

Substation Maintenance Instruction

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SMI 161 Condition assessment of assets using health index

SECTION 6 – CURRENT TRANSFORMERS

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6.1 Asset description

Current transformers in the network are instrumentation devices that change high voltage system currents down to values that can be safely used by protection and control systems. They contain no moving parts but experience both static and dynamic electrical stresses, leading to the degradation of the asset.

Post current transformers consist of a tank, head, bushing, terminals, multiple secondary windings on cores, and terminal box. The physical design of a current transformer can be in a hairpin type where the secondary cores are located in the tank at the bottom around the hairpin shape primary winding; or top core type where the cores are located in the head housing around the straight primary winding.

6.2 Condition assessment

Current transformers are a vital element in ensuring the safety and reliability of the transmission and distribution network. The information obtained from current transformers is used by protection and control systems to detect any abnormal system conditions.

The components mentioned in Section 6.1 are assessed based on set criteria and given a condition based rating. The assessed condition of these components is the foundation on which the health index is calculated.

6.3 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:

6.3.1 Bushing condition

Condition Rating	Description
A	- Bushings are not broken and no visible chips, cracks and flashover burns. - Cementing and fasteners are secure.
B	- Bushings are not broken, however minor chips and cracks are visible. - Cementing and fasteners are secure.
C	- Bushings are not broken, however major chips, cracks and some flashover burns are visible. - Cementing and fasteners are secure.
D	- Bushings are broken / damaged. - Cementing and fasteners are not secure.
E	Bushings, cementing or fasteners are broken / damaged beyond repair.

6.3.2 Tank, head and terminal box

Condition Rating	Description
A	- No external corrosion or rust on tank, head or terminal box. - No rust, corrosion or evidence of moisture within terminal box.
B	- No external corrosion or rust on tank, head or terminal box. - Some evidence of moisture ingress or condensation in terminal box.
C	Significant rust and corrosion on tank, head or terminal box.
D	Severe rust and corrosion on tank, head or terminal box, high probability of failure.
E	Rust and corrosion on tank, head of terminal box have caused equipment failure or damaged / degraded beyond repair.

6.3.3 Primary termination

Condition Rating	Description
A	Primary terminations are tight, free from corrosion and show no evidence of overheating.
B	Primary termination shows normal signs of wear.
C	Some corrosion and evidence of overheating.
D	Severe corrosion and evidence of overheating.
E	The primary terminations are damaged / degraded beyond repair.

6.3.4 Secondary terminations and wiring

Condition Rating	Description
A	- Secondary wiring and fittings are free from damage and corrosion and in good condition. - All wiring, terminal blocks, switches, relays, monitoring and control devices are in good condition. - All connections and terminations are tight and show no evidence of overheating.
B	Secondary terminations and wiring shows normal signs of wear.
C	Some corrosion and deterioration of secondary wiring.
D	Severe corrosion and deterioration of secondary wiring.
E	The secondary terminations and wiring are damaged / degraded beyond repair.

6.3.5 Overall current transformer condition

Condition Rating	Description
A	- Current transformer is externally clean, and corrosion free. - All primary connections (hotspots), secondary connections are in good condition. - No external evidence of overheating. - No oil leaks. - Support steelwork and/or anchor bolts are secure and free from corrosion. - Earthing connections are secure, free from corrosion and made directly to tanks, cubicles and supports, without any intervening paint or corrosion.

B	Current transformer shows normal signs of wear.
C	- Some corrosion and evidence of overheating. - Minor oil leaks.
D	- Severe corrosion and evidence of overheating. - Major oil leaks.
E	The current transformer is damaged / degraded beyond repair.

6.3.6 Insulation resistance test

Condition Rating	Description
A	$>IR_{min}$ and less than 10% of previous IR test result
B	$>IR_{min}$ and between 10 – 20% of previous IR test result
C	$>IR_{min}$ and between 20 – 30% of previous IR test result
D	$>IR_{min}$ and greater than 30% of previous IR test result
E	$<IR_{min}$

Minimum IR value: Primary winding and earth $>500\text{ M}\Omega$

Secondary winding and earth $\geq 1\text{ M}\Omega$

6.3.7 DDF test

Oil-impregnated paper insulation:

Condition Rating	Description
A	Less than or equal to the pre-commissioning value (if available) or within manufacturer's limit or $\leq 5.0\text{ mrad @ }20^{\circ}\text{C}$.
B	Less than 30% increase from the pre-commissioning value (if available) or within manufacturer's limit or between $5.0 - 6.5\text{ mrad @ }20^{\circ}\text{C}$.
C	Between 30 – 70% increase from the pre-commissioning value (if available) or within manufacturer's limit or between $6.5 - 8.5\text{ mrad @ }20^{\circ}\text{C}$.
D	Between 70 – 100% increase from the pre-commissioning value (if available) or within manufacturer's limit or between $8.5 - 10.0\text{ mrad @ }20^{\circ}\text{C}$.
E	Greater than 100% increase from the pre-commissioning value (if available) or exceeds manufacturer's limit or $\geq 10.0\text{ mrad @ }20^{\circ}\text{C}$.

Resin-impregnated paper insulation:

Condition Rating	Description
A	Less than or equal to the pre-commissioning value (if available) or within manufacturer's limit or $\leq 7.0\text{ mrad @ }20^{\circ}\text{C}$.
B	Less than 30% increase from the pre-commissioning value (if available) or within manufacturer's limit or between $7.0 - 9.0\text{ mrad @ }20^{\circ}\text{C}$.
C	Between 30 – 70% increase from the pre-commissioning value (if available) or within manufacturer's limit or between $9.0 - 12.0\text{ mrad @ }20^{\circ}\text{C}$.
D	Between 70 – 100% increase from the pre-commissioning value (if available) or within manufacturer's limit or between $12.0 - 14.0\text{ mrad @ }20^{\circ}\text{C}$.
E	Greater than 100% increase from the pre-commissioning value (if available) or exceeds manufacturer's limit or $\geq 14.0\text{ mrad @ }20^{\circ}\text{C}$.

Resin-bonded paper, cast or moulded resin insulation:

Condition Rating	Description
A	Less than or equal to the pre-commissioning value (if available) or within manufacturer's limit or ≤ 15.0 mrad @ 20°C.
B	Less than 30% increase from the pre-commissioning value (if available) or within manufacturer's limit or between 15.0 – 19.5 mrad @ 20°C.
C	Between 30 – 70% increase from the pre-commissioning value (if available) or within manufacturer's limit or between 19.5 – 25.5 mrad @ 20°C.
D	Between 70 – 100% increase from the pre-commissioning value (if available) or within manufacturer's limit or between 25.5 – 30.0 mrad @ 20°C.
E	Greater than 100% increase from the pre-commissioning value (if available) or exceeds manufacturer's limit or ≥ 30.0 mrad @ 20°C.

6.4 Health Index formulation

The current transformer is 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	Bushing condition	15	A, B, C, D, E	4, 3, 2, 1, 0	60
2	Tank, head and terminal box	5	A, B, C, D, E	4, 3, 2, 1, 0	20
3	Primary termination	5	A, B, C, D, E	4, 3, 2, 1, 0	20
4	Secondary terminations and wiring	5	A, B, C, D, E	4, 3, 2, 1, 0	20
5	Overall current transformer condition	10	A, B, C, D, E	4, 3, 2, 1, 0	40
6	Insulation resistance test	20	A, B, C, D, E	4, 3, 2, 1, 0	80
7	DDF test*	40	A, B, C, D, E	4, 3, 2, 1, 0	160
		100			400

* If DDF test is not required as part of routine maintenance then the weighting allocated to the DDF test is to be added to Insulation resistance condition weighting.

All 7 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: $\sum_{i=1}^N T_i = 400$

$N = 7$

6.5 Health index results and condition assessment

An overall health index for a current transformer 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 the overall condition of the asset. The resultant overall condition will dictate the strategic asset management requirements of the asset.