

# Batteries, Rectifiers and Inverters: Test the whole package

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# Battery Health Testing

- **Battery Capacity Test:** assess battery age
- **Battery Load Profile Test:** assess battery ability to supply protected load at a voltage level above the required minimum for the required period of time
- **Battery integrity check** during discharge operation
- **Individual cell health check** during discharge operation

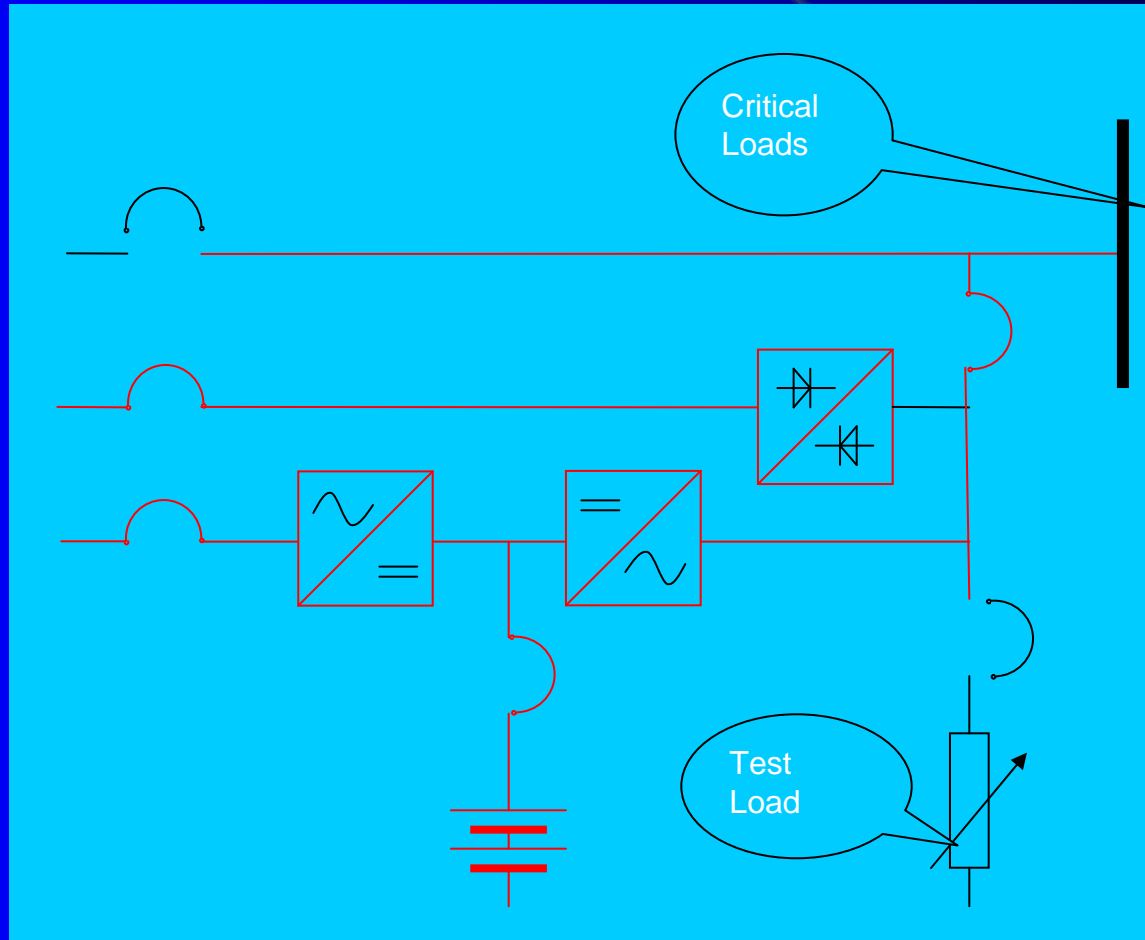
# Testing a battery and UPS as one system allows us to determine:

- UPS ability to switch from normal supply to battery supply during rectifier supply power failure
- UPS ability to supply Inverter loads from battery for the required period of time
- Inverter battery operation on decaying DC bus voltage
- UPS ability to transfer to bypass supply when minimum DC bus voltage has been reached
- UPS ability to switch from bypass supply to Inverter after rectifier input power is restored
- UPS/rectifier ability to supply power to critical bus and recharge battery after input power restoration

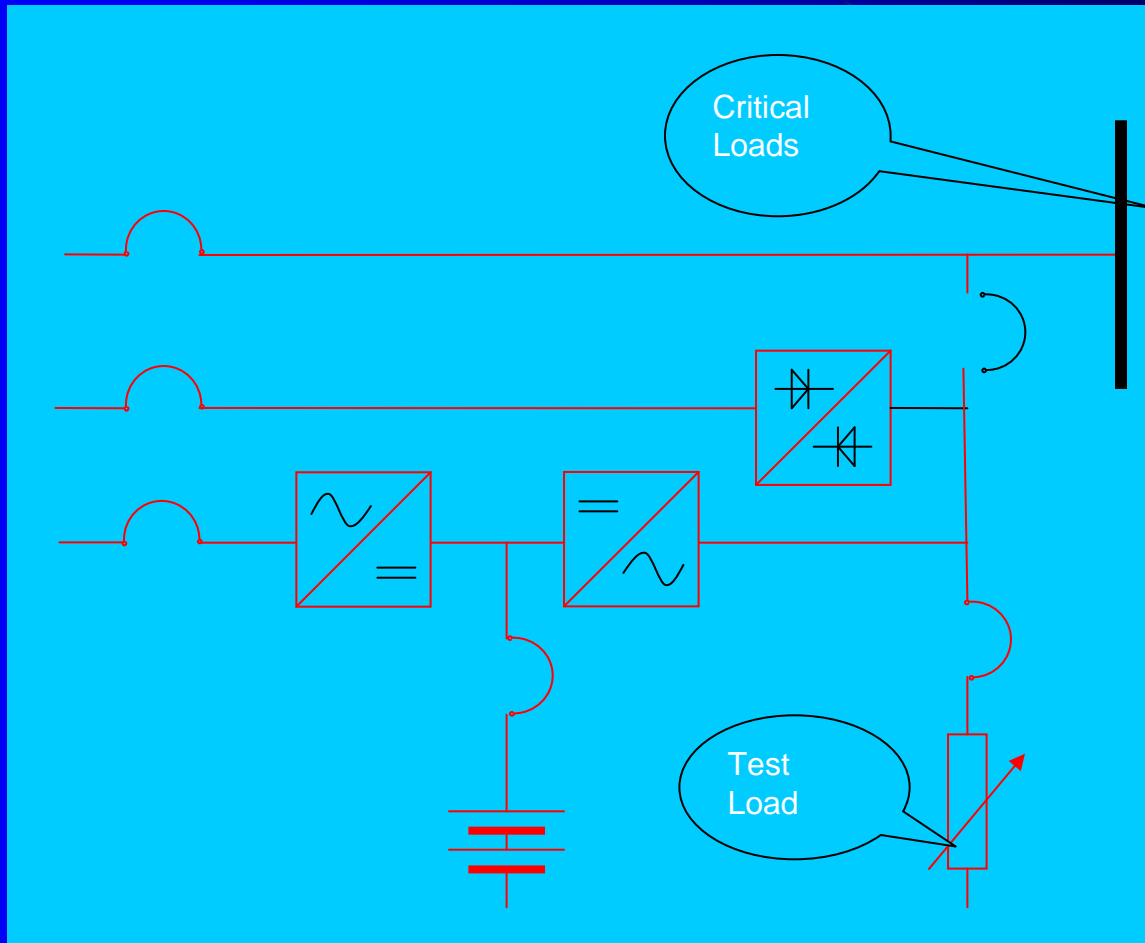
# Equipment specifications:

- 10 KV UPS, 3 phase 208V input/output, 100% load static bypass and manual bypass switch
- Battery: 102 KCR7 cells connected in series
- UPS bypass cabinet to allow for total UPS isolation and to provide load supply from bypass power

# Normal UPS/Battery configuration:



# UPS/Battery test configuration:



# Battery test data required to establish battery capacity using manufacturer constant current tables

- Average cell voltage at the end of test
- Battery average discharge current corrected to 25 deg C
- Test duration

# Challenges with assessment of battery capacity

- Battery will be discharged at steady KWs instead of steady current
- Lack of manufacturer KW tables only current tables are available
- How to apply temperature correction factor?
- Discharge end voltage is not defined, it depends on the UPS minimum DC bus voltage set point

# Data to be controlled and/or recorded during test

- UPS output to be controlled for constant KWs via adjusting output current in all 3 phases
- Battery cell average temperature
- Battery voltage and current to be recorded in sufficiently frequent time intervals
- DC bus voltage at the end of the test must be monitored closely to ensure proper recording of battery final voltage just prior to UPS transfer to bypass

# Data to be controlled and recorded during test (cont'd)

UPS alarm and operation system to be monitored to ensure proper sequence and indication

- UPS battery operation alarm
- UPS normal supply not available
- DC bus low voltage

UPS to be monitored when power is restored to UPS input

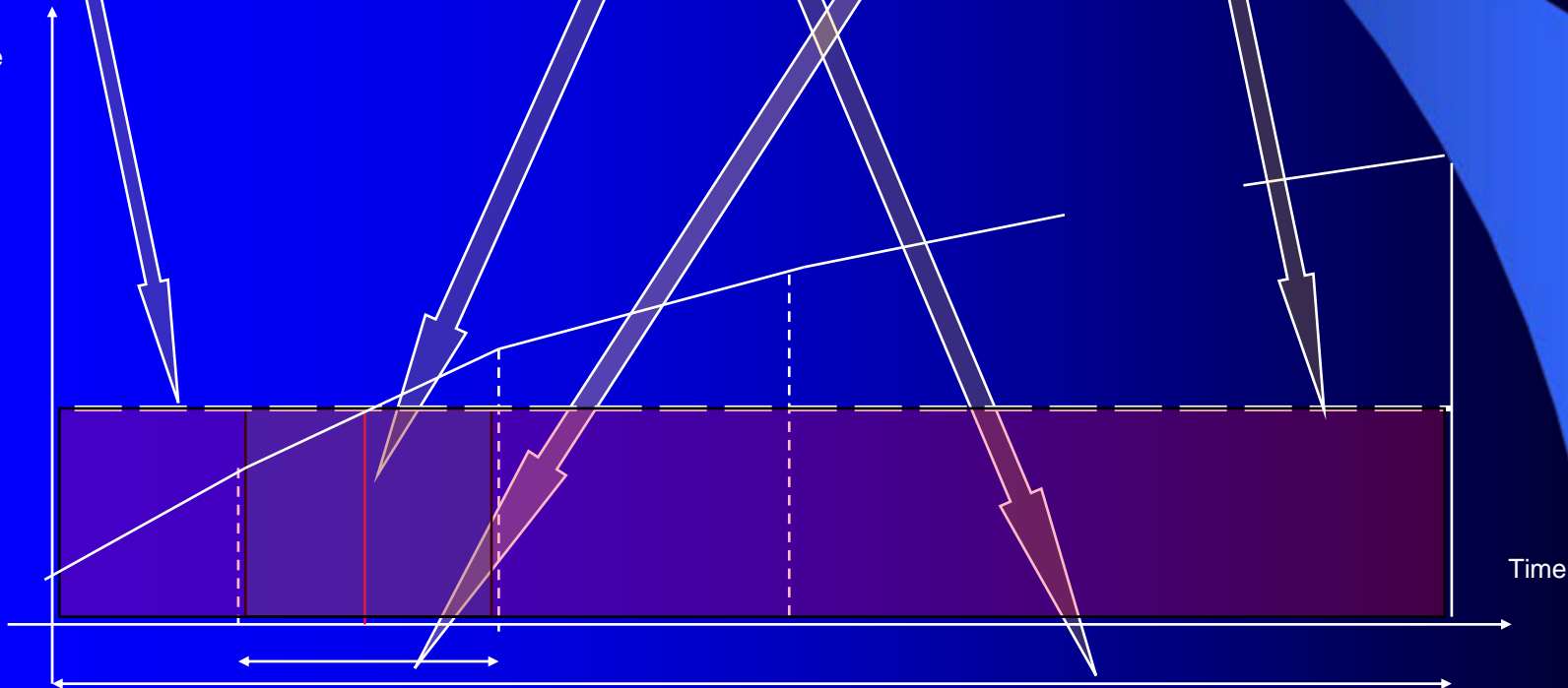
- Cancellation of all emergency alarms
- Confirmation that UPS loads are back on inverter
- Confirmation of normal rectifier operation
- Confirmation of battery charging operation

# Finding required data

Calculating battery average discharge current

$$I_{avg} = \int_0^{T_{test}} I(t) dt = \frac{\sum_{k=1}^n \frac{I_k + I_{k+1}}{2} \times (T_{k+1} - T_k)}{T_{test}} = \frac{\sum_{k=1}^n I_{avg_{xk}} \times \Delta T}{T_{test}}$$

Battery  
Discharge  
Current



# Finding required data (continuation)

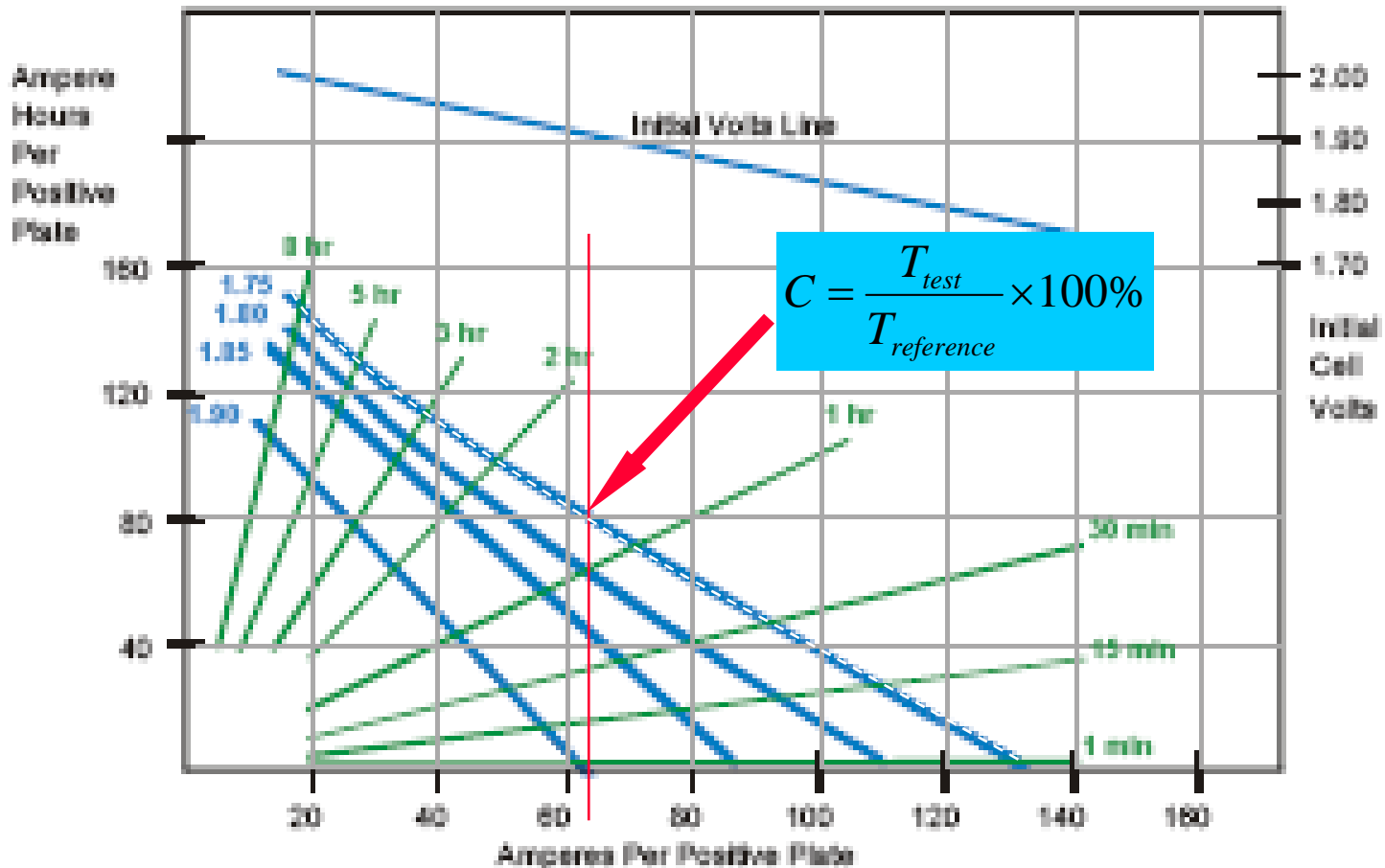
Calculating battery discharge current corrected to 25 deg C

$$I_{test} = \frac{I_{avg}}{K} \quad I_{\text{per positive plate}} = \frac{I_{test}}{\text{number of positive plates}}$$

Battery cell voltage at the end of the test

$$\text{Cell Final Volts} = \frac{\text{battery voltage just prior to UPS transfer to bypass}}{\text{number of cells in the bank}}$$

# Finding applicable 100% reference test time from discharge curves



# Advantages of UPS/battery testing over battery testing alone

- battery capacity
- battery ability to satisfy required load profile
- UPS operation in emergency situation
- UPS/battery operation when DC bus approaches minimum voltage level
- UPS/battery operation at the beginning of battery discharge (battery coup-de-fouet)
- UPS/battery recharging capabilities while supplying connected load

# Post Test Assessment Activates

- Are the battery banks performing as expected?
- Did we witness unpredicted cell behaviors?
- Do we need to perform any adjustments to UPS operating or alarm parameters?