Improving Standby Power :
For Railway Signals & Communication Systems

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What We Want You to Know

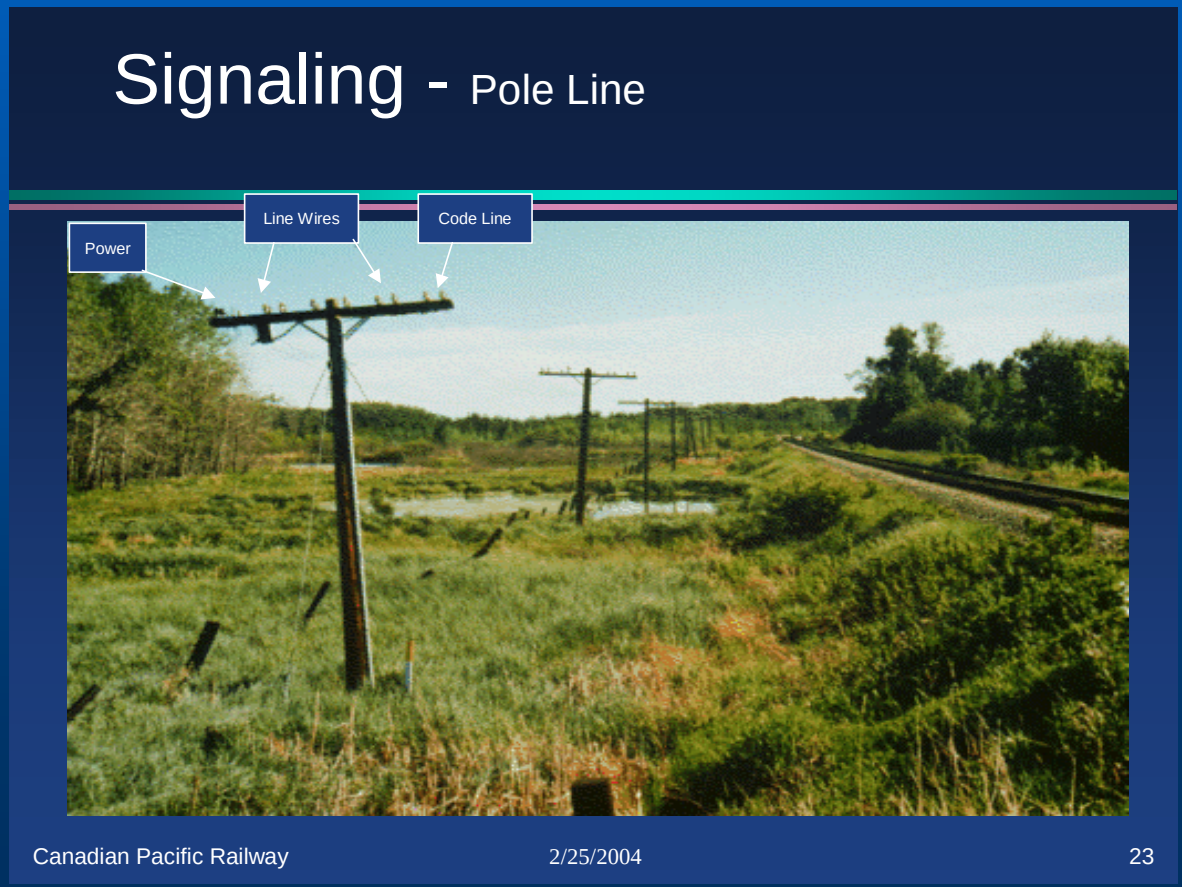
- **Raise the awareness of the importance of the reliability and predictability of standby power**
- **Provide technical and business case facts and issues for the Signal Engineering Team**
- **Highlight some results of actual testing**
- **Look to the future**
  - **Remote monitoring**
  - **Breaker resets**

Power Reliability

- **Having a source of power to provide:**
  - **Reliable performance & properly functioning equipment**
- **Minimizing opportunity for outages**
  - **Proper design**
  - **Fix or eliminate pole line**
  - **Proper surge protection**
  - **Remote monitoring**
  - **Breaker resets**

Recent Improvements for Power Reliability

- **Moving off open wire pole lines**



Recent Improvements for Power Reliability

- **Improving surge protection for the AC service (and also improving the track surge protection) by**
  - **putting arrestors on all external conductors**
  - **incorporating better low impedance ground references into the bungalow design**
  - **improving the AC line arrestors**
  - **improving bungalow – AC Power line ground schemes**
  - **working directly & proactively with utilities on power line fault protection**

Recent Improvements
LIRP- CPR Initiative
Low Impedance Reference Plane &SPD's

CSX Recent Improvements

AC Power protected by MOV in Faraday Box

Recent CPR_Improvements for Power Reliability

- **Adding transfer switches and external generators plugs to buildings to make it**
  - **Easier, Faster and much safer to connect an external generator**
- **Bus Mounted SPD**

Power Reliability is an Issue

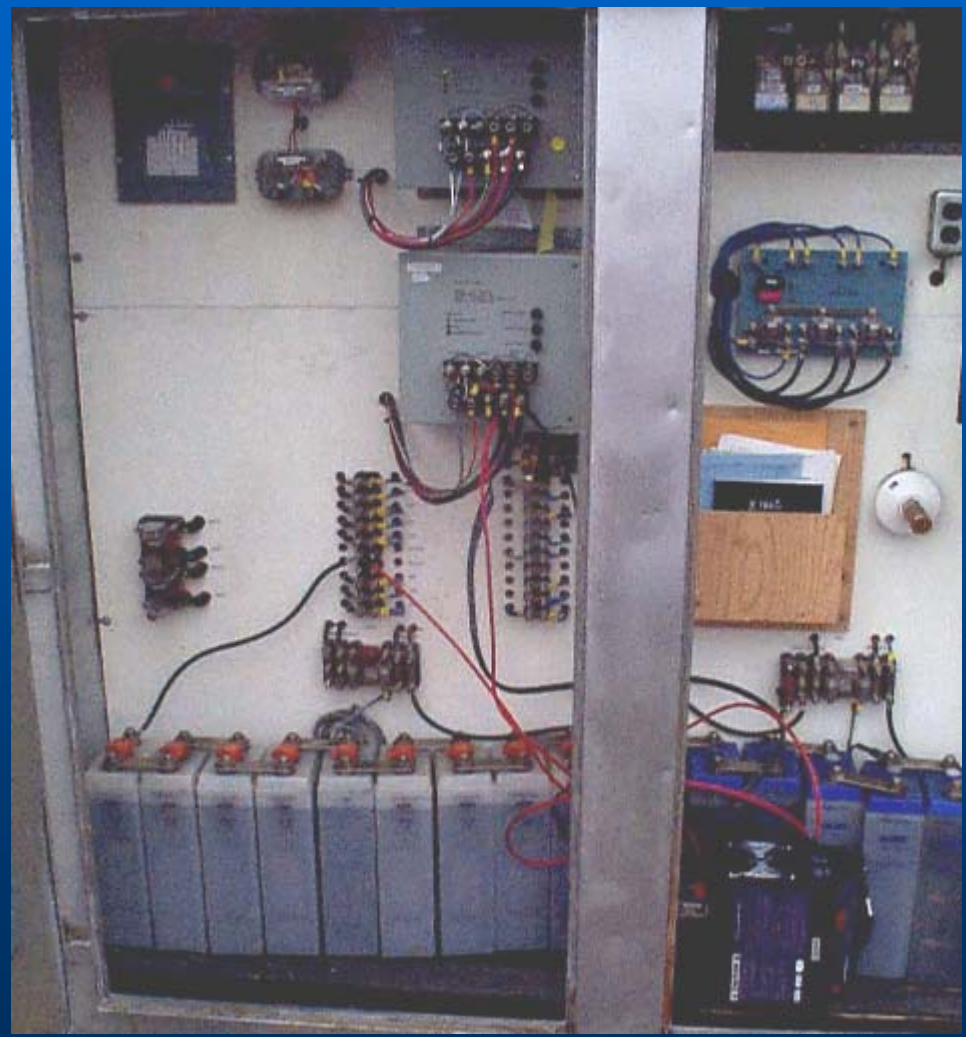
- **For Reliable Train Operations**

  Signals & Communications needs to operate Independent of local AC Power during outages

- **For Highway Crossing Warning Systems**
  - **Standby Power needs to be available if AC is not**
- **Goal: Reduce or prevent train delays**

Required Standby Power for Crossing Warning Systems

Required by FRA Regulation 234.215 or Transport Canada Rail Safety Act 26.1-.2



The Highway Crossing Warning Systems Power Issue

- Crossing Lights are Normally Dark
- **Must be lit to indicate a warning to the motorist**
- Hence, Standby Power is a crucial part of the system when AC power fails
- FRA Stats indicate that power failures are concern

Wayside Signals **Not** the Same Issue

When Wayside signal is not lit

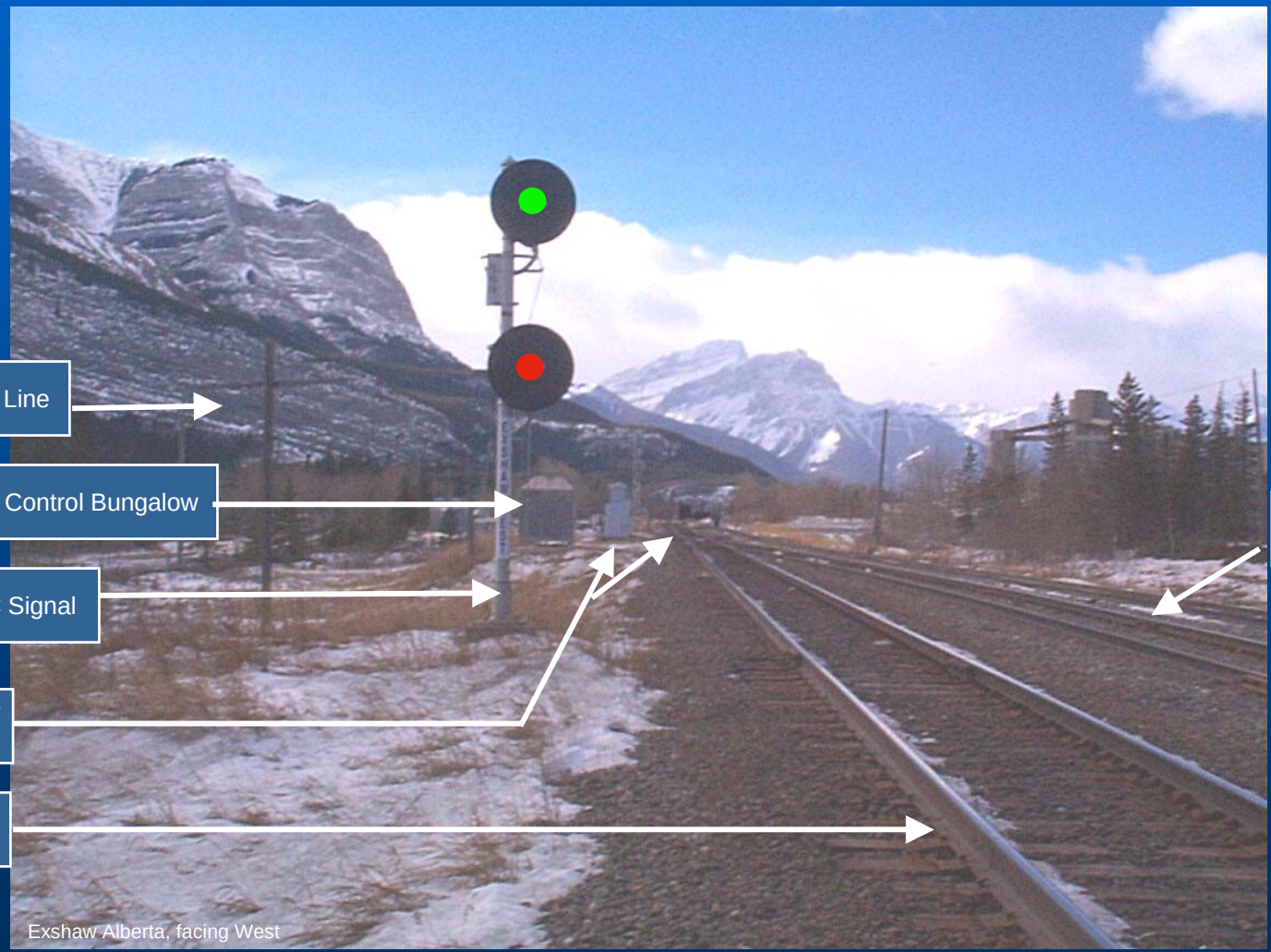
=

restrictive aspect (red)

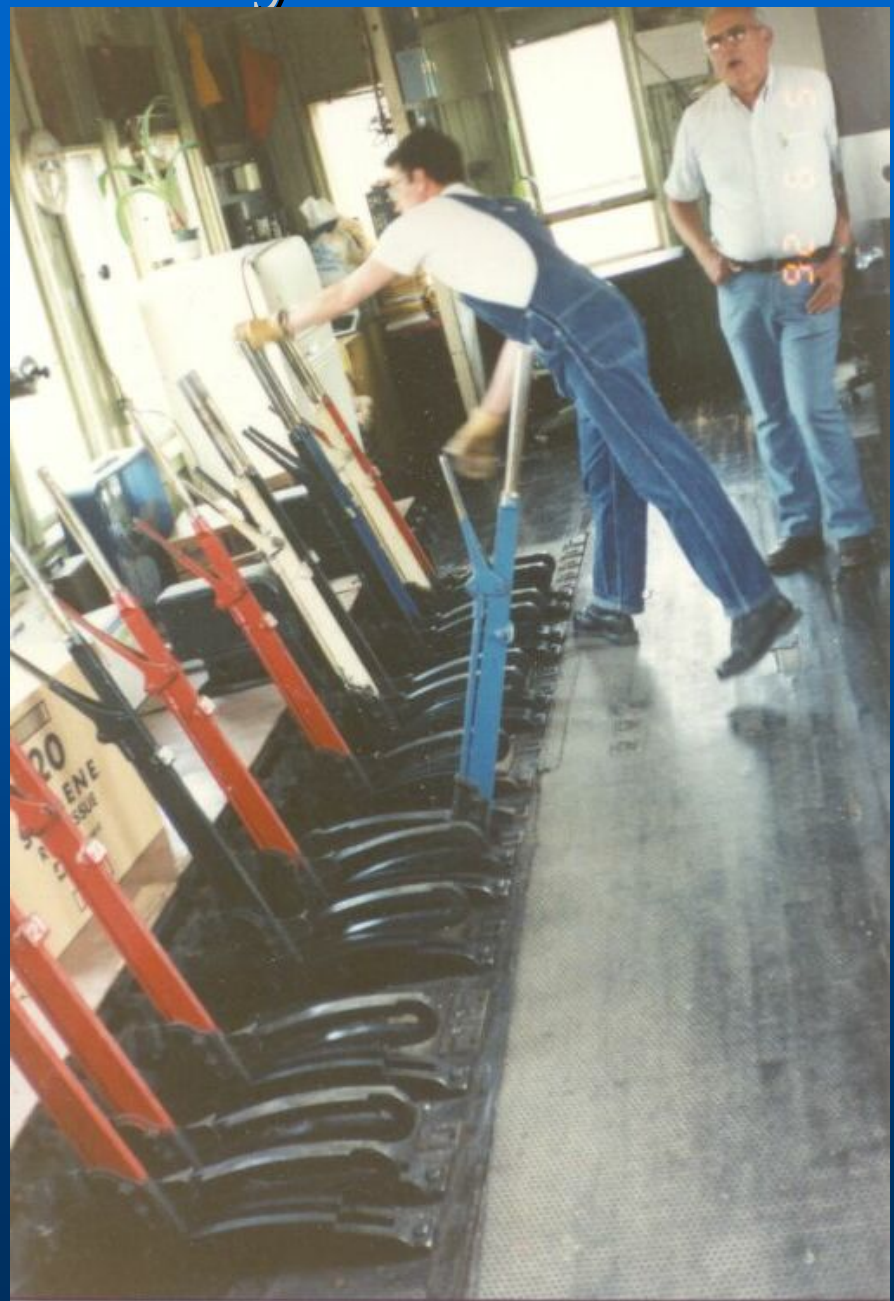
(Failsafe Design)

- **failure of power in the signaling system does not result in unsafe train operation,**
- **railroads provide standby battery for wayside signals for reliability of Train operations purposes.**

Signaling - Keep Trains Moving



Standby Switch Power



What provides Standby Power Today?

- **99% of Signals and Communication sites will have at least one battery bank**
- **Many will have multiple banks**
  - **For staged reliability/redundancy**
  - **Separation of functionality**
  - **Multiple voltage levels**

What Do We Need to Improve?

Predictability

- **Short Term**
  - **Is it going to work- insurances**
- **Medium Term Outage – 4 to 24 Hrs**
  - **Alternative measures**
- **Long Term Performance**
  - **Lifetime – Planned Replacement programs**

Battery Capacity

- **There are two separate issues regarding capacity:**
- **1) the initial design capacity**
  - **(i.e. the capacity designed into the installation when first installed)**
  - **De-rated for environmental conditions**
  - **Attached equipment high and low voltage limits**
- **2) the actual capacity following many years of service.**

Initial or Design Capacity

Rule 234.215 of the US FRA's Grade Crossing Signal System Safety Regulations specifies :

"sufficient capacity to operate the warning system for a reasonable length of time during a period of primary power interruption."

Batteries- A Simple Solution?

- **Batteries are simple – right?**
- **Any battery should work- right?**
- **Why can’t you just use a cheap car battery?**

- **Wrong**

Why can’t you just use a cheap car battery?

Reasons:

- **#1- Reliability & Safety**
- **#2- Capacity**
- **#3- Life cycle costs**

Railroad Batteries are Critical to Operations

- **have to count on the bank all the time**
  - **Can't dependent on getting a boost when you don't know it needs a boost**

- **Have to count on it In the full range of environments**
  - **Heat- cold- + 130 F, -60 F**
  - **Years of no activity**
  - **Deep discharge**
  - **Minimum maintenance**

- **Difference between a in town commuting car and a high performance race car**

Need:
High reliability & Guaranteed performance

But Also Desire:

- **extremely long service life**
- **minimum maintenance & attention**
- **Easy handling**
- **Low cost**
- **Cheap disposal**
- **Compact size**
- **Rugged and resistance to abuse**

Life Cycle Costs

- **Changing banks cost money and resources**
- **Shorter life cells have capacity or reliability risks**
- **Business case may be made for premium life cells**

Factors Affecting Performance

- **Type of Cell**
- **Connections**
- **Temperature**
- **Rate of Discharge**
- **Cell End Voltage**
- **Type & History of Charging**

Why is it a Problem to get this Reliability?

- **High Performance system**

- **Insurance (life)**
- **But this Insurance comes at a price**
  - **Testing**

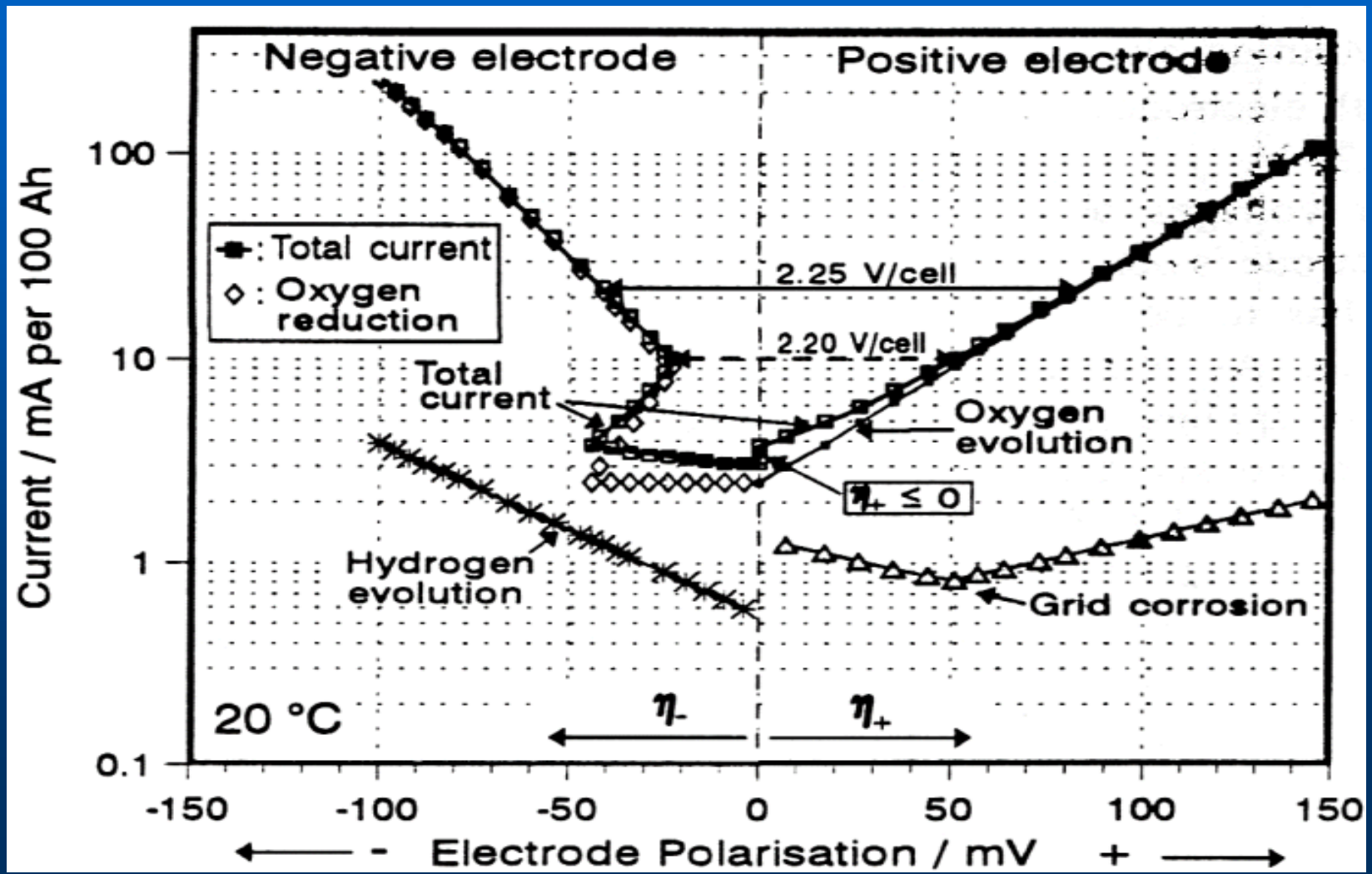
Problems Encountered

- **Takes long time to know results of choices**
- **20 year product- 5 year attention span**
- **Harsh environments**
- **Neglect**
- **Changing conditions but don’t change power systems**
- **Changing train operations**

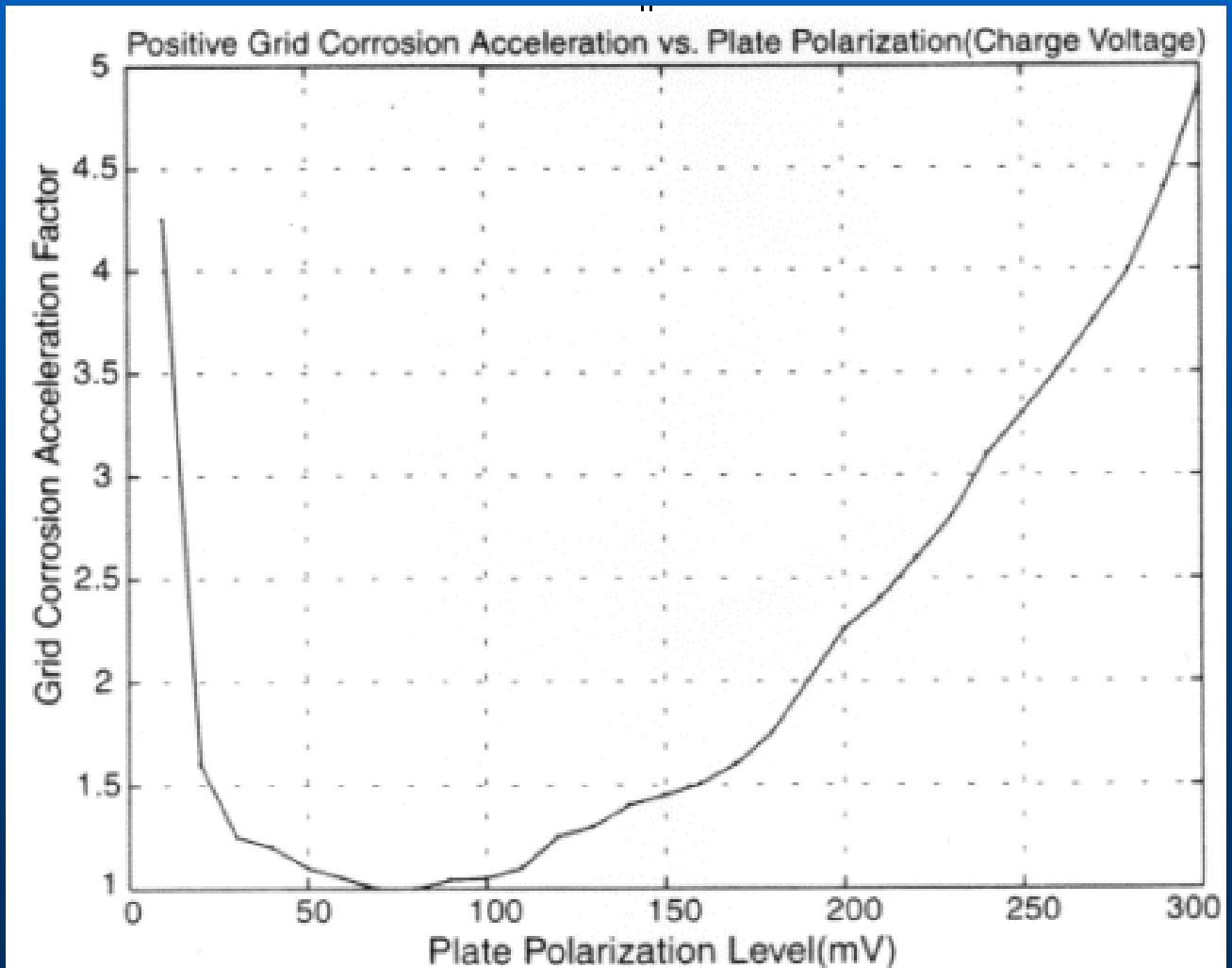
Why Is It Hard to Maximize Battery Performance

- **Working on edge of chemical sensitivity**
  - **Tafel Curves**
- **VI sensitivity not well understood**
- **Recharge rates**
- **Charger Current waveforms**
- **Temperature corrections**

Tafel Curves – Lead Acid Cell



Voltage settings are critical to battery life



Batteries Actual Capacity

- **Don’t Last Forever**
  - **Unavoidable aging**
- **Life = Years or # of Cycles**
  - **RR usage more limited by years of service**
- **Battery Technologies**
  - **Many different designs and performance issues**

How to Determine Capacity?

Natural Tests - Quebec Ice Storm

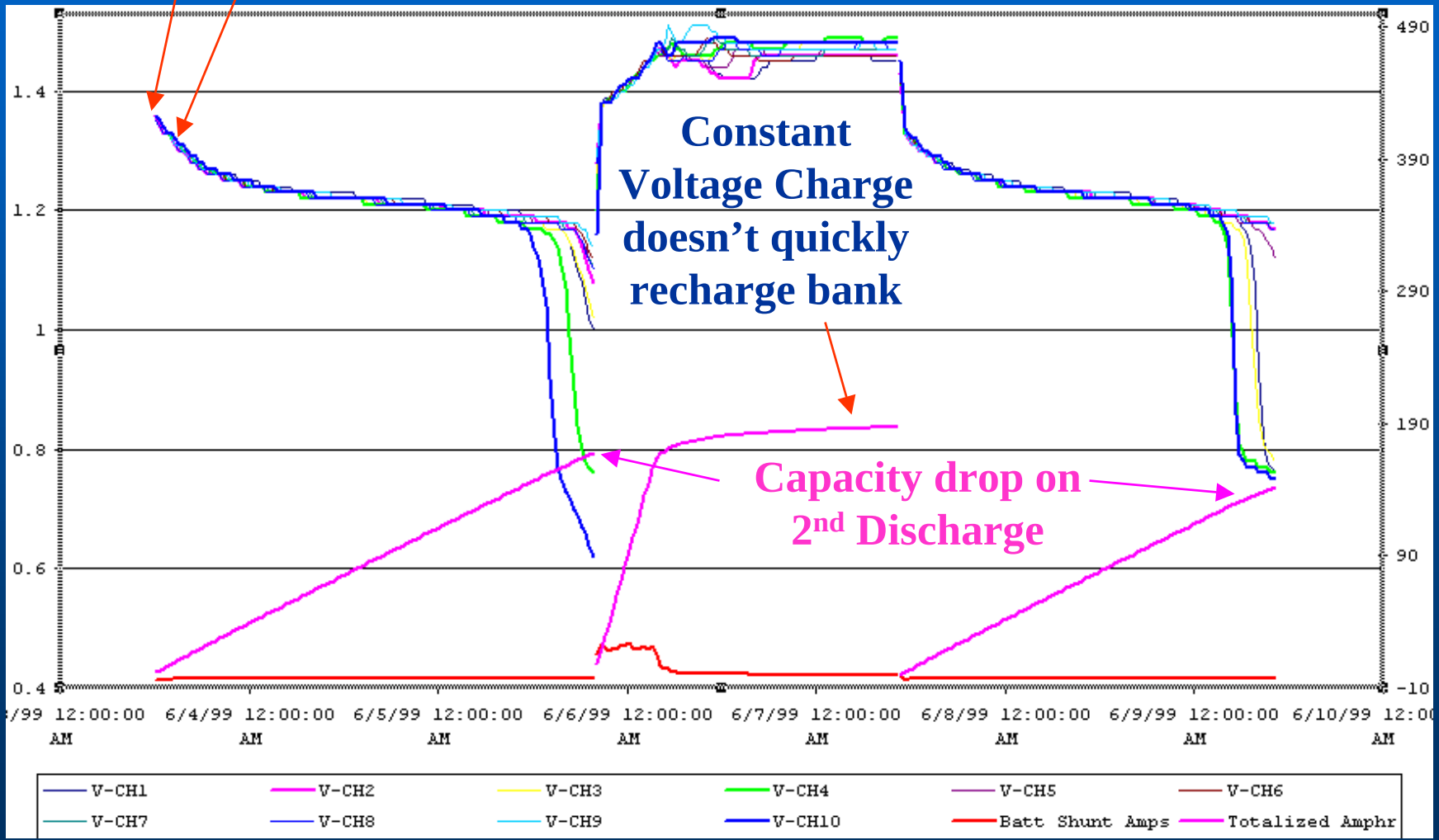
Blackout Aug 2003

What is useful in testing for Capacity?

- **The following do not tell the whole story about total capacity.**
  - float voltages,
  - charging current,
  - electrolyte level,
  - specific gravity and
  - short term load tests

Float & 30 Min Discharge Cell Voltage testing Example

TIME (min)	V-1	V-2	V-3	V-4	V-5	V-6	V-7	V-8	V-9	V-10
0 min	1.36	1.36	1.36	1.36	1.36	1.36	1.35	1.35	1.36	1.36
30 min	1.35	1.34	1.35	1.35	1.35	1.35	1.34	1.34	1.35	1.35



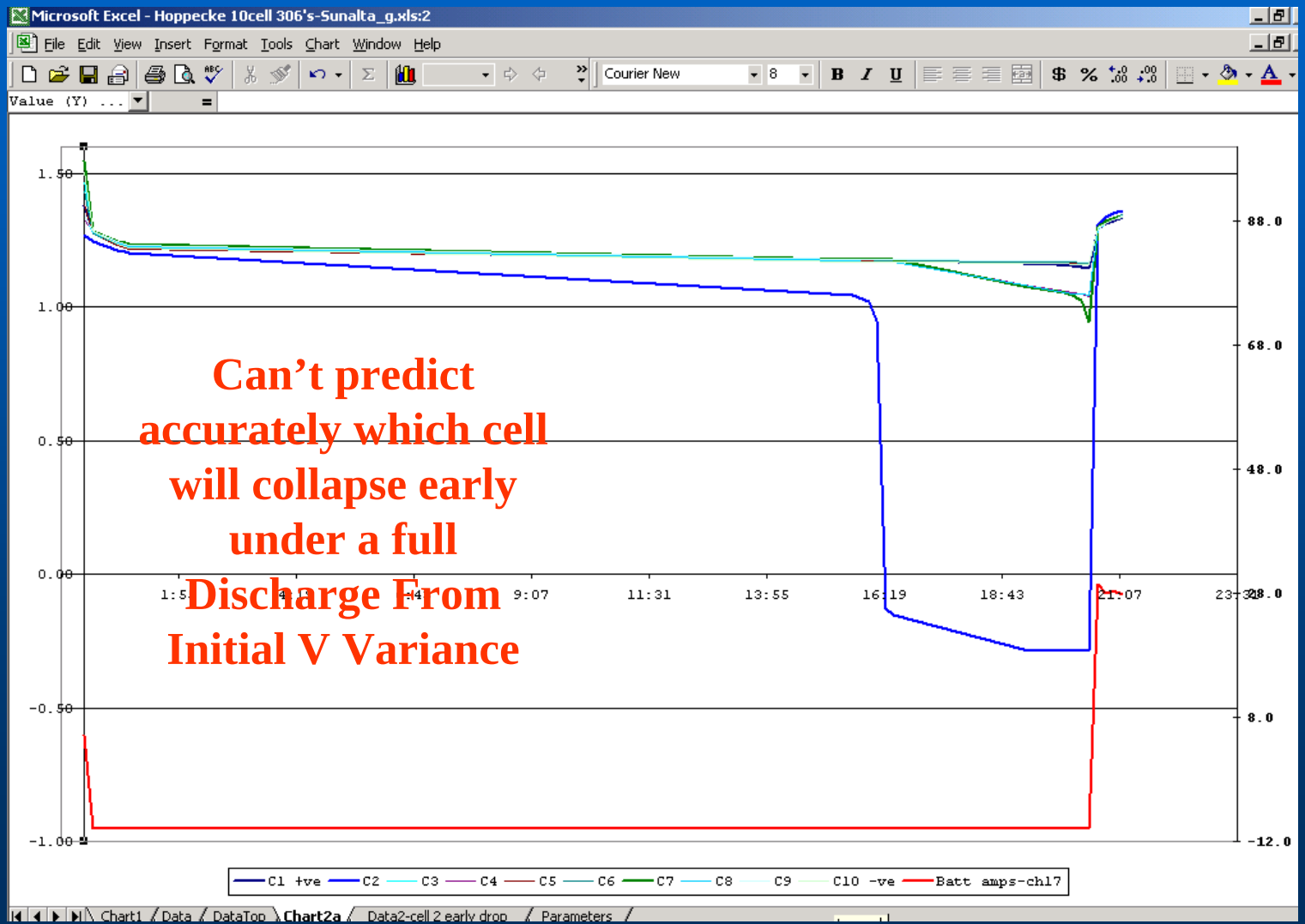
For Example, Float Voltages

Float voltages give a useful indicator of:

- the correct operation of the charging system,
- can be used to spot shorted cells,

- But Float Voltages are of limited value in determining available capacity.

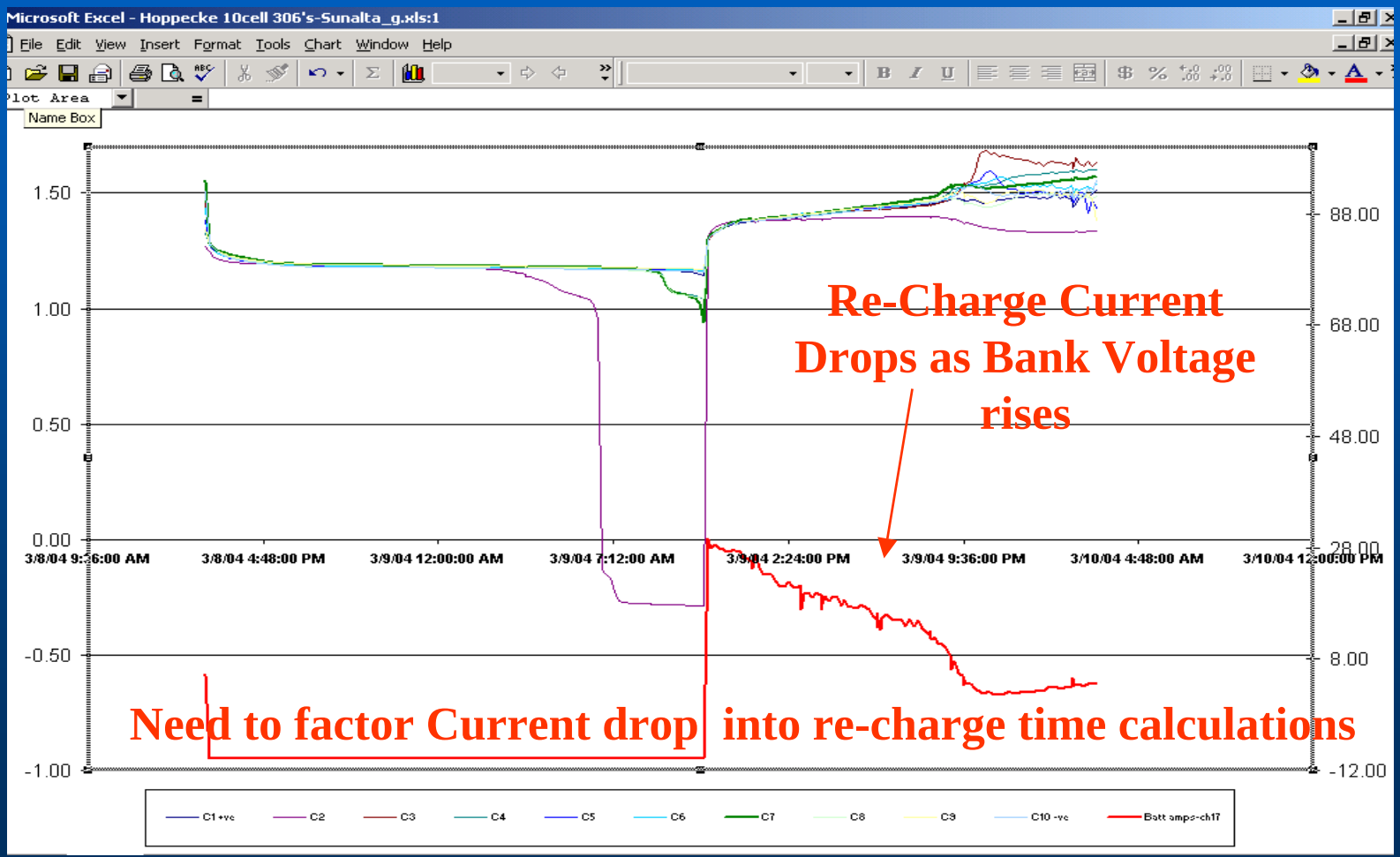
Initial Voltage May ≠ Total Capacity



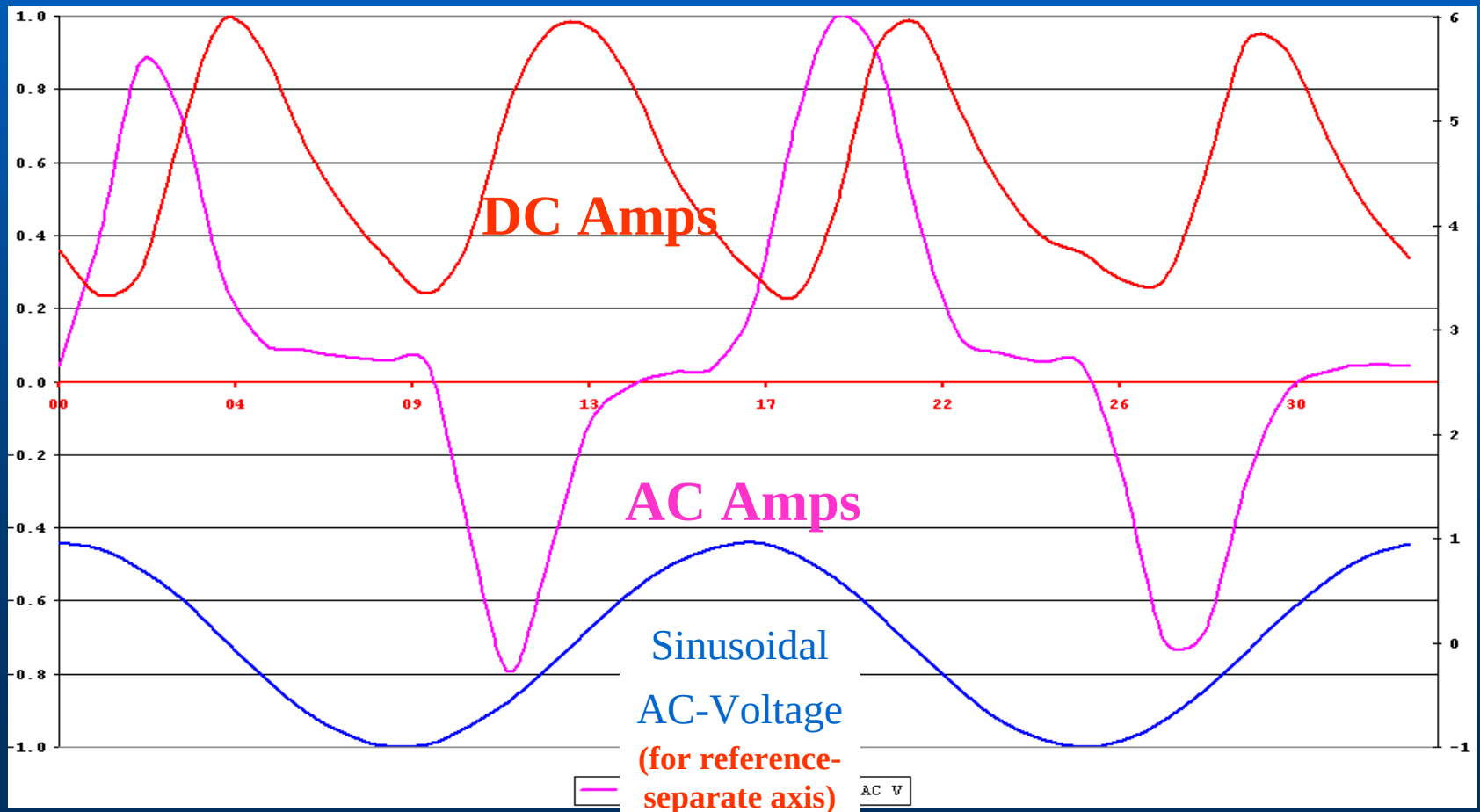
Design Considerations:

Recharge time =80 % based on charger output

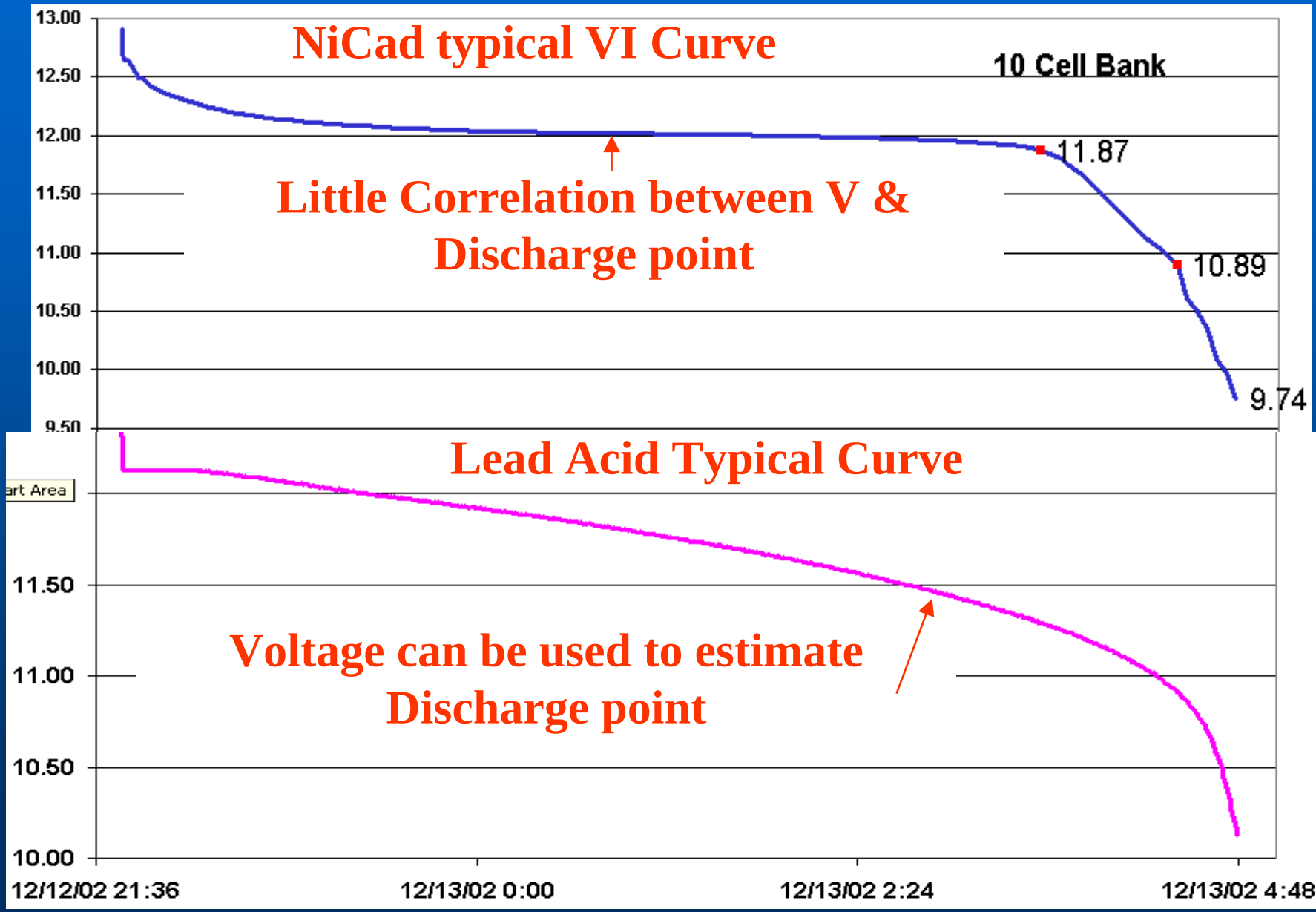
100% recharge is much longer



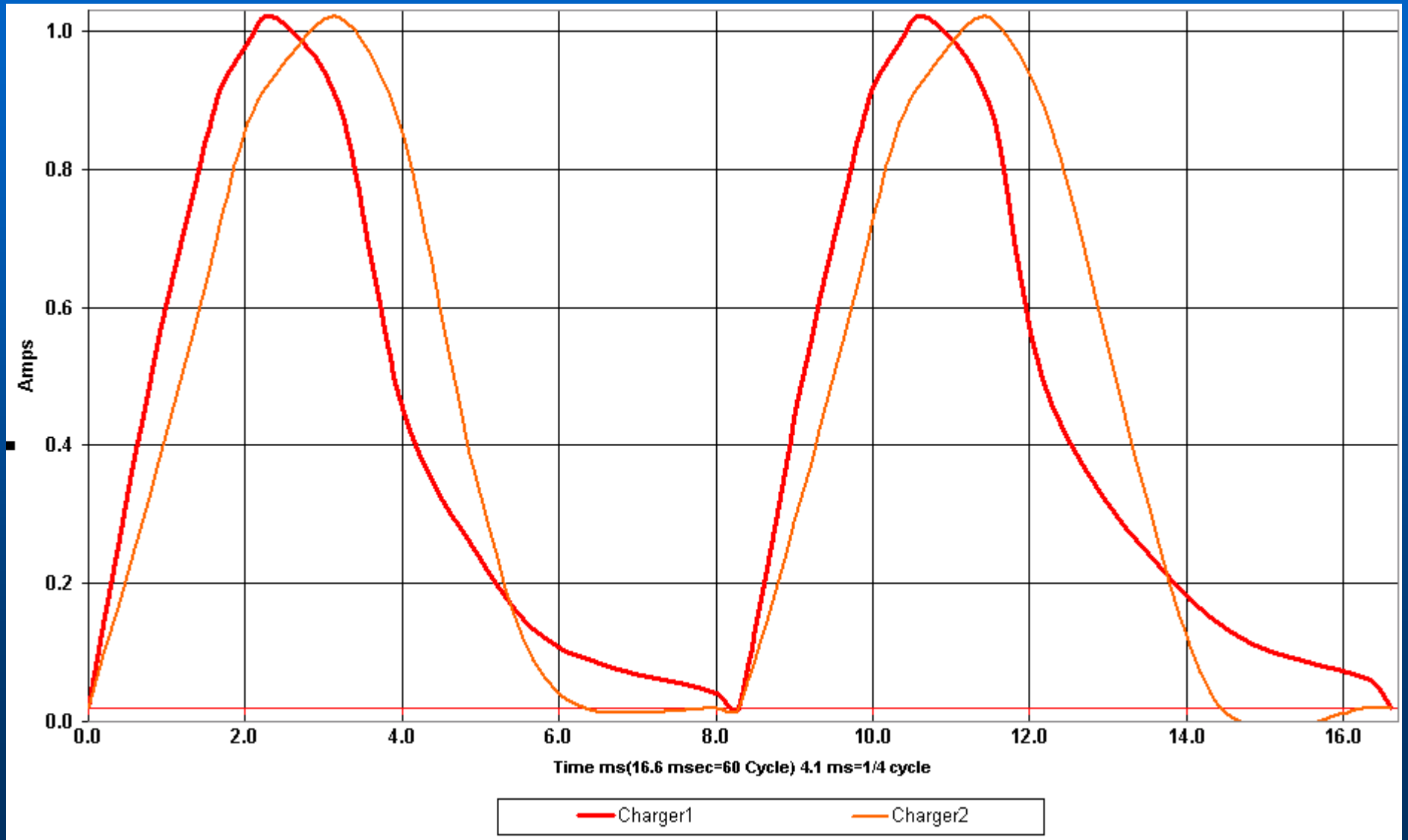
Another Railroad Charger Consideration
High Ripple (Non-Sinusoidal) Currents
Need batteries with Charger to filter output



Discharge VI Curves



Non-Sinusoidal – Large Ripple DC Currents
2 Different Chargers Types



Distorted Full Wave Rectified Sine Wave when chargers are charging at high rate into a discharged Battery Bank

What is a Capacity test?

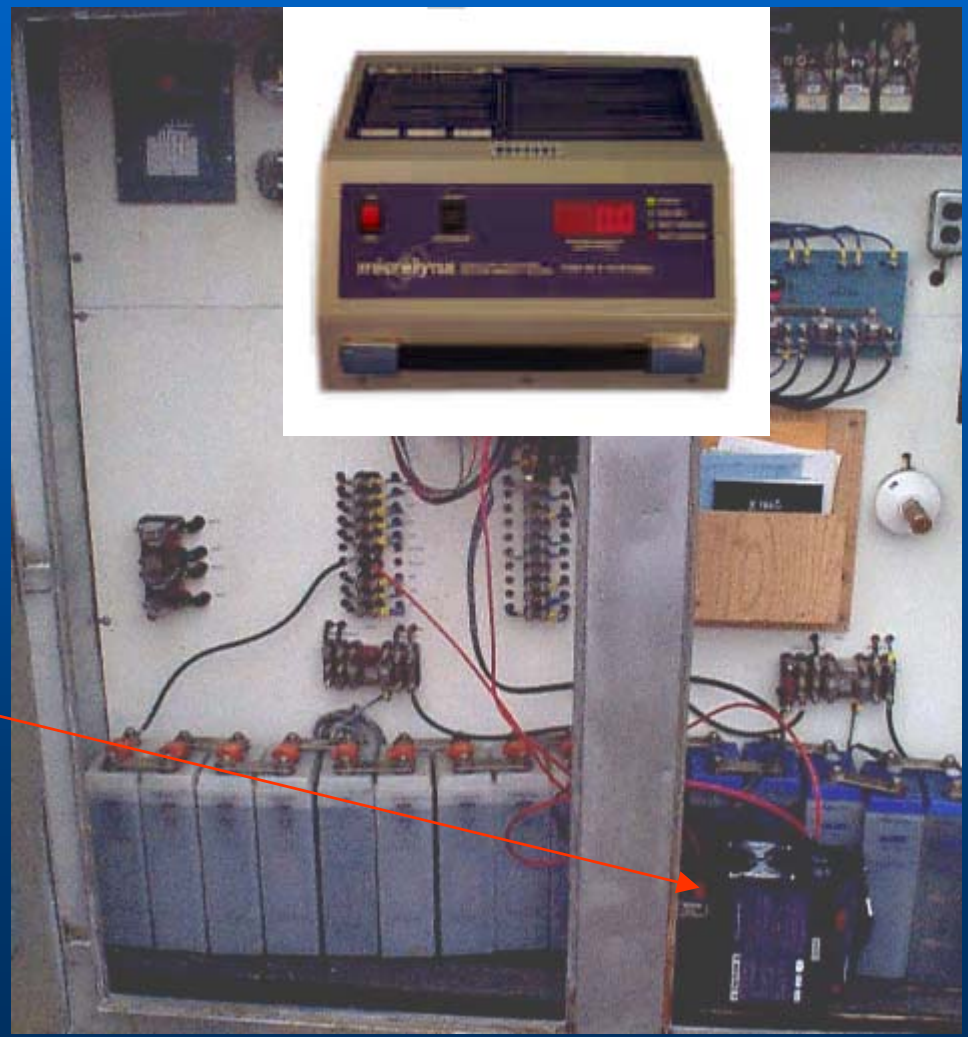
- Constant Current Load to an End Voltage
- Replacement below 80 %

Capacity testing serves 3 purposes:

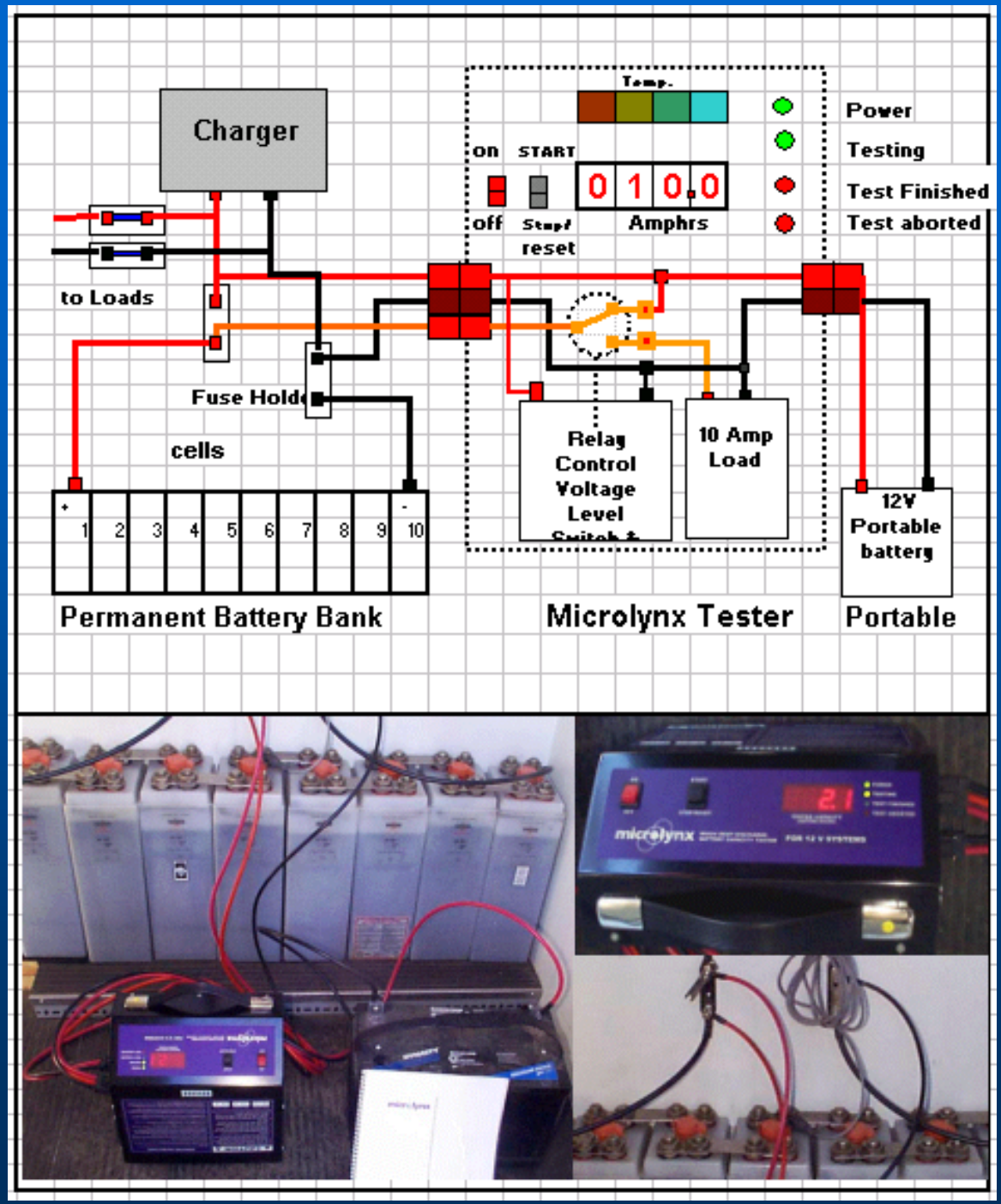
1. **Actual Capacity**
2. **Support Load**
3. **Reveals Internal Conduction Problems**

Capacity testing

- Takes Time
- Boring
- Possible Solution:
  - Automated capacity testing
    - Complete with adequate temporary reserve capacity



Automatic Tester with Portable Temporary Battery for Standby Protection



Battery Problems found in the field

- **Evaluating New Technologies**
  - NiCad Fibre Nickel Coated Plates
  - Constant Float usage = Separator Problems
  - VRLA –Dry outs & Negative Plate Self Discharge
  - Both have been improved
- **Conclusion:**
  - **Long time to verify 20 yr**
  - **expensive and time consuming to correct**
- **Up front warranty clarification is important**

Ways to Make Improvements

- **Select the best battery for the application**
- **Charge the battery properly (Follow manufacturer's instructions)**
- **Where possible limit temperature extremes**
- **At least annually check inter-cell connectors**
- **Water flooded cells when required**
- **Check voltages of individual cells to know when to equalize**
- **Perform a capacity test to understand end of life**

Select the Proper Battery

- **Know power requirement for location & size battery for environment (AH)**
  - **Load Current requirement - Batteries designed for high, medium or long rates. (# of plates and size)**
  - **Temperature effects**
    - **Listed AH rating is typically at 77degrees**
    - **Colder temperatures will de-rate available capacity**
    - **Higher temperatures may increase slightly but will speed up reactions and lower expected life**
  - **Different types of batteries have different temperature/capacity graphs. NiCd, LA, VRLA are all different.**

Charging is Critical

- **Charging is critical to battery life & capacity**
  - **Not only for VRLA batteries + or - 0.02 VDC**
  - **Temperature compensation good with lower and upper cutoffs**
    - **Verify temperature probes are on and working**
    - **Best location right on terminal**
  - **Constant current or constant voltage**
    - **Flooded usually ok with either**
    - **VRLA needs constant voltage**
  - **Under or over charging changes life and available capacity**
    - **VRLA curve shows critical voltage settings**
      - **Damage cell if too high or low**
    - **Flooded will use more water if overcharged and have reduced capacity if undercharged**

Inter Cell Connections are Important

- **Many studies show high resistant connections effect capacity**
  - **May undercharge cells in a bank if on constant voltage charger reducing total capacity**
  - **On discharge voltage drop will heat up connections and reduce available voltage to load**
  - **All cells could be at 100% capacity but deliver much less with poor connections**
  - **Torque the connections to maintain proper low resistance**

Water Flooded Batteries When Needed

- **Proper charging reduces watering**
  - **Follow manufacturers recommendations**
- **Need to replace Oxygen and Hydrogen generated**
- **Keep the plates covered to prevent damage and retain max surface area for capacity**
- **Keeps electrolyte at proper specific gravity**
- **Use distilled or de-ionized water to prevent contamination of the electrolyte**
- **Acts to moderate environmental temperature swings**

Check Cell Voltages Periodically

- **Check individual cell voltages to know when they differ**
- **Equalize charge if the variation exceeds manufacturers recommendations**
  - **Should bring cell into balance with others**
  - **If not may need to replace before it affects other cells**
    - **Don’t wait until the bank is in trouble**

Summary

- **Power systems are an important asset**
- **Batteries are a key element**
- **Maintenance and testing is necessary to get the maximum performance**
- **Automated Capacity Testing has potential to improve power systems reliability**

Improving Power Reliability

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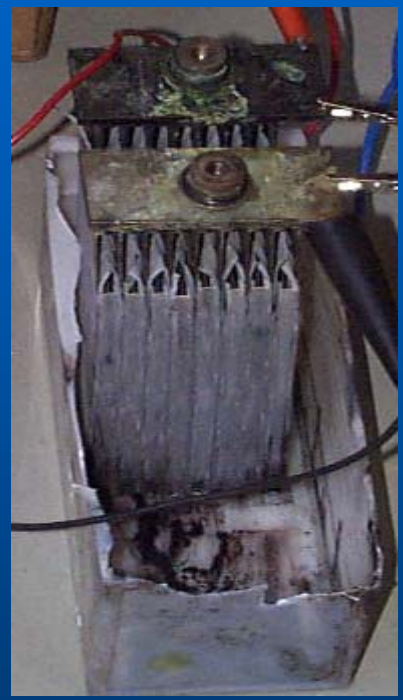
Exploded Cells

Static on Filling,
bolt inside- shorted plates when moved



VRLA Negative Plate Self Discharge

Key Points for self-discharge:

- **When oxygen reaches the negative plate it causes a reduction in the polarization of the plate.**
- **While the cell is on float charge, a portion of the charge current will try to increase the polarization of the negative.**

These two facts point out that there is an electrochemical balancing act occurring inside the cell.
If the depolarizing effect of the oxygen overpowers the polarizing effect of the charge current,
the negative will slowly descend to a depolarized (discharged) state.

What other options exist to augment the standby power provide by batteries?

- **Generators- pictures**

End of May 2004 Presentation- Extra info excluded for time constraints

Reason #1- Reliability

Anyone can but together a power system that will work a little bit

The challenge is to build a highly reliable, cost efficient system

- **Example- your car's battery system**
  - **Works most of the time, but if dies not big deal to get a boost**

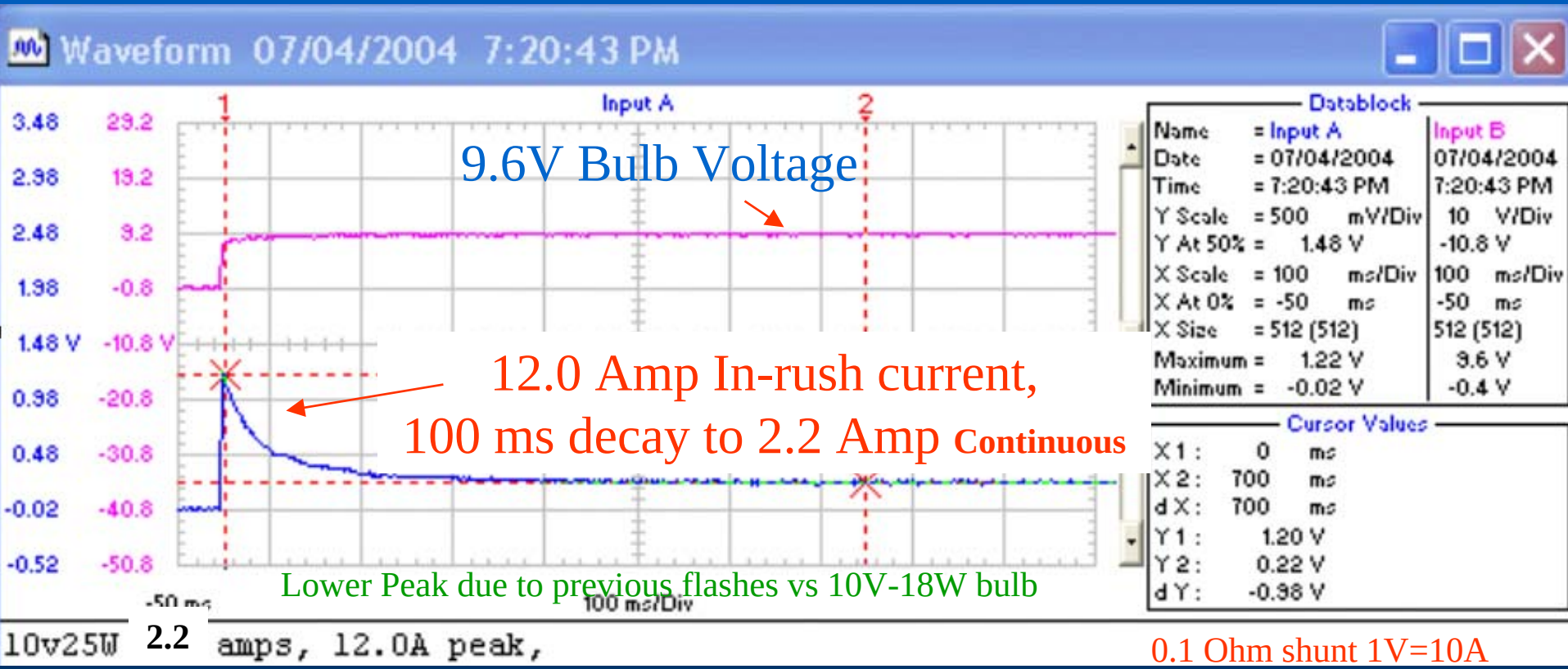
Batteries- the Necessary Evil

But the best option for reliable standby power

- **See MSDS (Material Safety Data sheets)**
  Warning: Do not handle, unpack or install batteries without a proper understanding of the safety risks

- **batteries contain sulfuric acid or Potassium hydroxide used as electrolyte**
- **This electrolyte can cause severe irritation and burns**
- **Batteries generate hydrogen which is extremely explosive.**
- **Batteries are extremely heavy**
- **Only personnel that have been properly trained on DC power safety should have access to the batteries for installation and maintenance**

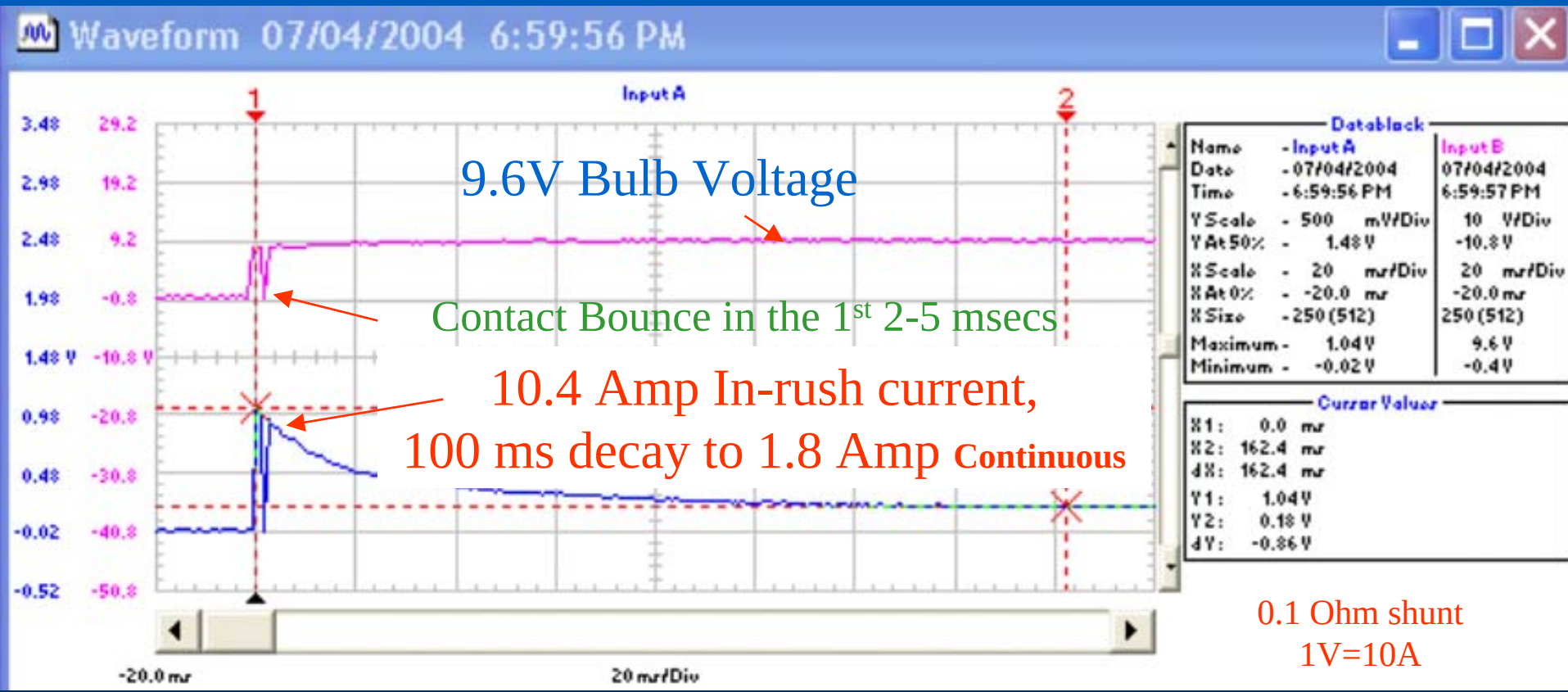
Simple Bulb-Relay Current Draw
10V-25W Incandescent Bulb



10v25W **2.2** amps, 12.0A peak,

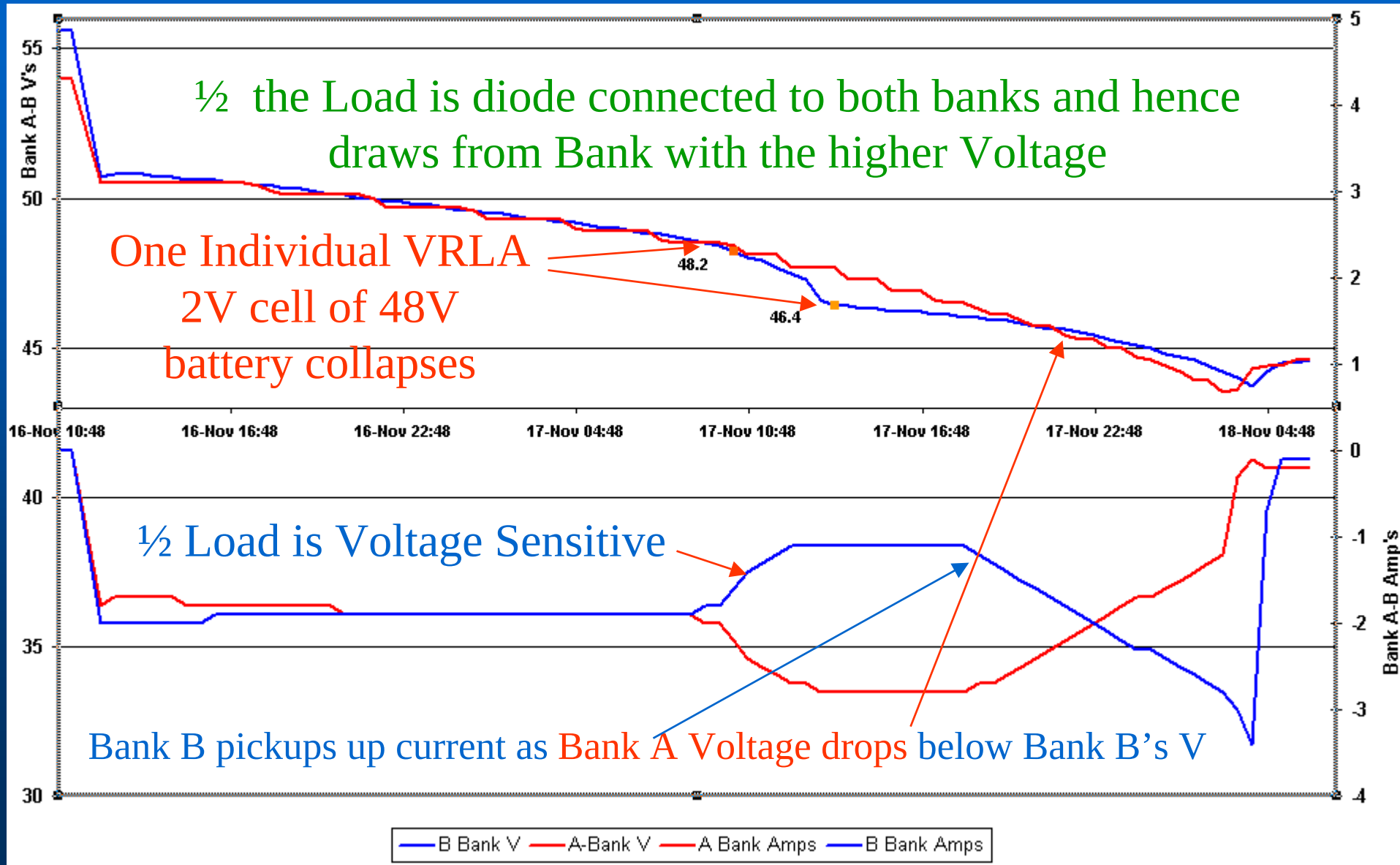
0.1 Ohm shunt 1V=10A

Simple Bulb-Relay Current Draw
10V-18W Incandescent Bulb



0.1 Ohm shunt
1V=10A

Load Current Sensitivity to Dual 48V Bank V



Improving Standby Power :
A Few Applications

- **Crossing Warning Systems**
  - **When the AC power goes off DC backup is critical**
- **Communications Systems**
  - **Radio both data and voice**
- **UPS Systems**
  - **PCs to PBXs and Dispatch Systems**
- **Signal Systems**
  -