

Battery Capacity Testing versus Total UPS/Battery Testing

Jack Kopytek
OPG Pickering B Nuclear
Station
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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

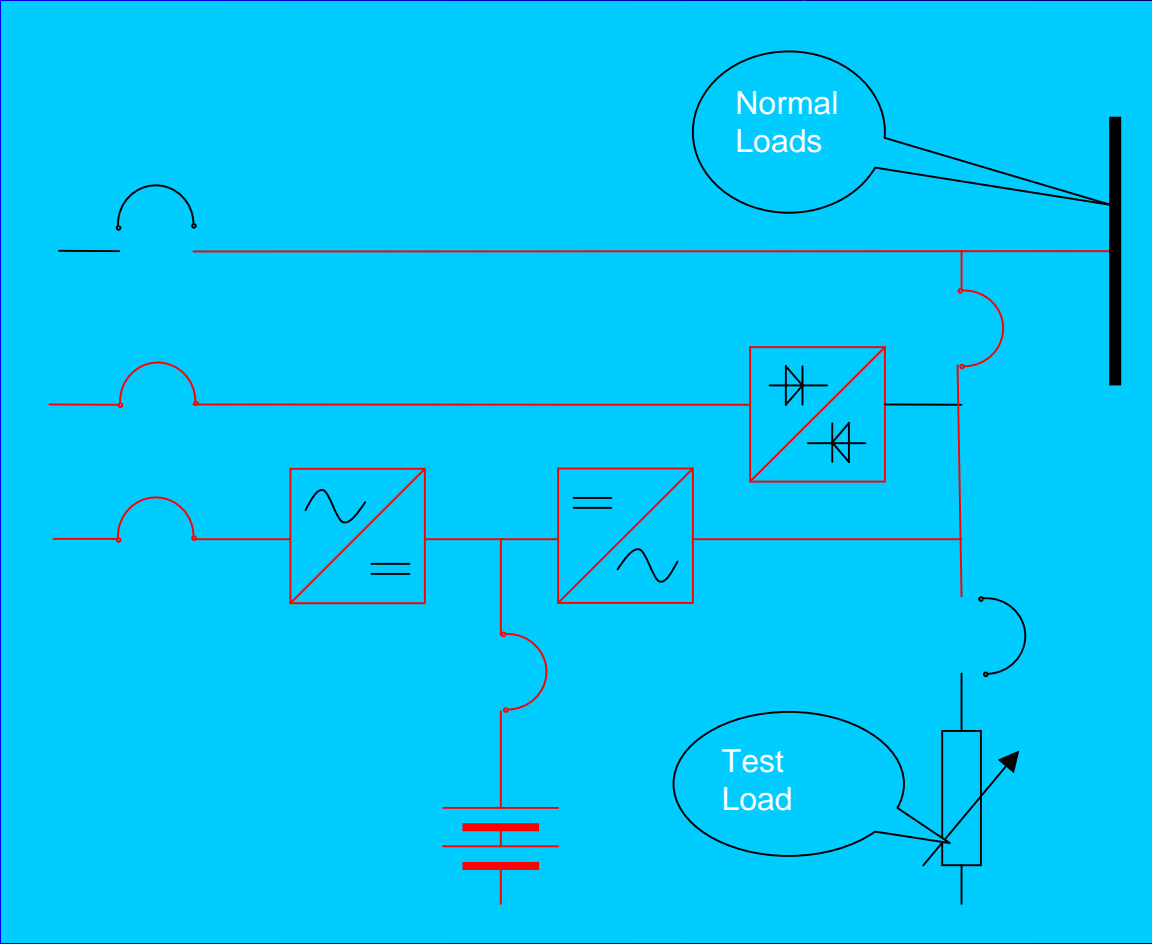
Testing a battery and UPS as one system allows us to determine:

- 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

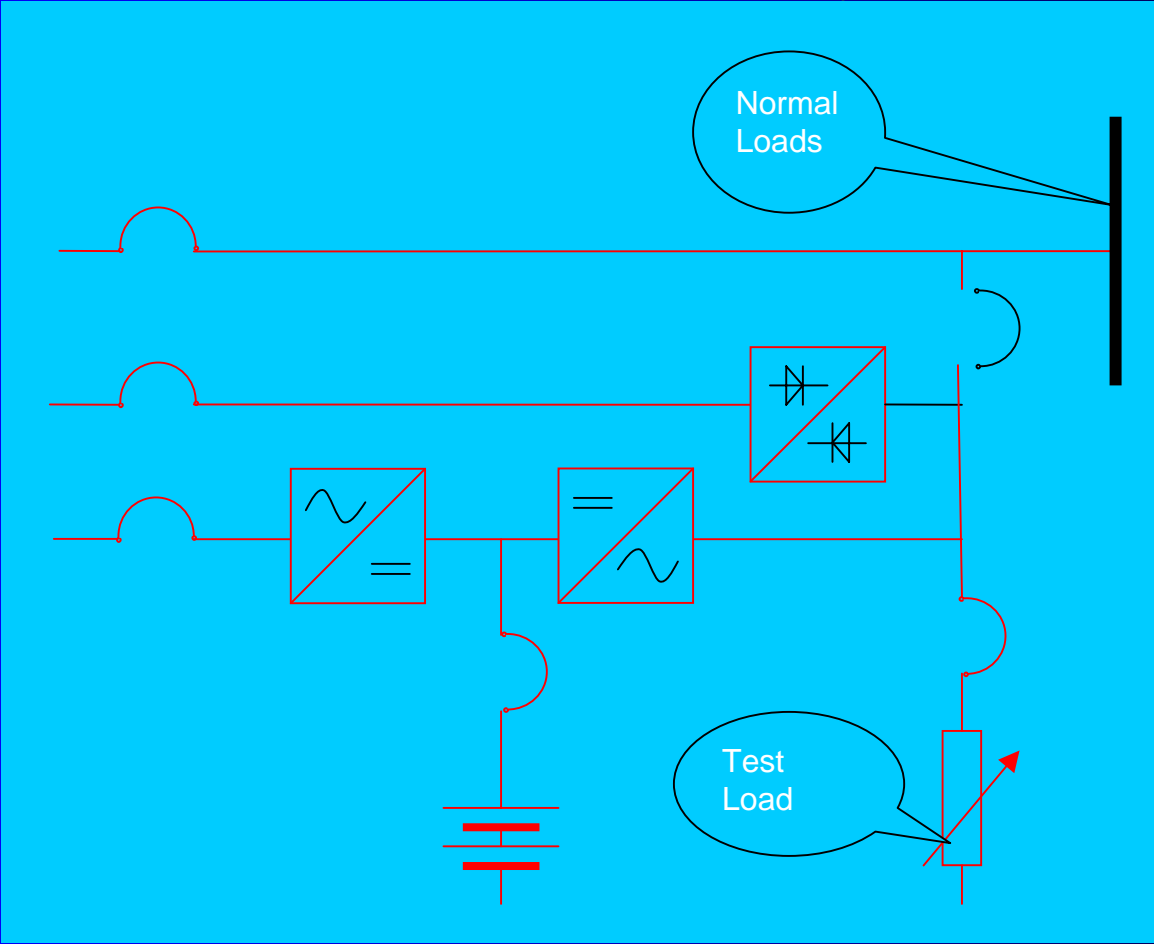
Equipment specifications:

- 10 KV UPS, 3 phase 208V input/output, 100% load static bypass and manual bypass switch
- Battery: 102 KCR7 or EC5 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

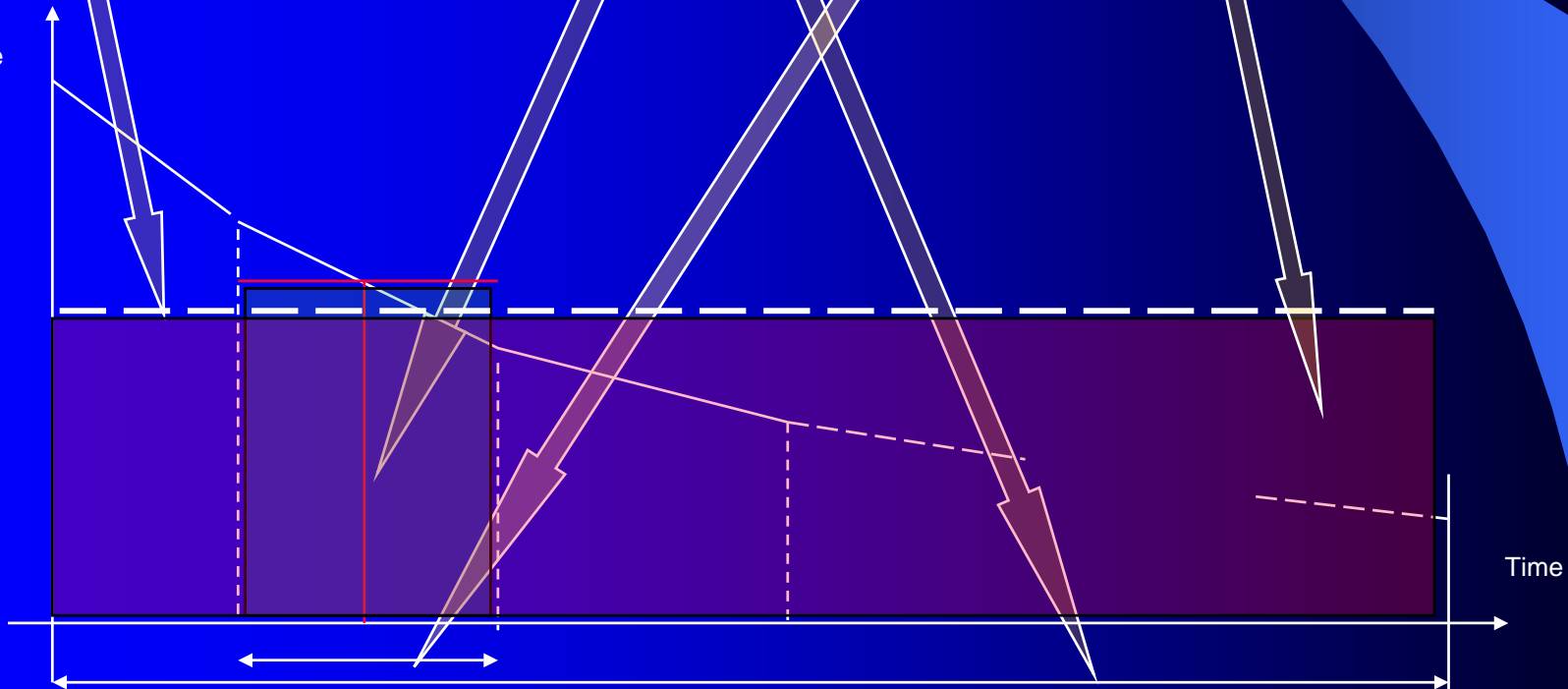
- Cancellation of all emergency alarms
- Confirmation that UPS loads are back on inverter
- Confirmation of normal rectifier operation
- Confirmation of battery charging operation

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)

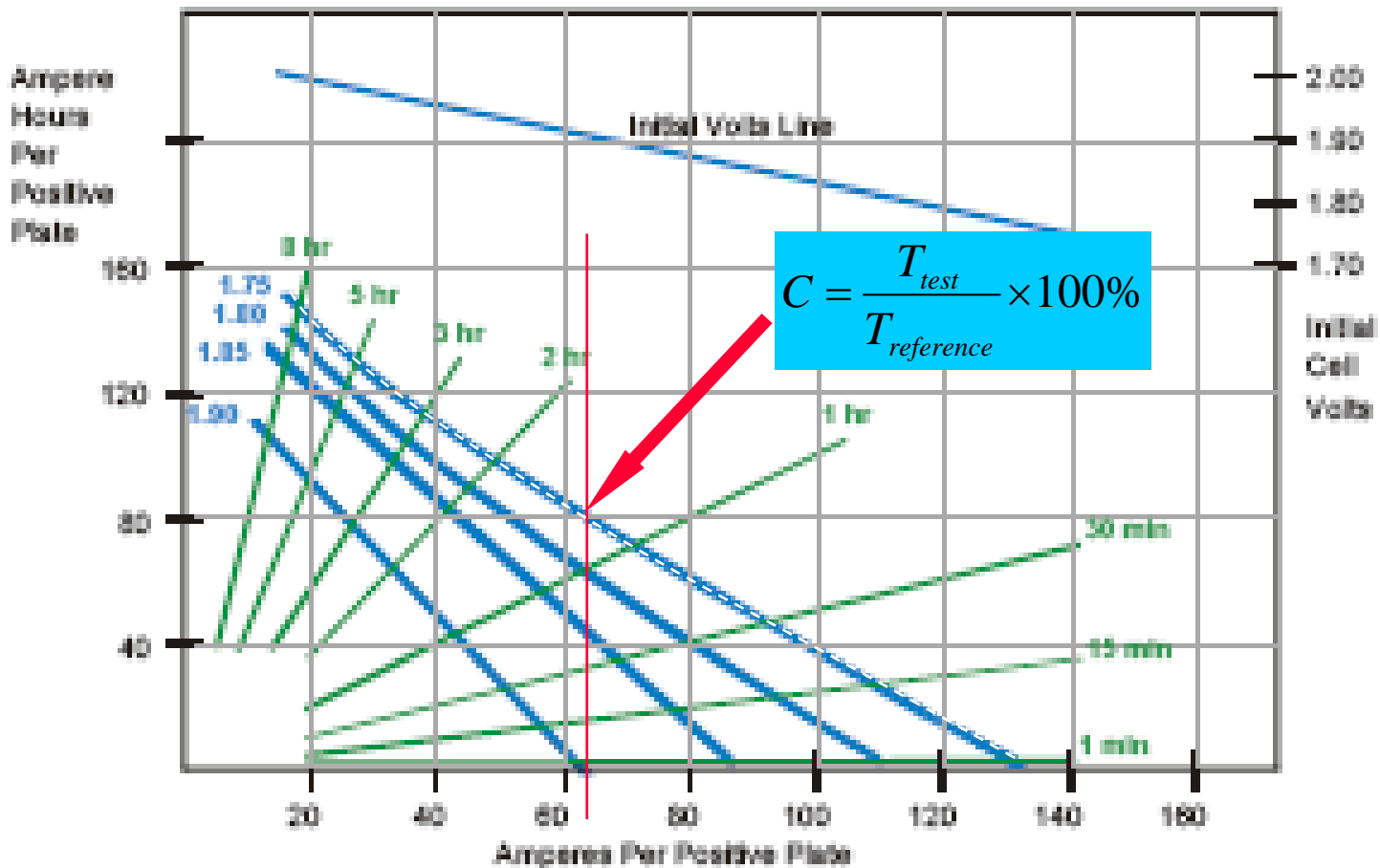
Calculating battery discharge current corrected to 25 deg C

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

Battery cell voltage at the end of the test

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

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?