

Substation Maintenance Instruction

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SMI 161 Replacement criteria for major primary system assets

SECTION 5 – BATTERIES

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5.1 Asset description

Substation batteries provide stand by power for critical equipment such as protection and control devices, switchgear, circuit breakers and power transformers. This is necessary for the safety and reliability of the network.

Substation batteries consist of a number of cells connected in series to the desired secondary system DC voltage, 120VDC. This health index covers the two types of battery cells used in Endeavour Energy's Substations; Nickel Cadmium and Lead Acid. Lead Acid cells can be vented or sealed.

5.2 Condition assessment

Substation batteries typically have a capacity of 300 Ampere-hours for 132kV substation with a firm rating of >20MVA and 200 Ampere-hours for all other substations. Degradation of batteries typically occurs due to usage, age and the environment in which they are installed. The physical indication of battery bank degradation depends on the condition of components such as:

- Terminals
- Connectors
- Cell containers
- Battery racks

The rate of internal deterioration can be measured by testing electrical characteristics, namely:

- Battery capacity
- Cell voltage

5.3 Condition rating

The condition rating process includes field inspections and detailed review of maintenance records and test reports. Each criterion represents a factor that is critical in determining the component's condition relative to potential failure.

The following tables contain specific definitions used for each condition rating for each component or test evaluated:

5.3.1 Battery location and rack condition

Condition Rating	Description
A	• Battery location and racks are clean, corrosion free and in good condition. • No evidence of any abnormalities. • Ventilation and environmental controls are functioning normally.
B	• Battery location and racks show normal signs of wear.
C	• Some corrosion and deterioration of battery racks.
D	• Severe corrosion and deterioration of battery racks. • Restricted ventilation in battery location.
E	• Battery location and racks are damaged / degraded beyond repair.

5.3.2 *Battery cases, covers, terminals and conductors*

Condition Rating	Description
A	- Battery cases and covers are clean and crack free. - Electrical conductors, connectors and terminals are clean, corrosion and build-up free and are in good condition. - No external evidence of overheating or any other abnormality.
B	- Battery cases, covers, electrical conductors, connectors and terminals show normal signs of wear. - No external evidence of overheating.
C	- Some swelling of battery cases or cracks in covers. - Some corrosion or build up on electrical conductors, connectors or terminals.
D	- Severe swelling of battery cases or cracks in covers. - Severe corrosion or build up on electrical conductors, connectors or terminals.
E	Battery cases, covers, electrical conductors, connectors and terminals are damaged / degraded beyond repair.

5.3.3 *Overall battery condition*

Condition Rating	Description
A	- Overall installation is clean, corrosion free. - All primary and secondary connections are in good condition. - No external evidence of overheating or any other abnormality. - Cell surface temperature normal.
B	Overall battery installation shows normal signs of wear.
C	- Some deterioration of overall battery installation. - Some battery cell surface temperatures are above normal.
D	- Severe deterioration of overall battery installation. - Majority of the battery cell surface temperatures are above normal.
E	Overall battery installation is damaged / degraded beyond repair.

5.3.4 *Battery float voltage test*

Condition Rating	Description
A	All cell float voltages are greater than 80% of rated cell voltage.
B	Less than 3% of the cells do not measure greater than 80% of the rated cell voltage.
C	Between 3 – 7% of the cells do not measure greater than 80% of the rated cell voltage.
D	Between 7 – 10% of the cells do not measure greater than 80% of the rated cell voltage.
E	Greater than 10% of the cells do not measure greater than 80% of the rated cell voltage.

Note: Typical rated cell voltages are 1.42V/cell for Nickel cadmium, and 2.25V/cell for lead acid.

5.3.5 Quick discharge and high current discharge test

Condition Rating	Description
A	All cell float voltages are greater than 80% of rated cell voltage.
B	Less than 3% of the cells do not measure greater than 80% of the rated cell voltage.
C	Between 3 – 7% of the cells do not measure greater than 80% of the rated cell voltage.
D	Between 7 – 10% of the cells do not measure greater than 80% of the rated cell voltage.
E	Greater than 10% of the cells do not measure greater than 80% of the rated cell voltage.

5.3.6 Battery capacity test

Condition Rating	Description
A	Battery ampere hour capacity is greater than 80% of rated ampere hour capacity.
B	Less than 3% of the cells do not measure greater than 80% of the rated ampere hour capacity.
C	Between 3 – 7% of the cells do not measure greater than 80% of the rated ampere hour capacity.
D	Between 7 – 10% of the cells do not measure greater than 80% of the rated ampere hour capacity.
E	Greater than 10% of the cells do not measure greater than 80% of the rated ampere hour capacity or the capacity has reduced by more than 10% compared to the previous test.

5.4 Health index formulation

The batteries are rated against set criteria for each condition parameter. The ratings are converted to a factor and multiplied by the given weight to obtain a health index score. The following table contains the associated weight for each condition criterion:

#	Condition Criteria	Weight (W _i)	Condition Rating	Factors (S _i)	Maximum Score (T _i)
1	Battery location and rack	5	A, B, C, D, E	4, 3, 2, 1, 0	20
2	Battery cases, covers, terminals and conductors	15	A, B, C, D, E	4, 3, 2, 1, 0	60
3	Overall battery condition	10	A, B, C, D, E	4, 3, 2, 1, 0	40
4	Battery float voltage test	15	A, B, C, D, E	4, 3, 2, 1, 0	60
5	Quick discharge and high current discharge test	20	A, B, C, D, E	4, 3, 2, 1, 0	80
6	Battery capacity test	35	A, B, C, D, E	4, 3, 2, 1, 0	140
		100			400

All 6 scores are entered into the formula below to convert to a rating out of 100:

$$HI = \left(\frac{\sum_{i=1}^N (S_i \times W_i)}{\sum_{i=1}^N T_i} \right) \times 100$$

where: $\sum_{i=1}^N T_i = 400$

$$N = 6$$

Note: Deterioration of more than three cells usual indicates potential widespread failure and functional failure of the total battery bank. An asset management strategy for the total battery bank should be developed to avoid additional cell failures.

5.5 Health index results and condition assessment

An overall health index for batteries can be derived from the above methodology. The overall health index is then compared to the Health index scale in Section 2.3 to determine to the overall condition of the asset. The resultant overall condition will dictate the strategic asset management requirements of the asset.