

Substation Maintenance Standard

Selection of distribution transformers for refurbishment

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Substation Maintenance Instruction

PRIMARY SYSTEMS

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SMI 111 SELECTION OF DISTRIBUTION TRANSFORMERS FOR REFURBISHMENT

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1.0 PURPOSE

To set the minimum requirements to determine if a distribution transformer is economic to refurbish or if it will need to be scrapped or sold.

2.0 SCOPE

The instruction covers all distribution padmount and pole substation transformers. The instruction will not set out the procedure for the refurbishment, scrapping or sale of transformers.

3.0 REFERENCES

Company Policy (Network) 9.2.6 – Network Asset Renewal
Company Policy (Network) 9.9.1 – Network Asset Maintenance
Company Policy (Network) 9.9.2 – Essential Spares
Company Procedure (Procurement & Logistics) GSU 0006 – Disposal of surplus goods and equipment
Division Workplace Instruction (Network) WNV 1016 - Preparation and disposal of surplus oil filled distribution electrical equipment
Environmental Management Standard EMS 0001 – Environmental due diligence and environmental management plans
Environmental Management Standard EMS 0002 – Pollution control
Environmental Management Standard EMS 0007 – Waste management
Environmental Management Standard EMS 0008 – Environmental incident response
Substation Maintenance Instruction SMI 101 – Minimum requirements for maintenance of distribution equipment
Substation Maintenance Instruction SMI 124 – Maintenance data entry and defect prioritisation
Substation Maintenance Instruction SMI 113 – Distribution and field transmission data entry asset structure and nameplate details
Substation Maintenance Instruction SMI 159 – Refurbishment of Distribution Transformers
Endeavour Energy Network Management Plan 2009-2014
Endeavour Energy Electrical Safety Rules
Internal review of distribution transformer refurbishment process (May-04)
Electricity Supply (Safety and Management Plans) Regulation 2001
Work Health and Safety Act 2011
Work Health and Safety Regulation 2011
Australian Standard AS 3000 - SAA wiring rules
NSW WorkCover documentation for the production of hazard assessment forms
ENA National electricity network safety code (Doc 01-2008)

4.0 DEFINITIONS AND ABBREVIATIONS

DF

Depreciation factor

FSC

Field Service Centre

High Voltage (HV)

High voltage - voltage exceeding or equal to 1000V AC (refers to 11kV, 12.7kV and 22kV in this document).

Low Voltage (LV)

Low voltage - voltage exceeding 32V AC but less than 1000V AC.

Network

The Endeavour Energy electrical network of poles, wires, substations and the like by which electrical power is transmitted/distributed to customers.

PCB

Polychlorinated Biphenyls

TX

Transformer

5.0 ACTIONS

This instruction is to be read in conjunction with Substation Maintenance Instruction SMI 101 – Minimum requirements for maintenance of distribution equipment.

5.1 General

Distribution transformers are returned to local Field Service Centres (FSC) in varying conditions, for either refurbishment or scrapping. The assessment of whether it is economical to refurbish these transformers depends on several factors, which are documented in Substation Maintenance Instruction SMI 159 – Refurbishment of Distribution Transformers (*as found* checks). They include age, size, transformer type, condition and total cost of refurbishment.

To determine if the transformer should be refurbished, the two (2) major factors are:

- the total estimated refurbishment cost; and
- the assessed value of the transformer (calculated by depreciation factor).

Note: The threshold of viability for refurbishment is the assessed value of the asset. The transformer is deemed economical to refurbish when the total cost of the estimated refurbishment is less than the assessed transformer value.

5.1.1 Transformer suitability

During the initial assessment process, a transformer's suitability can be assessed from the following list of unsuitable designs:

- transformers with goose neck explosion vents (pole mounted);
- transformers with pitch filled cable boxes;
- transformers requiring lightning arrestor brackets to be welded to the tank;
- transformers with lid mount conservators (where sufficient spares available in stores); and
- transformers where replacement parts that are unable to be sourced.

Note: All kVA ratings are still suitable for use and shall be evaluated using refurbishment viability assessment process in Figure 1 – Refurbishment viability assessment process.

All transformers unsuitable for use on Endeavour Energy's network shall be scrapped or sold.

5.1.2 As found testing

The first *as found* test to be carried out is an oil test, which determines the presence of Polychlorinated Biphenyls (PCB) in the oil. If the PCB level is greater than 2ppm, the transformer is unsuitable for refurbishment.

There are three other electrical tests as part of the *as found* testing:

- insulation resistance;
- turns ratio; and
- winding resistance.

The insulation resistance shall be greater than the minimum value calculated by the following:

$$IR_{min} = \frac{0.8 \times (\text{primary voltage})}{\sqrt{(KVA)}}$$

The turns ratio test value shall be within a $\pm 0.5\%$ tolerance of the calculated value.

The measured winding resistance shall be within 2% of the reported factory value.

All transformers unsuitable for use on Endeavour Energy's network shall be scrapped or sold.

5.2 Refurbishment cost

Annexure 1 – Refurbishment cost calculation form shall be used to calculate the estimated cost of refurbishing a transformer in accordance with Substation Maintenance Instruction SMI 159 – Refurbishment of Distribution Transformers.

5.3 Depreciation factor

The method of calculation of the depreciation factor (DF) depends on whether the transformer's insulation paper is inspected.

5.3.1 Minor overhaul

If a transformer only requires a minor overhaul, the condition of the insulation paper cannot be inspected as the transformer is not de-tanked. Hence, the depreciation factor is calculated based on the potential 65 years of the transformer economic life expectancy:

$$DF = \frac{(65 - \text{transformer age in years})}{65}$$

5.3.2 Major overhaul

If a transformer is de-tanked for a major overhaul, the depreciation factor shall be determined in accordance with the following guidelines after the insulation paper has been inspected:

- if the insulation paper appears brittle and frayed, then the DF = 0 and the transformer is suitable as scrap only;
- if the insulation paper appears somewhat brittle but still requires a degree of effort to remove from the windings, then the insulation can be assessed as suitable but a DF of no more than 0.5 is to be applied to the transformer; and
- if the insulation paper appears to be in good order then a DF of no more than 0.8 is to be applied to the transformer.

5.4 Assessed transformer value

The assessed transformer value is the estimated value of the transformer, which is calculated directly from the current contract price of a new transformer (TX), the calculated depreciation factor and set risk adjustment factor.

$$\text{Assessed transformer value} = \text{Cost of new TX} \times \text{DF} \times 0.85$$

The factor of 0.85 is an empirical risk adjustment factor, derived from the cost for loss difference between old and new transformers and the cost for maintenance works that may occur, but which are not covered by Substation Maintenance Instruction SMI 159 – Refurbishment of Distribution Transformers. This may include, for example, modification works of the new transformer's terminations (bushing termination converted to cable termination).

5.5 Assessment of economic viability/selection criteria for transformer refurbishment

Refurbishment works are to be carried out on the transformer only when economic viability for refurbishment remains possible.

The following economic evaluation formula is used to assess economic viability:

$$\text{Assessed transformer value} > \text{Refurbishment cost}$$

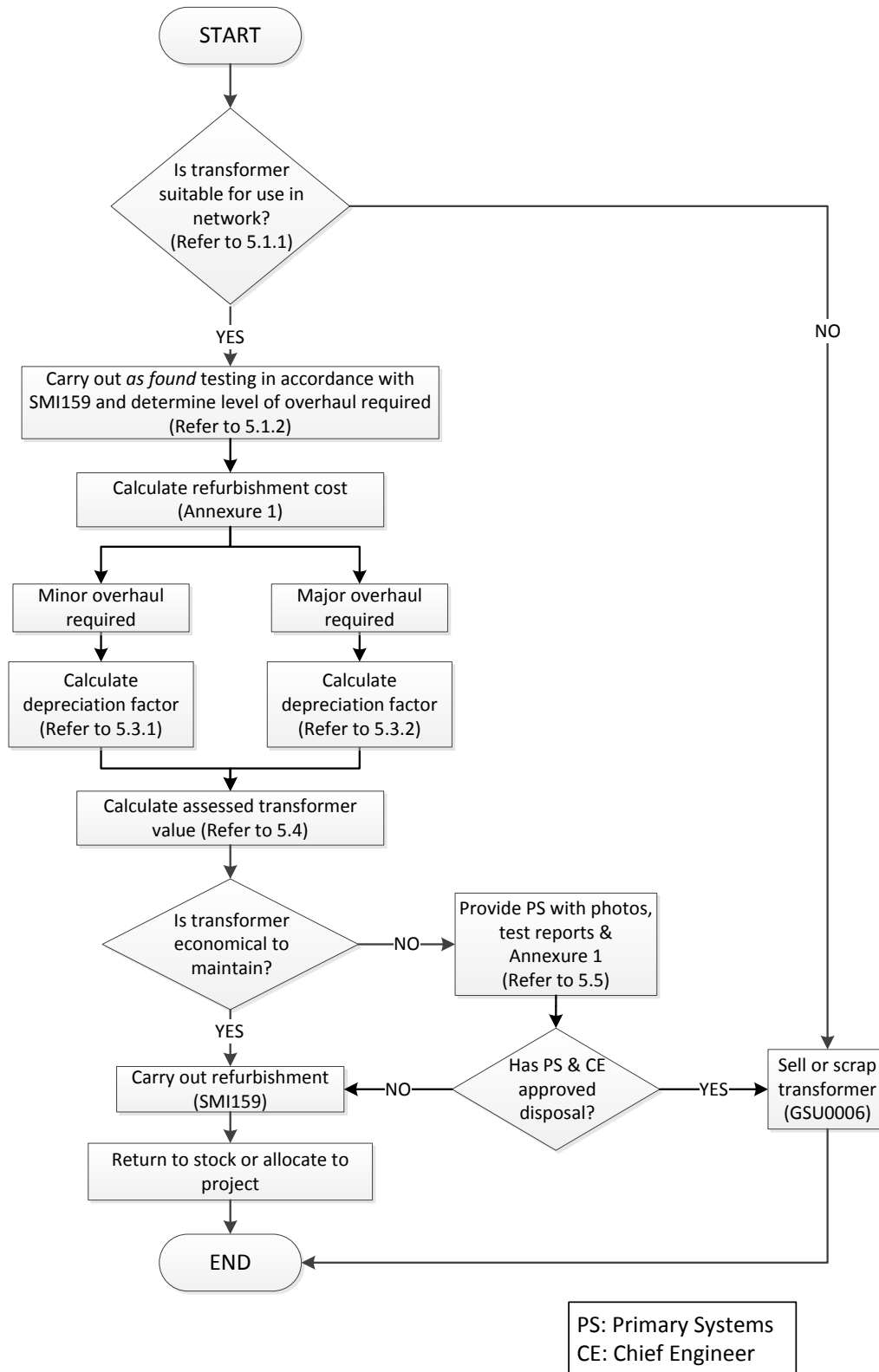
Hence, if the refurbishment cost is greater than the assessed transformer value, the refurbishment of that transformer is not economically viable.

If the transformer is not economically viable the transformer workshop shall submit photos, test reports and the cost of refurbishment (Annexure 1 – Refurbishment cost calculation form) to the Network Maintenance Manager to be reviewed and endorsed for disposal.

5.6 Process flowchart

The refurbishment viability assessment process for selection of distribution transformer for refurbishment is shown below in Figure 1: Refurbishment viability assessment process.

Figure 1: Refurbishment viability assessment process



6.0 AUTHORITIES AND RESPONSIBILITIES

Chief Engineer has the authority and responsibility for approving this Standard.

Manager Primary Systems has the authority and responsibility for:

- approving this document for minor changes; and
- making recommendations to the Chief Engineer for major changes.

Distribution Manager Support Services has the authority and responsibility for:

- selecting the transformers for refurbishment as set out in this Substation Maintenance Instruction;
- overseeing that the transformer is approved for disposal by Chief Engineer;
- setting out details of the items for disposal and overseeing disposal is carried out in accordance with Division Workplace Instruction (Network) WNV 1016 - Preparation and disposal of surplus oil filled distribution electrical equipment and Company Procedure (Procurement & Logistics) GSU 0006 – Disposal of surplus goods and equipment; and
- overseeing that data is entered into Endeavour Energy's asset management database (Ellipse) to reflect the current status and condition of the equipment.

Disposal Coordinator has the authority and responsibility for administering Company Procedure (Procurement & Logistics) GSU 0006 – Disposal of surplus goods and equipment.

Network Maintenance Manager has the authority and responsibility for:

- keeping the content of this Substation Maintenance Instruction up to date; and
- reviewing transformer selected for disposal.

7.0 DOCUMENT CONTROL

Documentation Content Coordinator : Network Maintenance Manager

Documentation Distribution Coordinator : Branch Process Coordinator

Annexure 1 – Refurbishment cost calculation form

Equipment ID: _____ Serial number: _____ Age: _____

Refurbishment work (as required)	Material Cost \$	Labour Hours	Labour Cost \$
Gaskets and seals:			
Replace gaskets.			
Replace tap changer seals.			
Replace tap changer O ring.			
Bushings:			
Replace bushings.			
Tighten LV and HV Bushings.			
Steelwork:			
Repair defects.			
Drain valve:			
Replace drain valves with sealing cap.			
Tap changer switch:			
Check operation is correct.			
General (major overhaul only):			
High pressure wash transformer.			
Core (major overhaul only):			
De-tank and inspect core.			
Dry core in oven until satisfactory insulation reading is obtained.			
Liquid dielectric (oil) (major overhaul only):			
Replace liquid dielectric.			
Testing:			
Electrical tests (final checks).			
Painting:			
Treat rust.			
Fill in lesions that may hold water with suitable metal filler.			
Re-paint in accordance with manufacturer's instructions.			
Other:			
Miscellaneous costs.			
Subtotal costs:	\$		\$

Total refurbishment cost (materials + Labour): \$

Assessed transformer value:

Cost of new tx (\$) x Depreciation Factor () x 0.85 = \$

Assessed transformer value > Total refurbishment cost (Yes/No)