Response to NRC Concerns on TSTF-360

July 12, 2006 Meeting

Agenda

I. Desired Outcome
II. History of Battery Tech Specs
III. Industry Response to Industry Concerns
    1. Inoperable battery charger
    2. Float current monitoring
    3. Cell voltage, electrolyte level & temperature
    4. Licensee controlled program
    5. Miscellaneous

Technical Specification Task Force (TSTF) Desired Outcome

TSTF desired outcome of this effort is to resolve the NRC's concerns regarding TSTF-360 that would permit TSTF to develop a final TSTF Traveler that the NRC can approve and make available to Industry for adoption through the Consolidated Line Item Improvement Process (CLIIP) in the near future.

Battery Tech Spec History

- 1984 STS (NUREG-0123, Rev 4)
- 1992 ISTS (NUREG-1433, Rev 0)
- 2000 TSTF-360 (NUREG-1433, Rev 3)

NRC Concern 1
Inoperable Charger TS 3.8.4.A

- Increased Allowed Outage Time (AOT)
  - 2 hours under existing TS
  - 7 days under TSTF-360
- 'Alternate means' power source –
  - not supplied from back-up power source independent of offsite supply

TSTF Response 1
Inoperable Charger TS 3.8.4.A

- Increased Allowed Outage Time (AOT)
  - 3-tiered Actions (2h, 12h, & 7d)
  - At 2h, Restore Charge Volts to $\geq$ MEFV
  - Every [12]h, Verify Float Amps $\leq$ [2]A
  - Within 7 days Restore Charger to OPERABLE
  - Any action not met, default to Condition D or E

TSTF Response 1 (cont'd) Inoperable Charger TS 3.8.4.A

- ACTION A.1 Bases
- Within 2h, normal charger is restored or an alternate charger capable of restoring BTV $\geq$ MEFV may be used
- BTV $\geq$ MEFV indicates battery will be fully charged within [12] hours
- In addition, this result is verified

TSTF Response 1 (cont'd) Inoperable Charger TS 3.8.4.A

- ACTION A.2 – Bases
- Verifying float current ≤ [2]A every [12]h ensures a fully-charged battery
- This focused approach confirms the battery is fully capable throughout the 7-day time allowed to restore a charger to OPERABLE (A.3)

TSTF Response 1 (cont'd) Inoperable Charger TS 3.8.4.A

- Fully-charged battery is verified throughout 7-day AOT
- Battery capable of meeting design function (DBA/LOOP/SBO) as appropriate
- If normal charger not OPERABLE after event, AC power can be restored to alternate charger via manual actions

TSTF Response 1 (cont'd) Inoperable Charger TS 3.8.4.A

- Redundant train/division charger remains OPERABLE & DG-Backed
- Single failure need not be considered when not meeting an LCO and being in an Action statement

NRC Concern 2
Float Current versus SG

- Float current may or may not accurately indicate State of Charge (SOC) routinely?
  - Due to variation in voltage and cell resistance shown in the Equation: $I = (E - E_b)/R$
  - Uncertainty during steady-state?
- Recommend using SG for routine SR's and float current after discharges

TSTF Response 2, Summary Float Current versus SG

1. With proper voltage applied, float current accurately indicates SOC after discharge as well as during steady-state operation
2. Float current is a more meaningful SOC indicator because current is primary means of discharging & charging the battery

TSTF Response 2, Summary Float Current versus SG

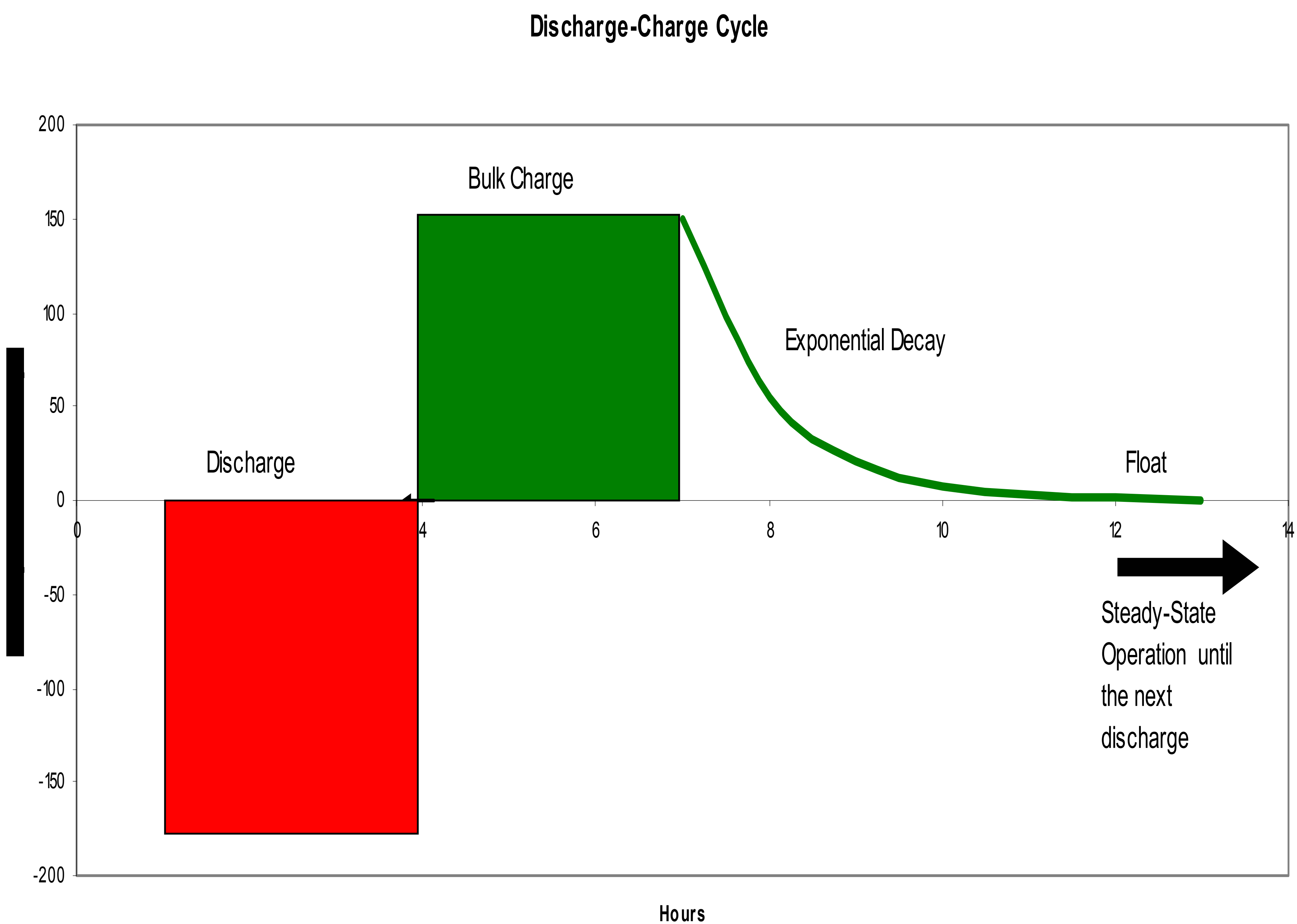
3. Specific gravity readings have an inherent time lag on charge and discharge
4. Existing TSs for many plants, which were based on old STS, allow unrestricted use of float current in lieu specific gravity as SOC indicator

TSTF Response 2, Detail
Float Current versus SG

- Note: Equation used to illustrate how cell voltage varies with state of charge (SOC)
- Charging voltage E is fixed by charger control setting (normal float voltage)
- Driving voltage ($E-E_b$) varies with internal cell voltage E_b which is related to SOC
- True float operation doesn't start until battery is fully-charged (all sulfate ions converted)

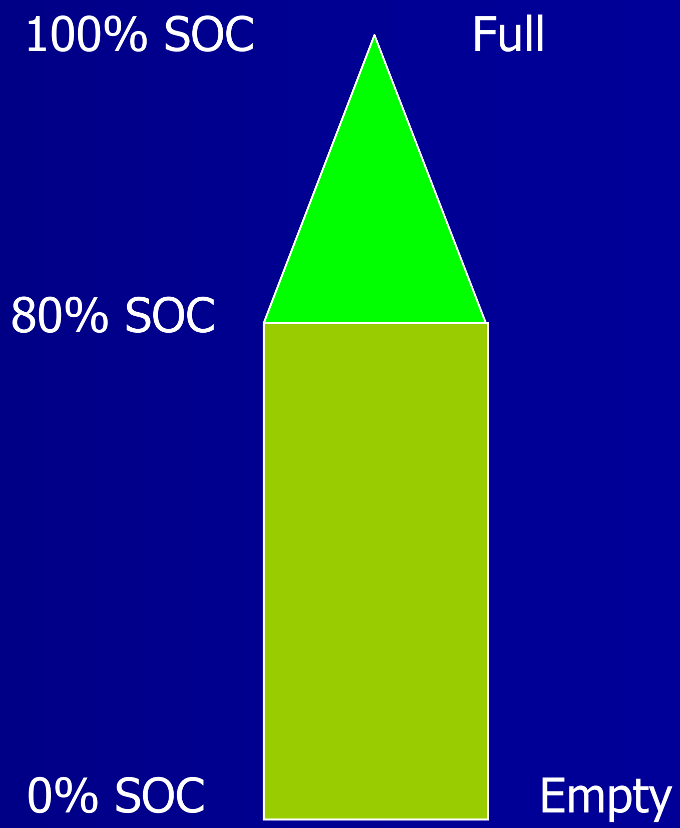
TSTF Response 2, Detail
Float Current versus SG

- The use of float current monitoring to determine state of charge after a discharge has been recognized since the 1984 STSs as well as the 1975 and later editions of IEEE 450


Discharge-Charge Cycle
200
150
100
50
0
-50
-100
-150
-200
[redacted]
0
4
6
8
10
12
14
Bulk Charge
Exponential Decay
Discharge
Float
Steady-State Operation until the next discharge
Hours

Bottle Analogy

- When no sulfate ions remain to be converted, the battery is fully charged!
- Exponential curve defines charge remaining.
- Full = Float only



TSTF Response 2, Detail
Float Current versus SG

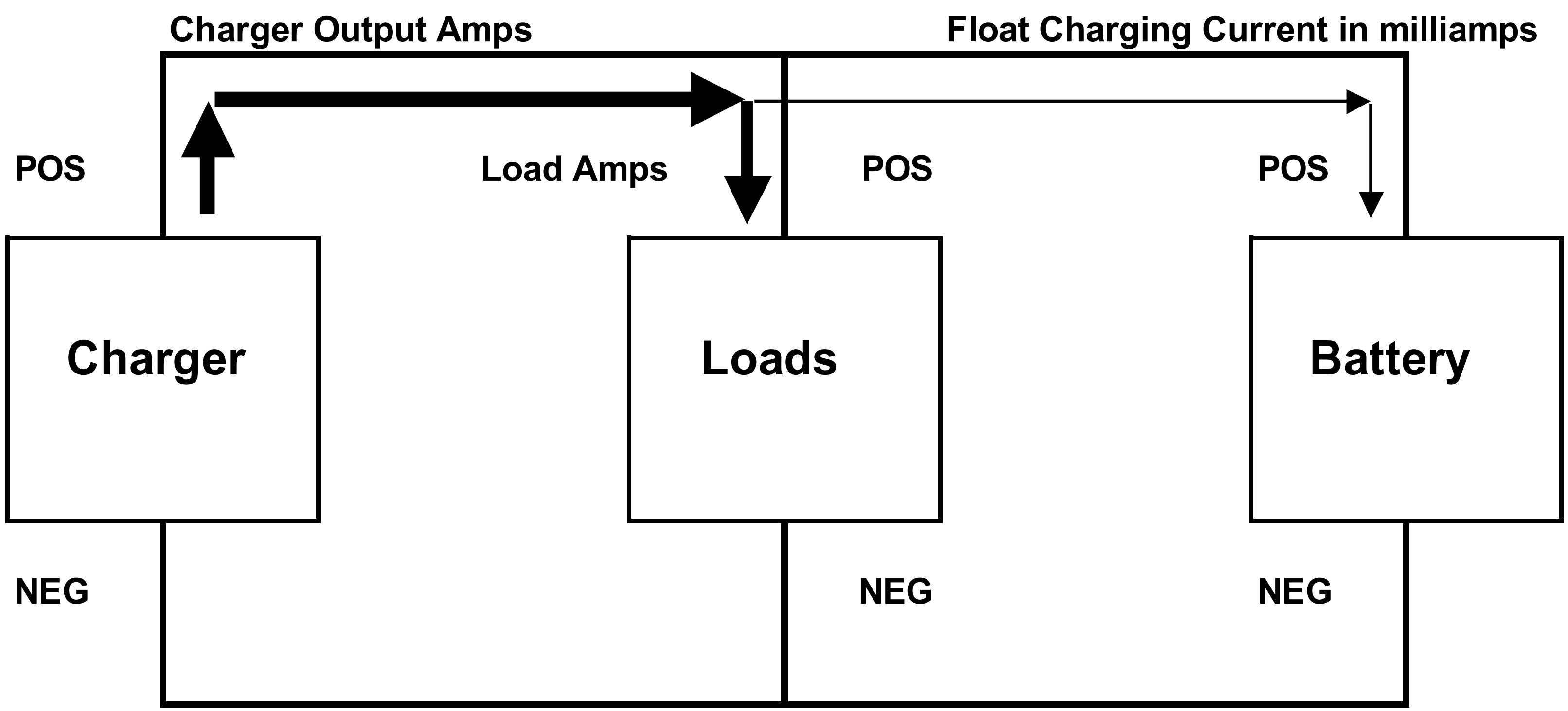
- Charging current easily observed on exponential curve
- Battery manufacturers average float current data are available for various cell types to define float limits
- DC shunts, clamp-on ammeters, and specialty float current monitoring instruments are available

TSTF Response 2, Detail
Float Current versus SG

- 'Steady-state' (normal float) operation for a DC system consists of a charger supplying sufficient dc voltage to carry house load current and also provide float current to maintain a fully-charged battery
- If there is no discharge, battery on float remains fully-charged.

Charger Supplying Loads

Charger Output On & Battery Charged
(Loads fed from Charger)



Steady-State Operation Sequence (Outage into Oper.)

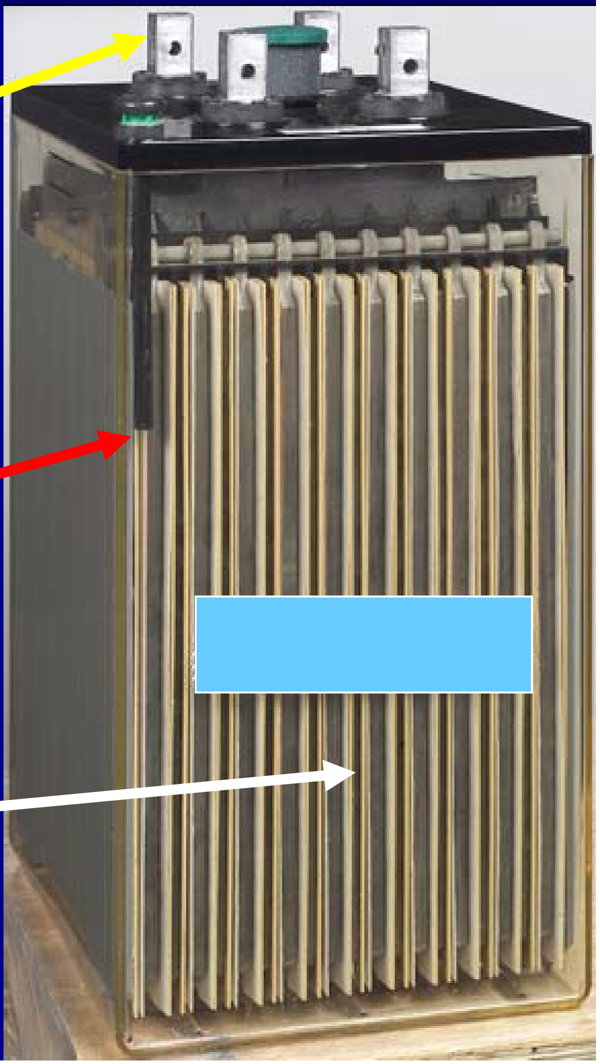
Battery Condition	Battery Current	Specific Gravity
Charged after Modified Performance Test	Amps ≤ Float Limit flowing into battery	SG<Full charge, but increasing
3 weeks	≤ Float Limit	Still increasing
Valve Stroking	Momentary current out	May not see a change
˜6 weeks	≤ Float Limit	~ full chg SG

TSTF Response 2, Detail
Float Current versus SG

- With proper voltage applied, float current monitoring accurately indicates state of charge <u>at any time</u>
- Specific gravity readings have an inherent time lag behind actual SOC
  - SG readings taken in bulk electrolyte while actual reactions occur between plates (See illustration following)

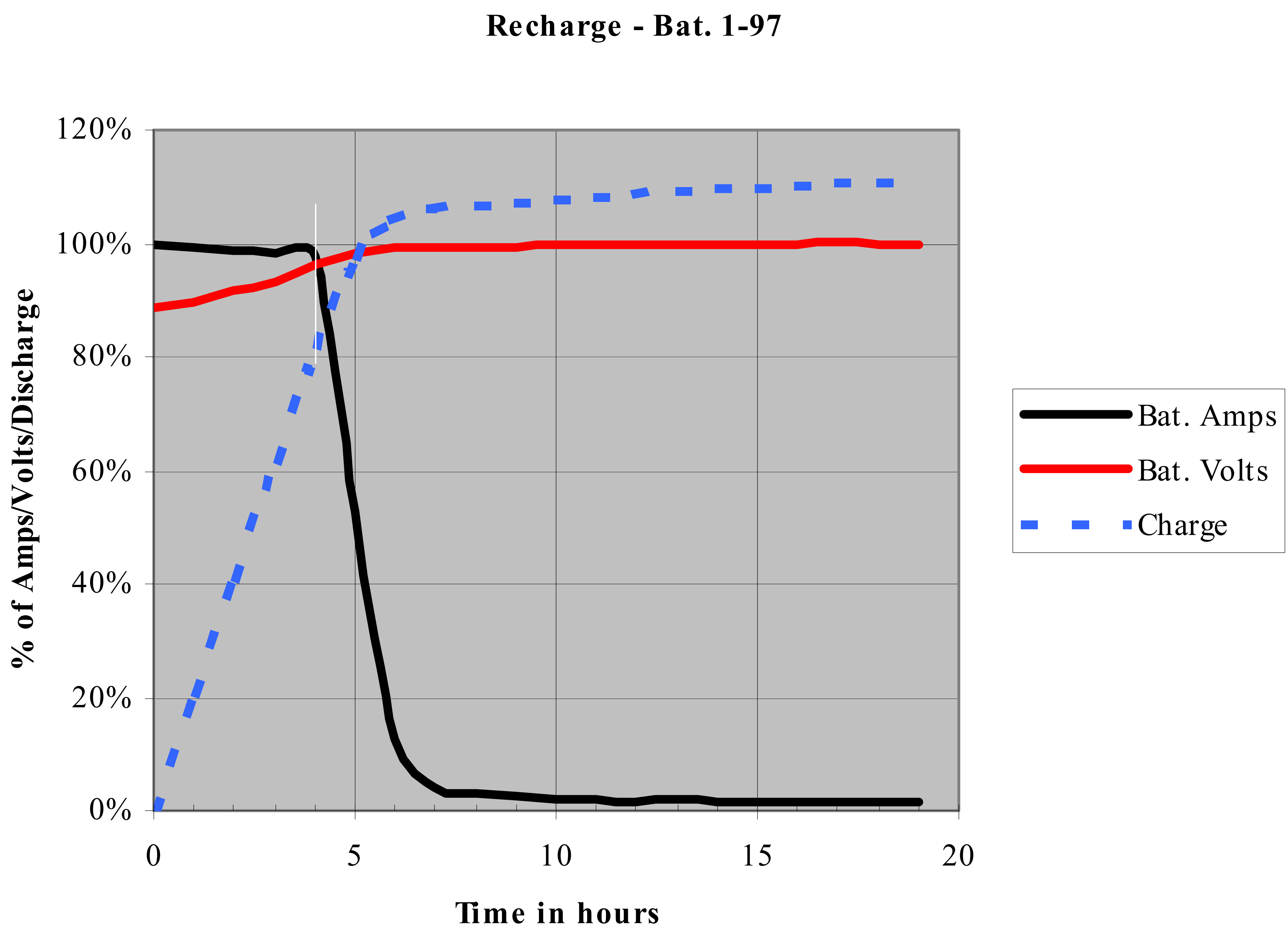
Where SG is measured in cell?

- Pos. & Neg. Posts carry current to external circuit
- Specific gravity is measured in corner of cell, in bulk electrolyte
- Reactions occur between plates



TSTF Response 2 (cont'd) Float Current versus SG

- A sample recharge graph will be used to illustrate how the state of charge is determined using float current monitoring
- Note: Specific data can be used to develop similar tables for each battery


Recharge - Bat. 1-97
120%
100%
80%
60%
40%
20%
0%
% of Amps/Volts/Discharge
0
5
10
15
20
Time in hours
Bat. Amps
Bat. Volts
Charge

TSTF Response 2 (cont'd) Float Current versus SG

- Assume 80% charge occurs at the end of the constant current portion of recharge as shown on graph
- This means 20% of charge is returned under exponential curve
- Using the exponential characteristics, the following table is constructed
- Net Charging Amps=Charger Current Limit – House Loads
- Remember the Bottle Analogy

TSTF Response 2 (cont'd) Float Current versus SG

	% Net Charge Amps	% State of Charge
Full Charge	≤Float Limit	100%
	5%	98%
	13%	95%
	36%	90%
At Curve Knee	100%	80%

TSTF Response 2, Summary Float Current versus SG

- Float Current Monitoring provides an accurate indication of state of charge after discharges as well as during steady-state operations
- Many past and current TSs allow the unrestricted use of float current monitoring for SOC indication

TSTF Response 2, Summary Float Current versus SG

- Battery current is the primary means of changing the state of charge
- Specific gravity at one point in the bulk electrolyte is a secondary indicator at best
- There is always some time lag involved with specific gravity readings
- In the lead-calcium cells used in nuclear plants, there is an inherent inaccuracy in measuring SG due to electrolyte stratification (non-homogeneous mixture)

TSTF Response 2, Summary Float Current versus SG

- Float current measurements can be taken quickly without having to suit up and extract electrolyte from cells
- Multiple SG readings in each cell must be taken to get representative average
- SG readings must be level corrected to determine true state of charge

NRC Concern 3
Cell Volts, Level & Temperature

- Reduce Pilot-cell Voltage Limit
  - 2.13V versus 2.07V
  - Pilot-cell voltage and Discharge Tests
  - 2.07V and assured capacity
  - Pilot-cell volts and average volts during a discharge

TSTF Response 3
Cell Volts, Level & Temperature

1. Reduce Pilot-cell Voltage Limit
   - The voltage limits are not changed. Existing TSs use 2.07V as the operability limit
   - How we address voltages between 2.13V and 2.07V is not changed, but simply relocated to the Maintenance and Monitoring Program (MMP)
   - The 2.13V limit is applied to all cells

TSTF Response 3 (cont'd) Cell Volts, Level & Temperature

1. Reduce Pilot-cell Voltage Limit
   – Meeting the minimum float voltage during the weekly surveillance provides reasonable assurance that multiple cells are not below 2.13 volts
   – Discharge test methodology has not changed since IEEE 450-1975 which was endorsed by RG 1.129

NRC Concern 3 (cont'd) Cell Volts, Level & Temperature

2. Average versus Pilot-Cell Temperature
   - Action for other cell temperatures?
   - Margin Bases too broad
   - Recommend min. acceptable margin

TSTF Response 3 (cont'd) Cell Volts, Level & Temperature

2. Average versus Pilot-Cell Temperature
   - Bounding analysis using a maximum of 5°F has been provided
   - If a battery cannot meet the 5°F bounding analysis a site specific analysis is required

NRC Concern 4
Licensee-Controlled Programs

- Based on IEEE 450-1995
- Not endorsed by NRC
- Disagree with use of float current in lieu of SG
- Recommend removing all references to consistency with IEEE 450-1995 and replacing w/plant procedure

TSTF Response 4
Licensee-Controlled Programs

- TSTF-360 technical justifications were not based on IEEE-450 and required site specific verification
- We agree references to IEEE-450-1995 or 2002 should be moved to the Bases until endorsed by the NRC
- Float Current vs. SG has been previously addressed
- We will add guidance to to include a commitment in the submittal

NRC Concern 5
Miscellaneous

- Must hold relocated parameters at current level, Use corrective action program, & Submittal to Staff

- *Response:* We will add guidance to include in the submittal a commitment to implementing a MMP in accordance with IEEE-450

NRC Concern 5 (cont'd) Miscellaneous

- 'Minimum established limits' to be tied to Mfr's recommendations
- *Response:* 'Minimum established float voltage' now given in SR 3.8.4.1 Bases and 'Minimum established design limit' for temperature is site specific

NRC Concern 5 (cont'd) Miscellaneous

- 'Minimum established float voltage' to be identified in Bases

- *Response:* This value is included in Bases as noted above. Per-cell value is multiplied by 'No. of connected cells' to get 'MEFV'

NRC Concern 5 (cont'd) Miscellaneous

- Alternate charger test criteria must accurately reflect design capacity described in USFAR

- *Response:* Agree this must be completed by Licensee to agree with design basis

NRC Concern 5 (cont'd) Miscellaneous

- Each requested change in submittal must be supported by site specific data

- *Response:* Agree that bracketed values and site specific data to be supported in submittals