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Thermal Battery Tester Uncertainty and Mistakeproofing Project – An Update

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National Nuclear Security Administration

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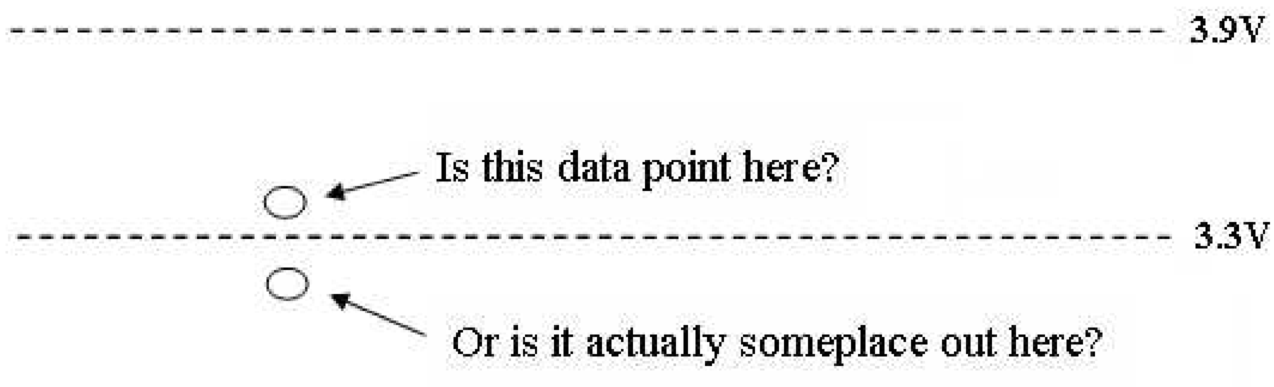
Major Project Objectives

- Reduce the number of bad tests caused by equipment failure, setup errors, etc. on destructive thermal battery tester
  - Thermal batteries one-time use only; once test is started, battery is destroyed, costs > $5000
- Develop an accurate standard for tester verification
  - Check out tester to verify that all equipment/cabling is properly configured
  - Collect, analyze data over time, determine whether tester is drifting. May lengthen intervals between calibrations, cut down on travel time/costs.
  - Right now, calibration interval is three months.

Major Project Objectives

- **Quantify an uncertainty number for the tester**
  - **Recent battery developments have required very tight tolerance bands**
  - **Establish an error band around each reading**



Need for Mistakeproofing

- Each battery requires re-routing of cables and/or special cable/box setup
- Improperly routed cables
- Sometimes cables have invisible loose or broken connections
- A test not properly performed destroys a battery that costs thousands of dollars to build with no good data to show for it.
- Reduce the risk of these “no-tests”

Check Standard

- Mimics performance of a thermal battery in terms of voltage rise and response to varied load levels.
- Will be used in a simulated test once each day during lot acceptance testing. Serves several purposes:
  - Validates tester and cabling/load box setup
  - Tester alerts operator if problem is found
  - Tester gathers data set for PMAP analysis
    - Data used to detect drift trend
    - Drift can indicate need for calibration; lack of drift may indicate no need to calibrate
    - Obviously out-of-tolerance data (0.04V when should be 10V) could indicate improper equipment configuration
  - Gathers its own data set for comparison to tester data set

Check Standard – Final Design

- About the length, width of a briefcase, but greater height
- Integrated Reference Standard (10V, 5V, 3V, 2.048V Outputs)
- Storage for battery and charger

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Check Standard Enclosure

- **Weighs 10.26kg (22.5 lbs)**

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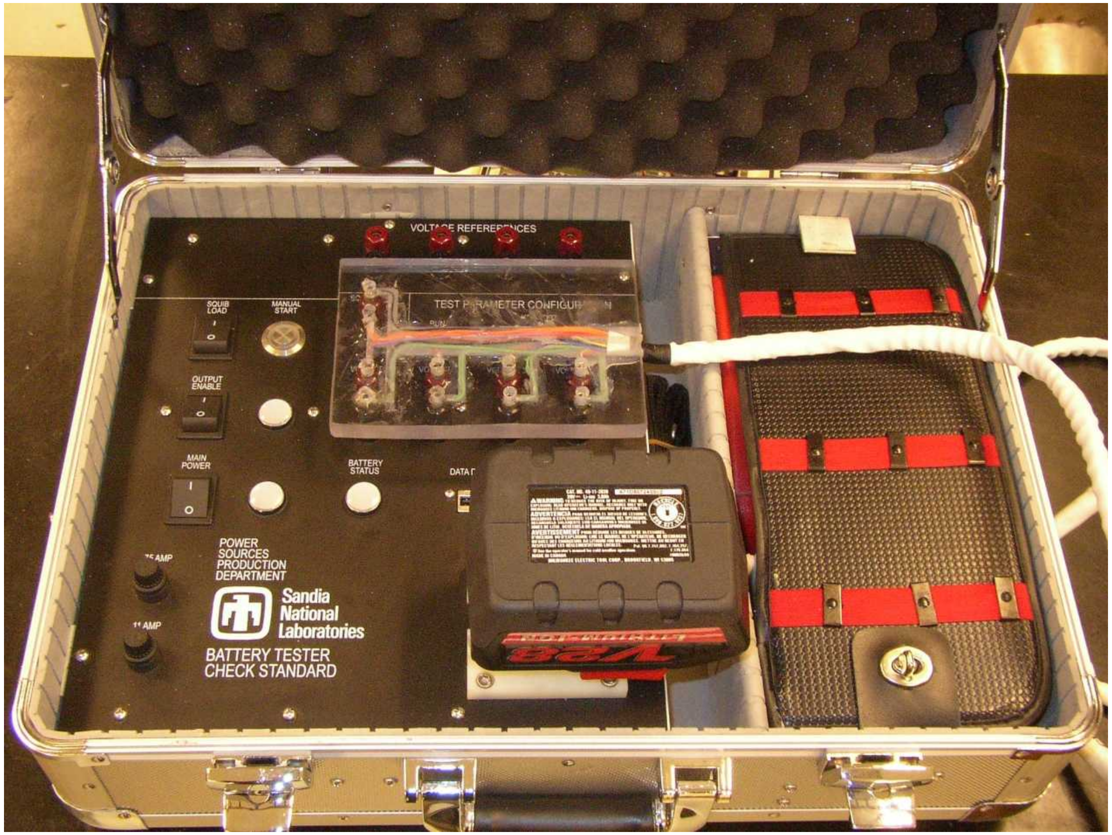
Check Standard – Final Design

- Voltage Output Ports
- Voltage Reference Standard Outputs
- Data Drive Port (Flash Drive)
- Test Parameter Input Ports (Future)

Check Standard – Final Design

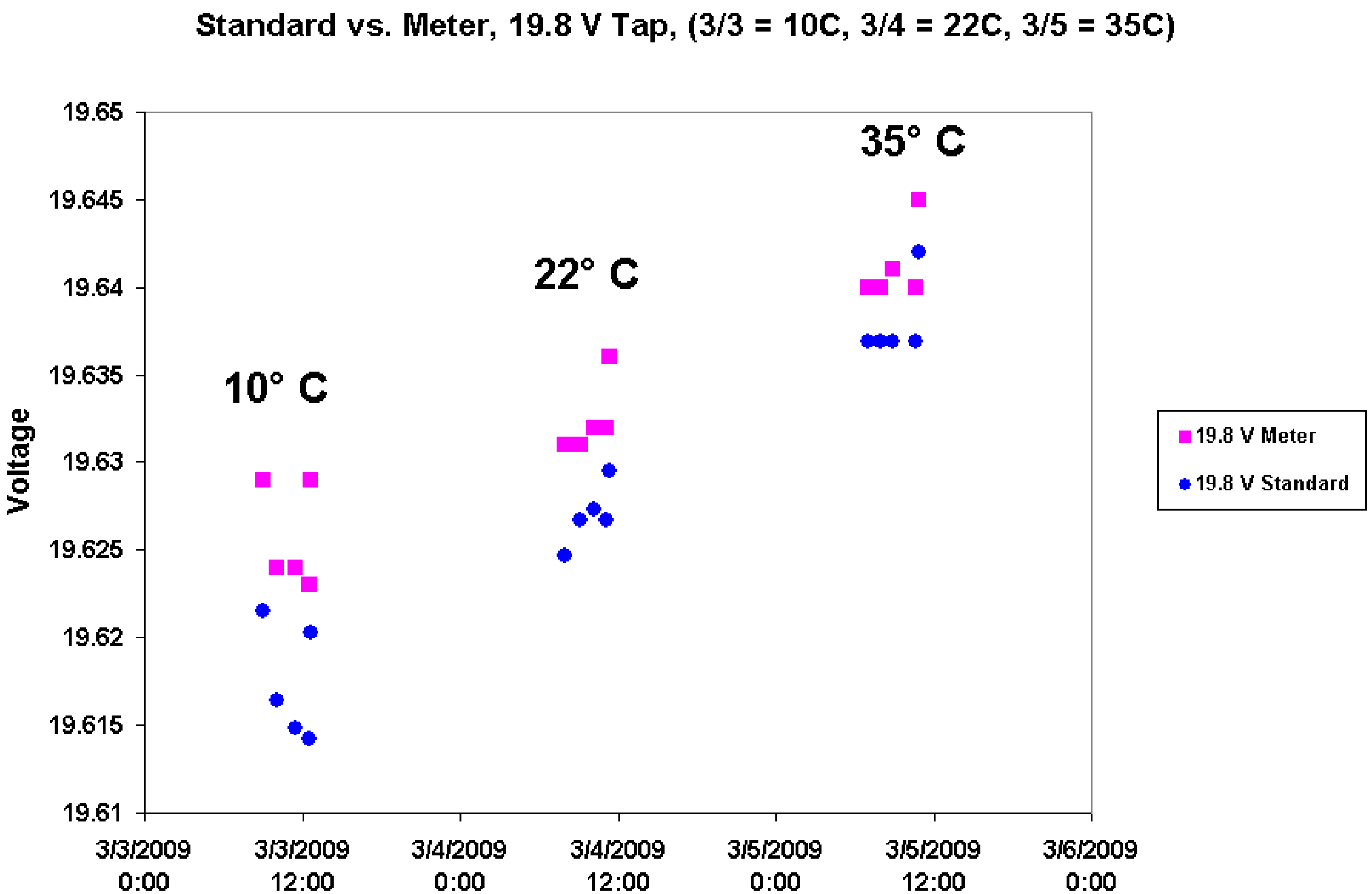
- Shown with custom cable for attachment to tester equipment
- One-step attachment - easier than running ten banana leads!



Check Standard Temperature Testing

- Measure how temperature affects performance
  - Test area at production facility is known to experience seasonal temperature variations
- Placed check standard in temperature chamber
- Connected four calibrated meters and one voltage calibrator (for activation signal)
- Set chamber to temperature (10C first day, 22C second day, 35C third day)
  - Simulate max and min in environmental test area
- Four test runs approx. 1 hour apart, then one run ten minutes after the fourth run.
- Manually recorded voltage on each channel 5 seconds after activation
- Compared against check standard's data reading at 5 sec. after activation

Temperature Test Results – Channel 1



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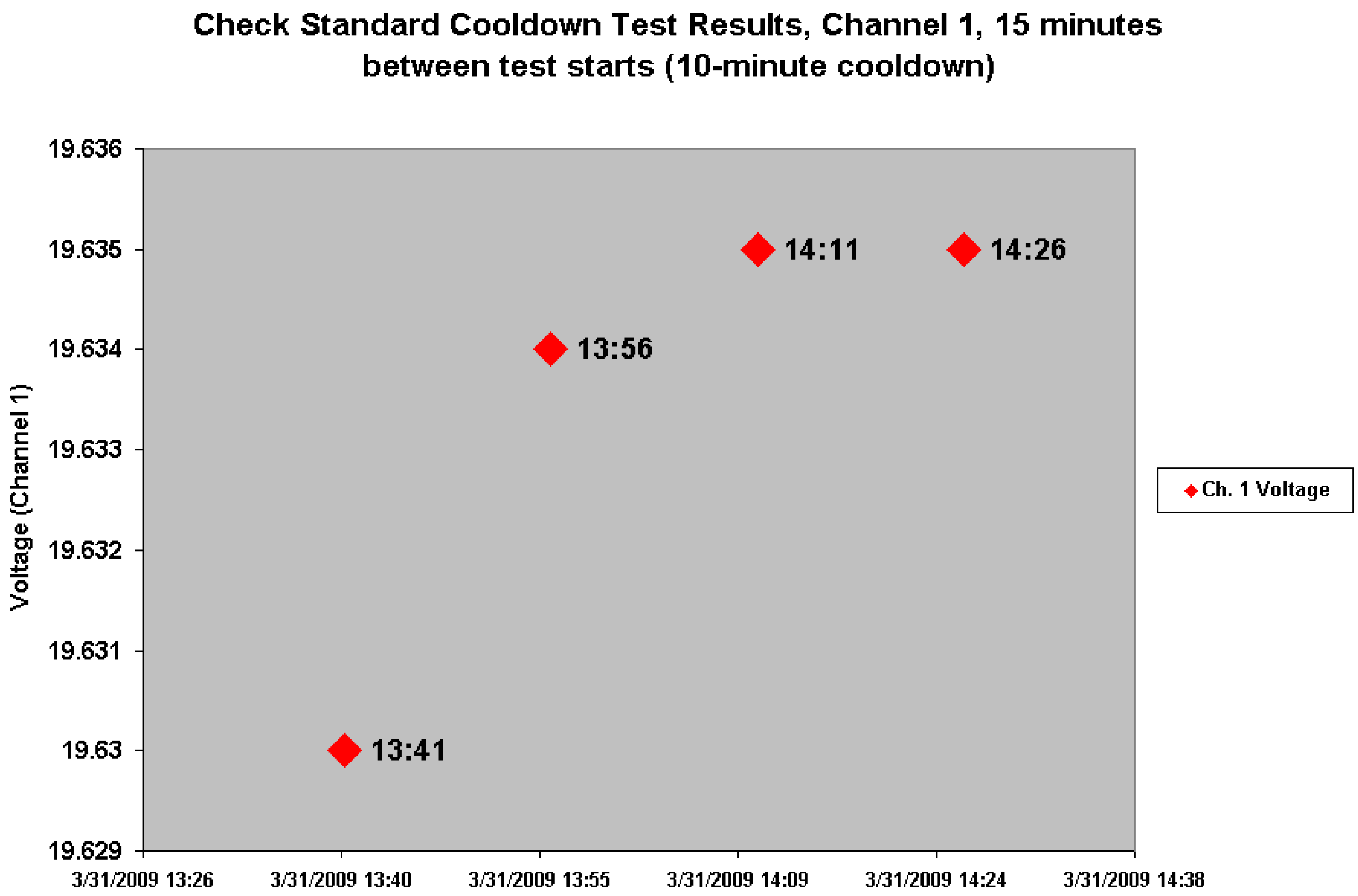
“Cooldown” Testing

- During temperature testing, noticed that readings were elevated when a test was run 10 minutes after the previous one (or if standard was on for several minutes before activation)
- Problematic because we want the standard to show as little variability as possible from run to run (within 2 mV)
- Needed to find out shortest interval between activations that would consistently show readings within 2 mV at 5 sec. after activation

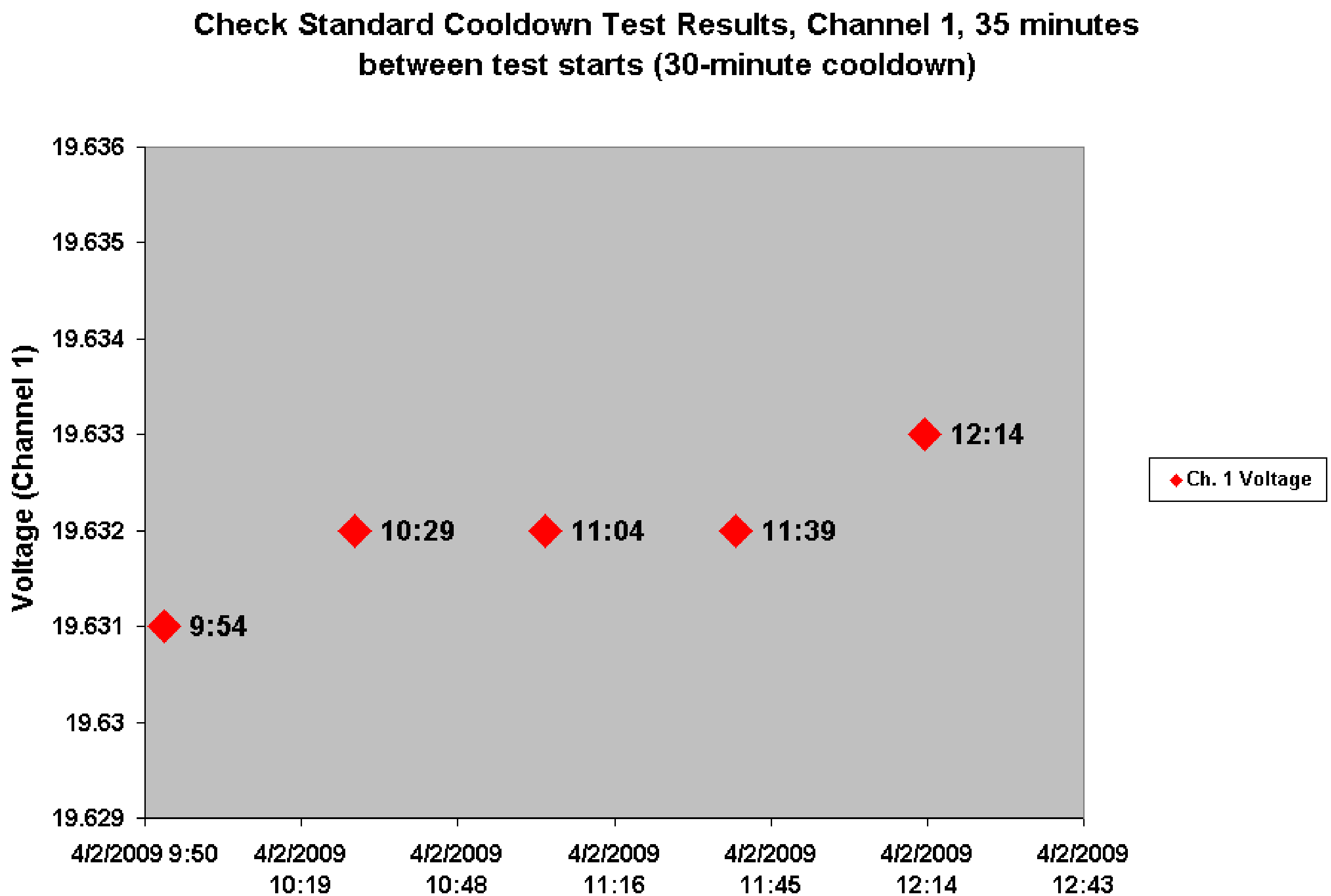
"Cooldown" Testing

- Used the same meter/calibrator setup as with temperature testing
- Took readings at 5 sec. after activation
- Started with 10-minute cooldown
  - 5 minutes from activation to end of data file flash drive transfer plus 10 minutes until next activation
- Widened cooldown interval to 15, 20, then 30 minutes

10-minute Cooldown Interval



30-minute Cooldown Interval



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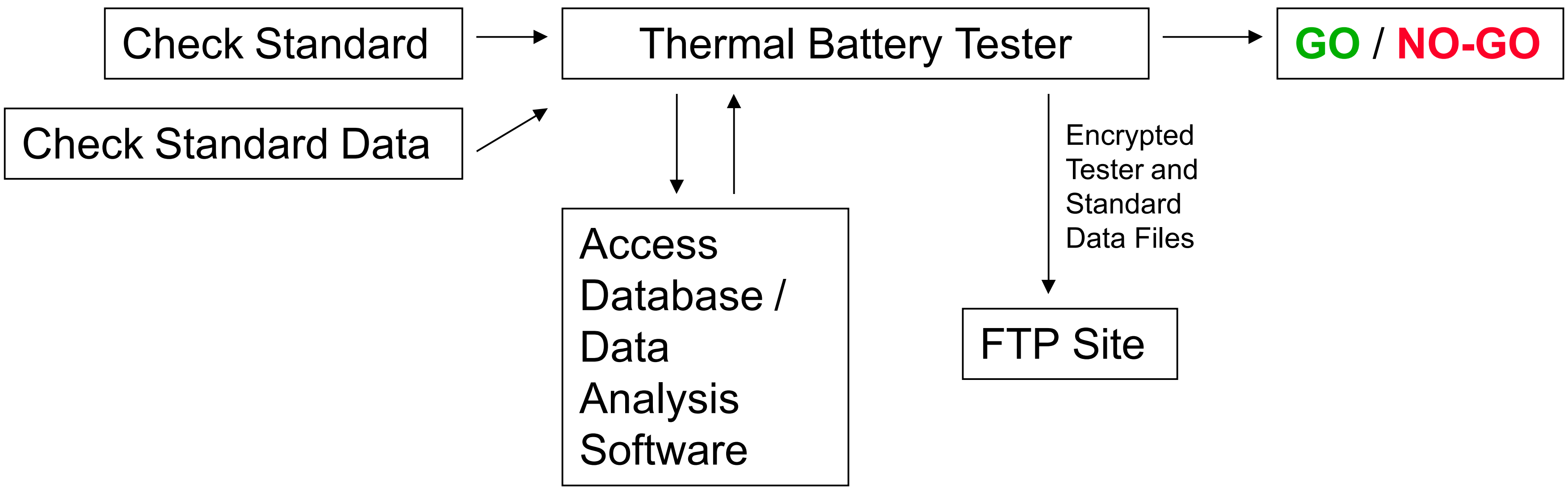
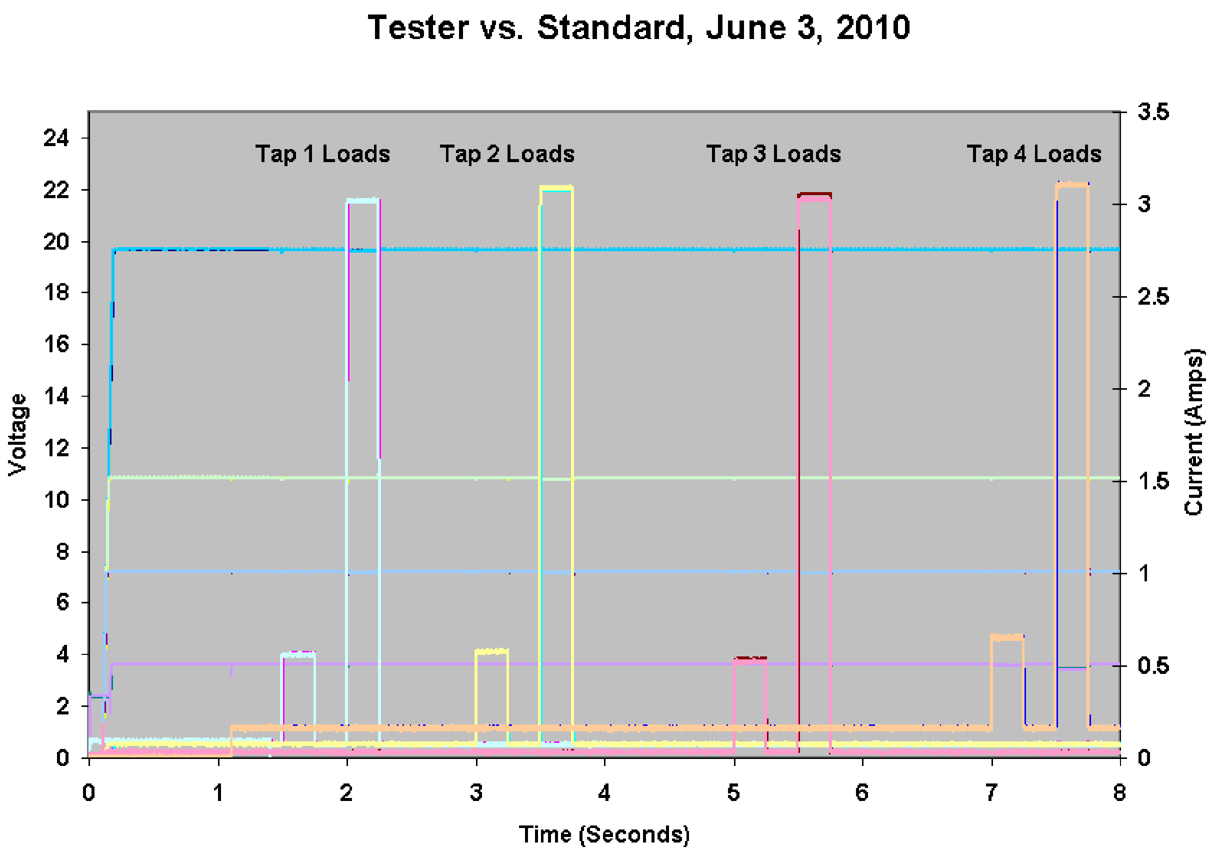
How the Check Standard Works with the Tester

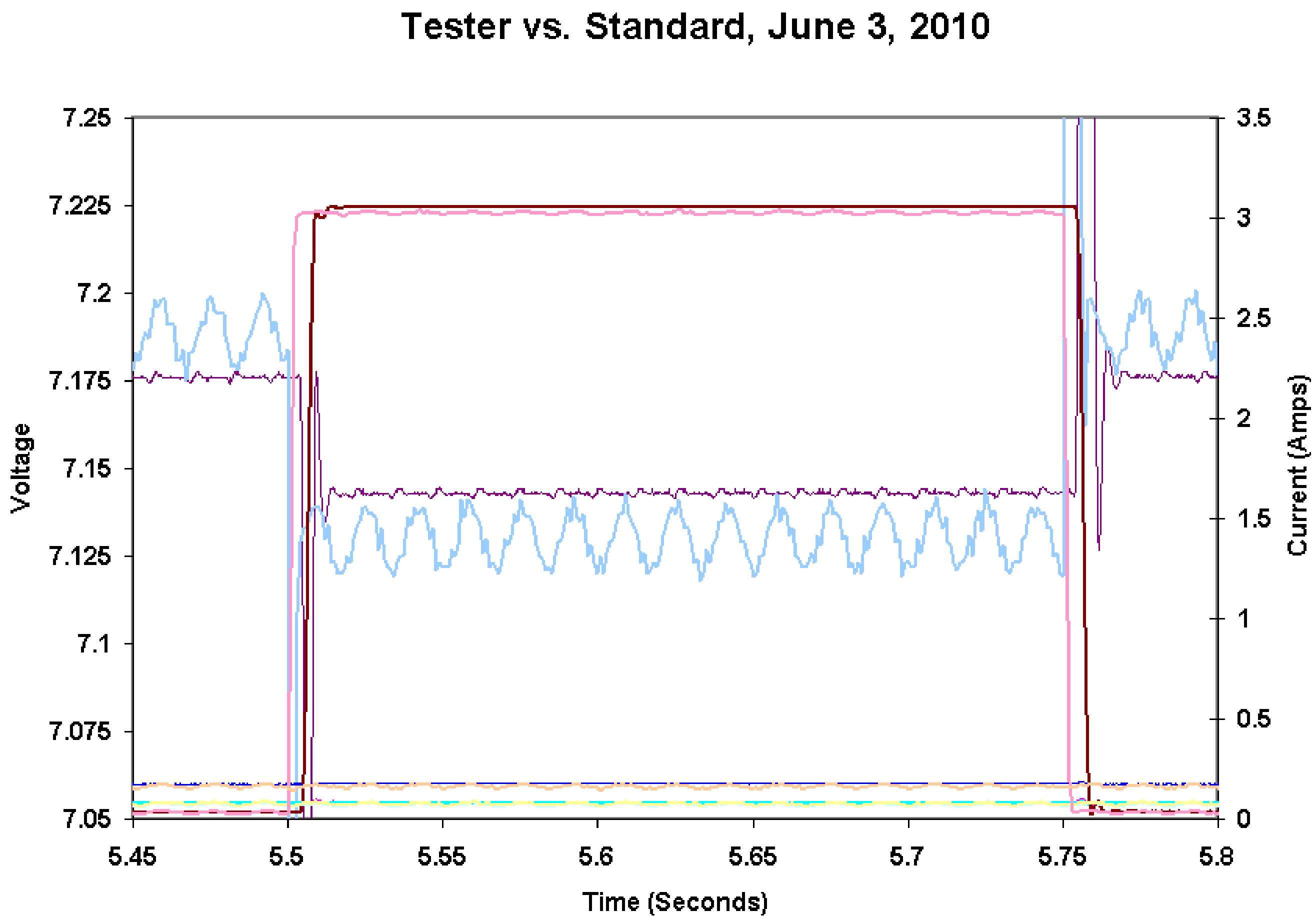


Sample Tester/Standard Overlay Graph

- **Shows load profile for each channel**
  - **0.5 Amp and 3.0 Amp pulse on each of 4 channels, 250ms wide**
  - **Each channel has a different constant-resistive background load**
    - **Accounts for differences in background loads**



Tester/Standard Data Overlay – Single Channel Close-up



Data Analysis

- Looking for drift trends
  - Trend line may indicate need for calibration
- Looking for out-of-tolerance conditions
  - May indicate tester malfunction or improper equipment configuration
- User sets up analysis criteria sets
  - Can analyze minimum, maximum, standard deviation, or average in voltage or current data between two time points of interest
  - Can also analyze voltage or current at one time point
- Analysis criteria sets and results are stored in Access database
  - Code within Access performs data analysis

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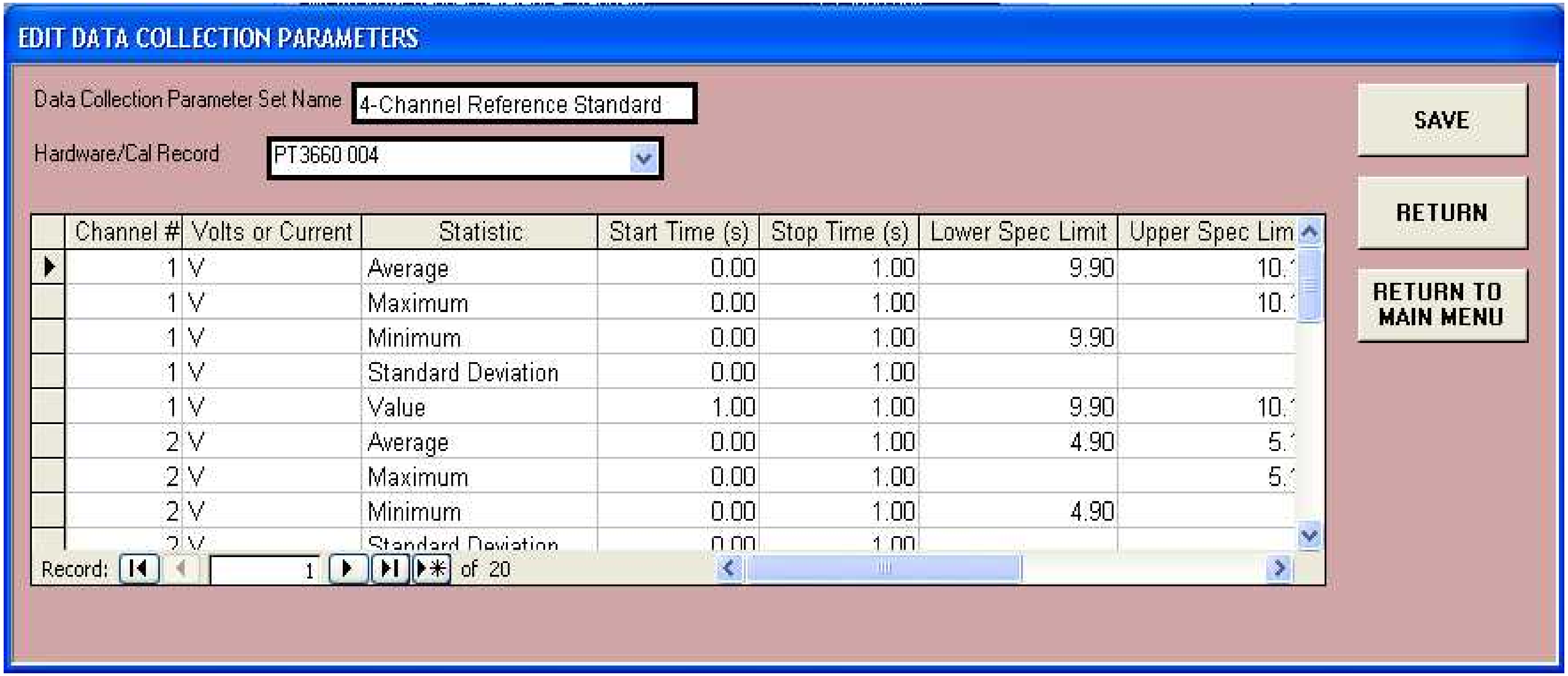
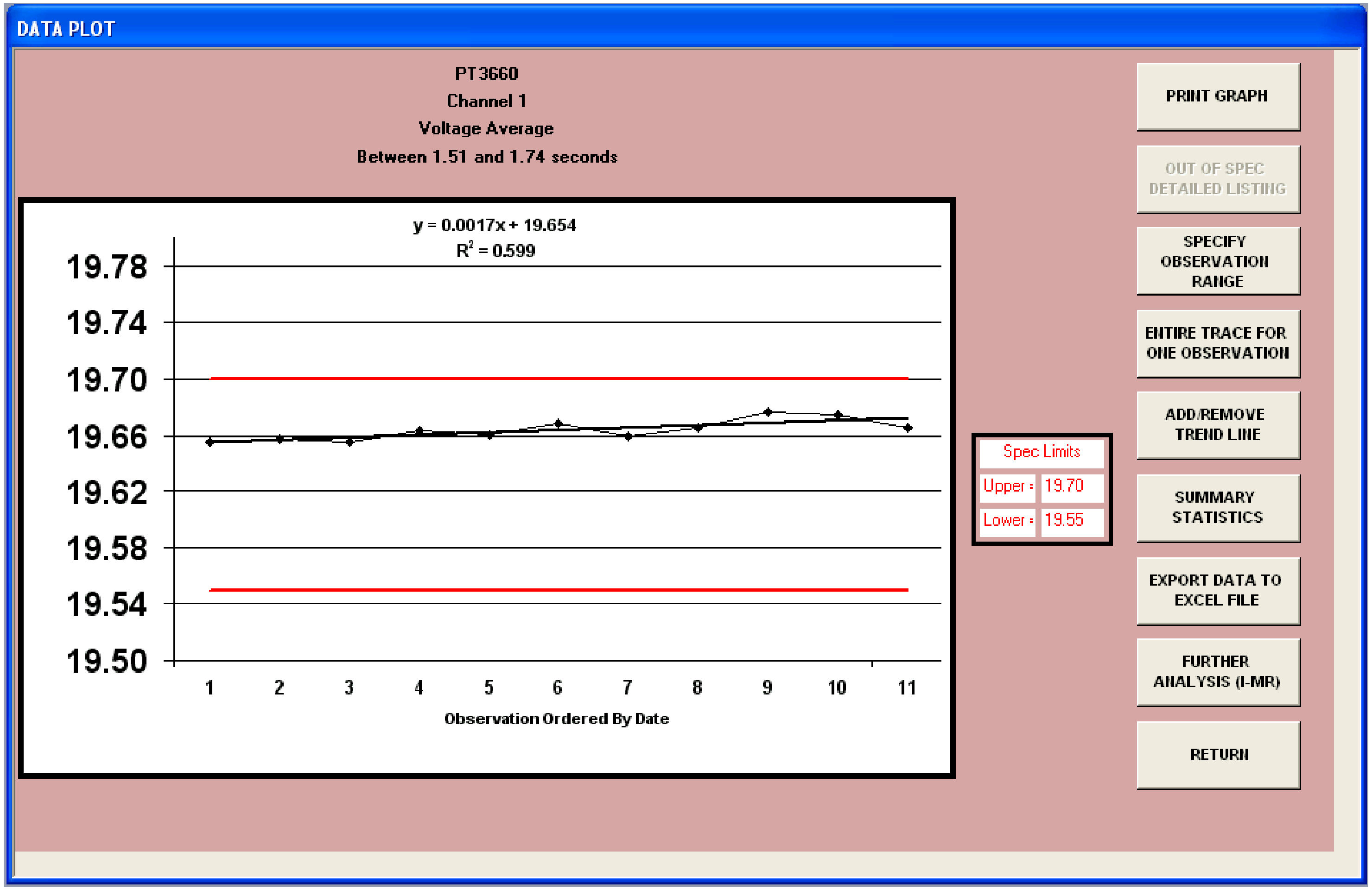
Example of Data Analysis Criteria Set



Drift Trend Analysis (Tester Data)

- Taken recently at Sandia test facility



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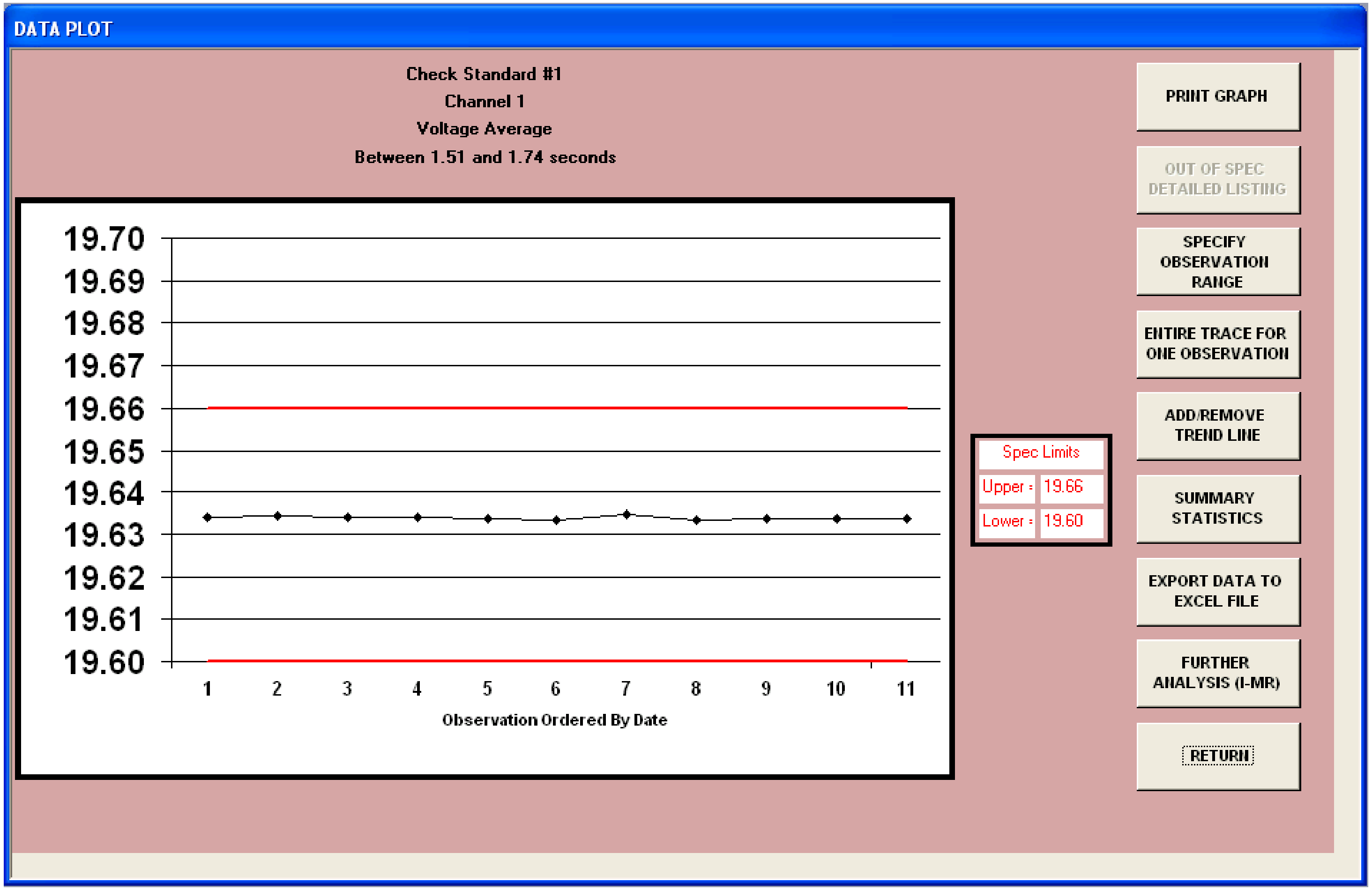
Drift Trend Analysis (Check Standard)

- Same set of test runs as shown in tester data on previous slides
- Much less scatter than tester data



Remaining Tasks

- Uncertainty Determination
  - Automated Operational Uncertainty Software is under development
    - Takes voltage inputs from reference standards on-board the check standard
    - Also takes measurements on highly-accurate meter
    - Gather a set of data from tester and meter every calibration
    - Calculation methodology has yet to be determined
      - RSS calculation with standard deviations of tester and meter data
      - Possibly bias factor (account for difference between tester and meter)
      - Combine each data set for tester and meter into one long-term set for each, then run RSS?
      - Take average of each data set's standard deviation over time, then run RSS?

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Remaining Tasks

- Collect more data at production facility where most acceptance testing takes place
  - Use for development of expanded data analysis parameter sets
  - May help to extend interval between tester calibrations
    - Right now is every 3 months
    - No MTBF analysis, as cost of rejected lot would be too great
    - If we could extend calibration intervals, we could cut travel costs and time away from home
- Develop check standard calibration procedure and tester operating procedure
- Update software document
- Qualify tester software before next production lot (2011)