certified manufacturer's discharge data is supplied with the batteries and gives a range of discharge rates for various times and end voltages based on various factory tests. The discharge times typically range from 1 minute to several hours. This discharge data may be in a tabular form or a discharge characteristic curve as described in IEEE 485-2010, Annex F. e. Certified discharge data load profiles similar to FLEX load profiles should now be available for most if not all station batteries which support the FLEX sizing calculations.

NRC Staff Response:

With respect to IEEE 485, the staff agrees that it is the correct standard to use when sizing batteries. If the batteries are to support a different duty cycle (from what was originally considered) or under different environmental conditions (e.g., temperature), the battery sizing should be re-evaluated. With respect to IEEE 450, licensees need to keep in mind that this standard was developed for batteries with duty cycles of up to 8 hours in duration. The 8-hour duration is supported by operational experience and known failure modes for this product for this duration. However, for an extended duty cycle, testing prescribed by IEEE 450 may not be valid since different failure modes might be introduced by the extended duty cycle. The new failure modes (if any) may require a revision to the existing testing programs that may also vary from the existing IEEE-450 guidance. As mentioned previously, the staff would consider reviewing type testing as a way to demonstrate the capability of the batteries to perform under extended duty cycles. The staff would consider reviewing this information if it is provided under oath and affirmation provided the data shows each battery's capability and that the discharge curves are officially published for the duration of the extended duty cycles by the manufacturer. The staff position is that performance of a battery must be demonstrated by suitable tests to verify that it will perform its design duty function if it is not demonstrated by current TS requirements.

Industry Comment:

8) In terms of battery qualification, the same battery model can be qualified for a 2-hour duty cycle in one application and a 4-hour duty cycle in another. In addition to these qualified uses, this same model could also deliver capacity for an 8-hour duty cycle and longer runtimes if

required. While it was not qualified for the longer runtimes, such a battery can perform in projected BDB functions consistent with the certified discharge data available.

NRC Staff Response:

While it is possible that the existing batteries may be able to supply power for extended duty cycles the staff does not have supporting data that provides reasonable assurance that the existing batteries can perform their intended function during a BDBE for extended duty cycles. It is therefore, licensee's responsibility to verify that it will perform its design duty function if it is not demonstrated by current TS requirements. We disagree because new failure modes might be introduced by the extended duty cycle.

Industry Comment:

9) The preliminary test results from on-going testing at Brookhaven National Laboratory (BNL) demonstrate performance during extended discharge runtimes is consistent with the above calculation methodologies. In addition, the BNL testing has not identified any new or unusual battery failure mechanisms associated with extended battery load durations.

NRC Staff Response:

The results from this testing haven't been finalized. The staff also notes that the BNL testing is limited in that it was intended to demonstrate the capability of the existing battery technology to potentially support extended duty cycles, however this testing did not and will not demonstrate the capability of the existing battery technology to support extended duty cycles for the expected service life (i.e., the batteries that were tested were not aged). It also has yet to be seen whether the synergistic effects of normal operation versus BDBE operation have been considered in this application in order to consider it valid for this situation.