Thermovision of zone and transmission substations

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SMI 140 Thermovision of zone and transmission substations

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1.0 **PURPOSE**
To specify the requirements for carrying out thermovision on equipment in zone and transmission substations.

2.0 **SCOPE**
This instruction guides the use of thermovision on equipment in zone and transmission substations. The thermovision survey may be conducted after faults have been encountered or as part of a routine inspection.

The instruction provides a guide for the conditions under which an effective survey may be carried out and recommends compensation factors to be applied, as well as prioritisation of defects.

This instruction specifies reporting requirements.

3.0 **REFERENCES**
- Company Policy 9.9.1 – Network Asset Maintenance
- Company Procedure GAM 0089 – Authorisation Governance and Management
- Company Procedure GQY 1110 - Control and calibration of instrument and test equipment
- Division Procedure GNV1092.1 – Non Invasive Network Asset Condition Assessment Testing – Infrared (Thermovision) Surveys
- Division Form FNV 1075 – Thermovision Survey Report – Substation Equipment
- Division Form FNV 1076 – Substation Load Status
- SMI 100 – Minimum requirements for maintenance of transmission and zone substation equipment
- Network Management Plan December 2013 Review
- ENA National Electricity Network Safety Code (Doc. 01-2008)
- *Work Health and Safety Act 2011*
- *Work Health and Safety Regulation 2011*

4.0 **DEFINITIONS AND ABBREVIATIONS**
- **Contractor**
  Person bound to execute the work under a contract.
- **Ellipse**
  Endeavour Energy’s asset database
- **Thermovision**
  Process by which thermal imaging infrared equipment is used to survey overhead transmission lines to detect hot joints and zero/low insulation insulators. Also known as infra-red survey.
- **Substation**
  Transmission or zone substation
- **NATA**
  National Association of Testing Authorities, Australia

5.0 **ACTIONS**
Thermovision of transmission and zone substations shall be carried out in accordance with this instruction.

5.1 **General**
Where a hot joint or connection is detected, a more detailed examination of the component or equipment shall be carried out. The healthy phases or conductors shall be used as a reference to determine the relative temperature rise of the hot joint. As potentially all phases may be defective for a set of connections, in such cases the reference shall be used from nearby components. Where no suitable reference is available, temperature rise and/or absolute temperature shall be recorded and reported.
5.2 Authorisations
These instructions shall be carried out only by Endeavour Energy staff who have been authorised in accordance with GAM 0089 - Authorisation Governance and Management.

5.3 Thermovision equipment
Equipment used for thermovision shall be approved by the Network Maintenance Manager, Primary Systems to confirm, that it is capable of fulfilling the requirements of this instruction. It shall be calibrated based on the manufacturer’s recommended calibration interval, and carry a current calibration sticker in accordance with GQY 1110 - Control and calibration of instrument and test equipment.

Calibration must be carried out by a laboratory competent to carry out calibration of thermovision cameras, using equipment certified by NATA or equivalent.

5.4 Basis of surveying
The frequencies at which the thermovision surveys are to be carried out are specified in SMI100 – Minimum requirements for maintenance of transmission and zone substation equipment.

5.5 Thermovision scanning conditions
In order to minimise possible negative effects and increase the accuracy of the survey result, thermovision shall fulfil the conditions shown in the table below (weather and temperature conditions only apply to outdoor equipment).

<table>
<thead>
<tr>
<th>Basic operational conditions for thermovision</th>
</tr>
</thead>
<tbody>
<tr>
<td>Weather</td>
</tr>
<tr>
<td>Ambient temperature</td>
</tr>
<tr>
<td>Relative humidity</td>
</tr>
<tr>
<td>Wind speed</td>
</tr>
<tr>
<td>Circuit loading requirement</td>
</tr>
<tr>
<td>Time of loading the circuit</td>
</tr>
<tr>
<td>Survey distance</td>
</tr>
</tbody>
</table>

5.6 Components to survey
Unless otherwise specified, thermovision is required at all joints, bonds and terminations in the conductors and associated equipment within the substation. Equipment that is not under load shall be noted and revisited for survey when in service.
5.7 **Survey Method**

5.7.1 *Loading and current density of the tested circuit*

The load for all transformers, bus sections, and feeders shall be recorded on Division Form FNV 1076 - Substation Load Status. This can be used to assist in the prioritisation of defects. For example, if a hot joint is identified and the equipment is lightly loaded, the priority of the defect may be increased (see 5.7.3.1).

5.7.2 **Measurements**

Step 1 Measure the temperature of the Hot Spot, $T_H$ deg. C.

Step 2 Measure the temperature of the reference phase, $T_R$ deg C.

Step 3 Calculate the temperature rise of the hot spot $T_H$ above the reference phase $T_R$, $T_RR$ deg. C ($T_RR = T_H - T_R$).

5.7.3 **Wind correction factor**

For outdoor equipment, the effect of wind on the temperature of connections shall be considered.

In order to obtain better accuracy of measurement, thermovision shall be carried out only when wind speeds are less than 5.0 m/s (18km/hr).

Where a hot joint or connection is detected, a wind speed correction factor shall be applied to the measured temperature rise in order to convert the final result to a one meter per second wind speed.

When selecting the correction factor, the local wind speed should be obtained from an anemometer. Measurements of the wind speed shall be obtained as close to the conductor as practically feasible.

Wind speed correction factors are shown below:

<table>
<thead>
<tr>
<th>Wind speed (m/s)</th>
<th>Correction factor $C_w$</th>
</tr>
</thead>
<tbody>
<tr>
<td>≤1</td>
<td>1.0</td>
</tr>
<tr>
<td>2</td>
<td>1.36</td>
</tr>
<tr>
<td>3</td>
<td>1.64</td>
</tr>
<tr>
<td>4</td>
<td>1.86</td>
</tr>
<tr>
<td>5</td>
<td>2.06</td>
</tr>
</tbody>
</table>

The final temperature rise at full load after taking the correction factors into account is given as:

$$T_f = T_{RR} \times C_w$$

where:

- $T_f$ = Corrected temperature rise (deg. C) of the connection above the healthy conductor.
- $T_{RR}$ = The temperature rise (deg. C) [relative to the healthy conductor].
- $C_w$ = Wind speed correction factor.
5.7.3.1 Prioritisation of defects

For overheating joints and connections defects, the following repair priorities shall be used:

<table>
<thead>
<tr>
<th>Equipment type</th>
<th>Repair priority</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Repair within 48 hours</td>
</tr>
<tr>
<td>Temperature rise compared to reference</td>
<td>(apply wind correction as required) (Elevate priority if equipment is lightly loaded)</td>
</tr>
<tr>
<td>Main circuit conductor connections</td>
<td>&gt; 65</td>
</tr>
<tr>
<td>Indoor switchgear bushing stems</td>
<td>&gt; 20</td>
</tr>
<tr>
<td>Pooling of heat on external surface of cabinets</td>
<td>&gt; 10</td>
</tr>
<tr>
<td>Protection links</td>
<td>&gt; 20</td>
</tr>
<tr>
<td>Nearby structures with induced current heating</td>
<td>&gt; 10</td>
</tr>
</tbody>
</table>

5.7.3.2 Reporting requirements

A report shall be produced in accordance with Division Procedure GNV 1092.1 - Non Invasive Network Asset Condition Assessment Testing – Infrared (Thermovision) Surveys, for each defect identified and included in the monthly performance report.

The following information should be recorded and provided in the report:

- Substation / location
- Time and date of test
- Voltage level(s)
- Name of asset (and phase if applicable)
- Equipment type defective (for example, bushing stem)
- Load current (if applicable)
- The emissivity of the conductor involved in this measurement/calculation.
- Weather conditions (if applicable)
- Ambient temperature
- Estimated wind velocity (if applicable)
- Actual measured temperature rise (before adjustments)
- Correction factors used in calculation (for example, wind)
- Calculated temperature rise (with correction factors applied)
- Colour thermograph of the hot connection
- Normal colour photograph of the hot connection
5.8 Entering data into the Asset Management database (Ellipse)

Any thermovision defects detected shall be entered into Ellipse within two (2) weeks of the completion of the survey. All substations that are thermally scanned shall be registered in Ellipse irrespective of any faults being detected.

Defects shall be entered against the asset. If there is no switch, fuse, and the like, then it should go against the nearest asset.

The System Controller shall be notified as soon as possible of any defect that needs immediate action.

If, in the process of performing thermovision surveys, it becomes apparent that other adjacent equipment may have suffered damage due to heat, or other damaged or faulty equipment is observed, this shall be entered as a defect in the Ellipse database in an appropriate manner.

6.0 AUTHORITIES AND RESPONSIBILITIES

The Chief Engineer has the authority and responsibility for approving this instruction.

The Manager Primary Systems has the delegated authority and responsibility for approving this instruction.

The Network Maintenance Manager, Primary Systems has the authority and responsibility for keeping the content of this instruction up to date.

The Regional Transmission Managers has the authority and responsibility for:

- confirming that the requirements of this instruction are met when carrying out thermovision surveys on zone and transmission substation equipment;
- confirming that Endeavour Energy employees and/or contractors engaged to perform the work have appropriate qualifications and are competent to carry out the work;
- providing appropriate equipment and training;
- verifying that data is entered into the Endeavour Energy Asset Management database; and,
- verifying that data is analysed and necessary follow-up action is undertaken to rectify the defects identified.

All Endeavour Energy employees and/or contractors have the authority and responsibility for:

- meeting the requirements of this instruction when carrying out thermovision surveys on zone and transmission substations;
- upholding a high level of public safety;
- working in accordance with local and statutory requirements;
- working in accordance with Endeavour Energy’s Electrical Safety Rules;
- updating Endeavour Energy’s Ellipse database; and,
- communicating abnormalities found in zone and transmission substations to the Regional Transmission Manager.

7.0 DOCUMENT CONTROL

Documentation content coordinator: Network Maintenance Manager

Documentation process coordinator: Standards Process Coordinator