

Network Standard

Document No.

NS272

Title:

Cable Rating

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Revision

No	Date	Description	Technical Approver	Authorised By
0	4/03/2020	This Standard describes the requirements for undertaking steady-state rating calculations for underground cables that form part of the Ausgrid transmission and distribution cable network. This standard was created to enable underground cable ratings to be calculated in a consistent and transparent way.	Jessica Hui – Manager Reliability, Supply Quality and Ratings	Matt Webb - Head of Asset Investment
1	08/09/2021	Requirements for Native Soil test reports updated.	Jessica Hui – Manager Asset Investment Strategy	Matt Webb - Head of Asset Investment
2	30/09/2024	The main changes: <ul style="list-style-type: none"> Updated format with application table in Annexure A Changing the name to 'Cable Rating' rather than 'Underground Cable Rating' to encompass in air and other 'non-buried' installations of cables Clarification of where the standard applies, based on NS168, NS130 and NS159 Additional ambient and cable operating temperatures provided Changes to 'shall' and 'must' where applicable Removal of 'Ask Ausgrid' and changed to 'make a proposal and request Ausgrid approval' Simplification and removal of non-essential information. 	Ping Tan – Manager Transmission Planning	Murray Chandler – Head of Network Strategy and Future Grid
3	25/08/2025	Minor changes carried out to clause 2.2.2.15 and Annexure A	Ping Tan – Manager Transmission Planning	Murray Chandler – Head of Network Strategy and Future Grid

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Scope

This standard applies when required by:

- NS168 Design of 33KV, 66KV and 132KV Underground Cables,
- NS130 Laying Underground Cables up to and including 11kV, and,
- NS159 Installation of Cables and Conduits Using Trenchless Techniques

This Network Standard covers:

- The input and assumptions used by Ausgrid for cable rating,
- Where it aligns and deviates from IEC60287,
- The considerations for rating of Ausgrid's cables,
- The information Ausgrid will supply as part of rating Ausgrid assets, and,
- A summary of the requirements for a cable rating submission.

This standard is not intended to replace the use of appropriate cable rating software and is not to be used as a design tool.

This Network Standard must be interpreted alongside the Network Standards listed below. Where differences exist, Ausgrid must be contacted for clarification.

Reference Documents

All work covered in this document shall conform to all relevant Legislation, Standards, Codes of Practice and Network Standards.

Ausgrid Documents

NS001 Glossary of Terms

NS104 Specification for Electrical Network Project Design Plans

NS130 Laying Underground Cables up to and including 11kV

NS159 Installation of Cables and Conduits Using Trenchless Techniques

NS168 Design of 33KV, 66KV and 132KV Underground Cables

NS181 Approval of Materials and Equipment and Network Standard

NS204 Communication Pits – Specification and Installation

NS266 Telecommunications Cables in Ausgrid Premises

NS268 Specification for Design and Construction of Waterway Crossings

Other Standards and Documents

ENA Doc 001-2019 National Electricity Network Safety Code

IEC 60287 Electric cables - Calculation of the current rating

Acts and Regulations

Electricity Supply (General) Regulation 2014

Electricity Supply (Safety and Network Management) Regulation 2014

National Electricity Rules

Work Health and Safety Act 2011 and Regulation 2017

Clause Standard Requirements

1 Approach to Calculation of Ratings

- 1.1 All rating assessments of the Ausgrid network involving existing, proposed and future cables must include the following factors:
- Conductor Properties
 - Environmental Conditions
 - Installation Conditions
 - Proximity to Neighbouring Cables / Heat Sources
 - Operational Conditions
- 1.2 Rating calculations must be undertaken in accordance with IEC60287 and the requirements of this standard. These calculations are to be submitted to Ausgrid for review and subsequent approval.
- 1.3 Where rating calculations have been undertaken using CYMCAP rating software (the application presently used by Ausgrid) it is acceptable to provide the CYMCAP models with supporting reports instead of the detailed rating calculations.

2 Requirements for Ratings Calculations

The following are required for each cross section reviewed for cable rating calculations.

2.1 Conductor Properties

2.1.1 Conductor properties for all existing, proposed, and future conductors are to be as per the manufacturer's cable datasheet. These datasheets are to be provided to Ausgrid when submitting rating calculations for review.

2.1.2 The datasheets must include the following:

- cable cross section
- material and characteristics of each cable component; and
- the manufacturer's determined cable rating based on standard conditions.

2.1.3 For existing and future Ausgrid conductors where cable datasheets are not able to be sourced from the cable manufacturer, advice is to be requested from Ausgrid.

2.1.4 Maximum Permissible Cable Operating Temperature

2.1.4.1 Different maximum permissible operating temperatures are used based on different voltages, cable types, and installation. The maximum permissible cable operating temperature is found in Annexure A. For further information on maximum operating temperature refer to IEC60287 and the conductor manufacturer.

2.1.4.2 Further restrictions may be placed on the maximum permissible operating temperatures for cases where Ausgrid determines that existing, proposed and/or future cables are at risk of exceeding their maximum operating temperature as specified by the cable manufacturer.

2.1.5 Sheath Bonding Arrangement

2.1.5.1 To determine the sheath bonding arrangement for the proposed cable, refer to NS168 and NS260. For existing cables, the nominal cable sheath bonding arrangement for conductors on the Ausgrid network are outlined in Annexure A.

2.1.5.2 The bonding method must be clearly highlighted in the design and ratings report.

2.1.5.3 Cross bonded arrangements shall be modelled assuming minor sections are not known (as per IEC60287-1-1) to account for sheath circulating currents.

2.2 **Environmental conditions**

2.2.1 **Ambient Temperature**

- 2.2.1.1 The ambient temperatures in Annexure A are to be used when determining thermal ratings unless they are identified as a special case.
- 2.2.1.2 The temperatures in Annexure A apply to the entire ground or air temperature of the cross section being assessed, e.g., if the proposed cable is buried below 3000mm the whole ground ambient is treated as 22°C, not just the section below 3000mm.
- 2.2.1.3 For special cases, where temperatures are more variable, the Designer shall propose the temperature to be used as part of the rating assessment and demonstrate why it is appropriate and receive approval from Ausgrid. Special cases include (but are not limited to):
 - Tunnels
 - Troughs
 - Duct lines through buildings
 - Cables within bridge structures

2.2.2 **Thermal Resistivity**

- 2.2.2.1 All rating calculations shall be based on known thermal resistivity (TR) of the materials surrounding the installation.
- 2.2.2.2 All TR tests shall be undertaken in accordance with NS130 and NS168 and provided to Ausgrid when submitting rating calculations for review as described in the Design Information.
- 2.2.2.3 TR reports for native soil along the feeder route plan as well as all proposed bedding and backfill material (Ausgrid may request further TR testing be undertaken).
- 2.2.2.4 Refer to NS168 and NS130 for the TSB requirements.
- 2.2.2.5 Refer to Table 5 for standard bedding and backfill materials and their TRs. The use of a different TR value from Table 5 is permitted if it is supported by the relevant TR test reports.

Table 5 Standard bedding and backfills and their TRs

Installation Material	TR (K.m/W)	MC (%)
TSB	0.9	0
Grout	1.1	0
Road base	1.2	3
Concrete	1	0

2.2.2.6 **Bedding and Backfill**

- 2.2.2.7 TR of all bedding and backfill materials relevant to the rating calculations for the installation shall be based on measured TR from relevant TR test reports.
- 2.2.2.8 For existing cable installations in the absence of a TR test report or specific detail from the original installation contract for existing bedding or backfill, a proposal shall be made regarding the TR used for the calculation. Supporting evidence, or TR tests undertaken in accordance with Ausgrid Network Standards NS130 and NS168 shall be provided to Ausgrid when submitting rating calculations for review as described in the Design Information, to perform the ratings calculation.
- 2.2.2.9 All bedding and backfill materials shall be in accordance with the NS130 and NS168.
- 2.2.2.10 **Native soil (undisturbed)**
- 2.2.2.11 For new cables operating at voltages of 33kV and above, native soil TR sampling according to requirements outlined in NS130 and NS168 are required for ratings calculations. The thermal resistivity test locations must be shown on the cable route plan. Dry-out curves with sufficient

points to accurately define the Moisture Content (MC) vs TR relationship shall be included in TR test reports.

- 2.2.2.12 If a high TR test value is obtained that is significantly different to adjacent test locations, Ausgrid will require the use of the higher TR value for rating the conductor at adjacent test locations as well, unless further testing is completed for confirm otherwise.
- 2.2.2.13 Where a thermal resistivity test report is available the thermal resistivity value that corresponds to a moisture content of 3% on the dry out curve shall be used.
- 2.2.2.14 There are circumstances where it is appropriate to use a higher or lower MC than the standard 3%. Where a TR with an MC different to the standard is proposed to be used in calculations, supporting evidence must accompany the different MC proposed.
- 2.2.2.15 For existing cables and new cables with operating voltages of 11kV and below, a proposal shall be made regarding the TR used for the calculation. TR tests undertaken in accordance with Ausgrid Network Standard NS130 shall be provided as supporting evidence to Ausgrid when submitting rating calculations for review as described in the Design Information.

2.2.3 **Soil dry out and 50°C Isotherm modelling**

- 2.2.3.1 Soil dry out and 50°C Isotherm modelling shall be performed, if the 50°C isotherm around the cable is not fully enclosed within TSB.
- 2.2.3.2 The dry out curve shall be used to determine the appropriate TR for the MC. For further information on TR testing and dry out curves refer to NS130 and NS168.
- 2.2.3.3 Ausgrid assumes dry out will begin when the native soil is exposed to a temperature of 50°C.
- 2.2.3.4 Thermal stability shown via 50°C isotherm modelling shall be included in the ratings report.
- 2.2.3.5 The effect of dry out can be modelled, by assuming that the bedding, backfill and native soil within the 50°C isotherm (50°C isotherm is determined through modelling) will completely dry out and then use a fully dried value for the TR within this zone and TR at 3% MC, outside the 50°C isotherm (see Figure 1).

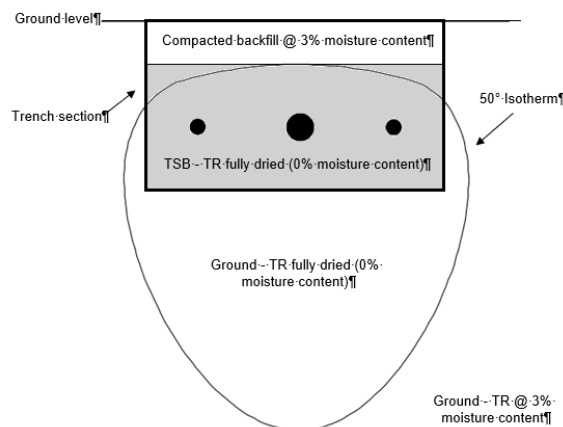


Figure 1: Three cables underground with an example of the 50°C Isotherm, TR within isotherm modelled as TR fully dried and TR outside isotherm modelled at 3% moisture. The bedding and backfill is specified as per NS130 and NS168.

- 2.2.3.6 The 50°C isotherm modelling is only required for the normal rating, not for the abnormally switched (emergency) rating.
 - 2.2.3.7 All areas within the 50°C isotherm in every trench in the cross section must be modelled as fully dry.
- 2.3 **Installation Conditions**
- 2.3.1 All rating assessments shall be submitted along with the proposed design. The designs shall be provided in .pdf and .dwg format.

- 2.3.2 Longitudinal sections of the proposed assets showing existing and proposed cover depth shall be provided.
- 2.3.3 **Cover Depth**
- 2.3.3.1 All cross sections at all depths, of any length, must be considered in the ratings assessment. Whenever possible, the horizontal spacing between cables or ducts must be increased when the cover depth is increased.
- 2.3.3.2 For works that would not ordinarily require a cable rating, that increase the cover depth of a cable (e.g., non-cable related construction works that incidentally increase the cover over a cable), a rating assessment is required.
- 2.3.3.3 TR testing is required for the section at cover depth according to NS168.
- 2.3.4 **Underbores**
- 2.3.4.1 For an underbore, a bore log shall be provided to Ausgrid that includes the following information:
- Bore hole samples taken down to at least the depth of the underbore,
 - Rock and soil layers present,
 - TR tests, or the proposed TR with justification and supporting evidence for each layer, and,
 - Water table depth if it was located.
- 2.3.4.2 Further TR testing by the customer, at the customer's expense, will be requested by Ausgrid if insufficient information is provided. Detailed design requirements for trenchless techniques are provided in NS159.
- 2.3.4.3 Ratings calculations shall include the TR of the grout. Grout shall be installed in accordance with NS159.
- 2.3.4.4 At locations where it is not possible to fully grout an HDD underbore, the rating assessment and design shall take this into account to ensure that the required cables ratings are met.
- 2.3.5 **Water Crossings**
- 2.3.5.1 For the rating of cables that cross a body of water, the method used and proposed inputs, with supporting evidence, must be submitted for approval.
- 2.3.5.2 Cables that traverse waterways are generally either laid direct on, installed in a shallow trench, or installed in a bore at a depth below the bottom of the body of water.

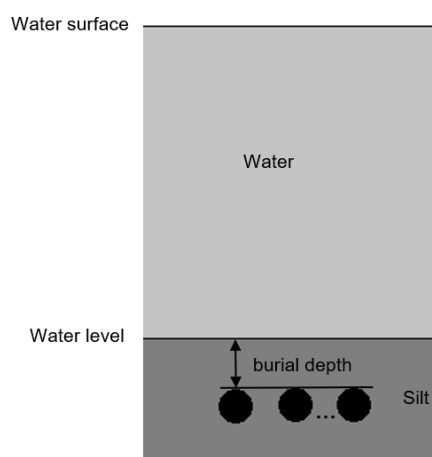


Figure 2: Three cables sunken into the silt when laid on the bottom of a body of water, showing the burial depth. Underbore depth is calculated using the same process.

- 2.3.5.3 Cables laid on the bottom of the body of water will sink into the silt; the depth of sinking is dependent on the nature of the bottom. To determine ratings of such cables (as well as underbores) it has been found satisfactory to regard these cables as direct laid, with the depth of burial being taken as the depth below the water level. The water level is defined as where the silt

meets the water at the bottom of the body of water (see figure 2). Ausgrid will review the proposed TR for the water crossing rating calculation (and reasons for using this TR) and determine if it is appropriate.

2.3.6 Cables in Air

2.3.6.1 Cables in air must be considered in the ratings calculation. This includes UGOHs (Underground-overhead connections) and cable risers, although these will often not result in the minimum rating for a cable if there is also an underground section.

2.3.6.2 For further information on cable in air design and spacing for negligible impact, see IEC60287 – Part 2 Section 2.

2.3.6.3 Ambient temperatures for cables in air are shown in Annexure A.

2.3.7 Trench Cross Sections

2.3.7.1 All ratings analysis and calculations must be supported by cross section drawings that show all dimensions with respect to relevant existing, proposed and future cables, ducts and bedding/backfill placement, as well as separation from existing Ausgrid assets or other heat sources.

2.3.7.2 The cross-section drawings must show the extent of encasement materials (bedding, backfill and native soil) and conduit material.

2.3.7.3 The cross sections must represent the locations that are expected to be the worst case thermally with respect to cable ratings.

2.3.7.4 The locations of all cross sections shall be clearly labelled on the cable route plan. If Ausgrid considers insufficient detail has been provided, Ausgrid will request additional cross sections.

2.3.7.5 The trench cross sections and route plan must include identification labels for each feeder to align with the connection diagram and ratings report.

2.3.7.6 For Certified Design/Design plan requirements refer to NS104.

2.3.8 Installation conditions that are not listed in this standard

2.3.8.1 For cables installed in conditions not described in this standard, the Designer must propose the methodology, assumptions, and inputs to be used, with supporting evidence as part of their rating assessment, for approval by Ausgrid.

2.4 Proximity to neighbouring cables or heat sources

2.4.1 Mutual Heating

2.4.1.1 The impact of mutual heating shall only be calculated from assets that are within 4m of the edge of the conductor for the length of the conductor, as opposed to the requirements of IEC60287, except where required by the Certified Design submission.

2.4.1.2 Where the edge of a cable or surface of a heat source is within 4m from the edge of the conductor, the impact must be assessed to ensure the ratings and the rating requirements of the existing assets are retained or reductions approved by Ausgrid, and that the new assets achieve the required rating. See section 3.4 regarding loads to be applied to existing Ausgrid assets.

2.4.1.3 Designs need to ensure the required ratings are achieved for the ultimate substation configuration (with mutual heating from future feeders and transformer cables considered) without the need for changes to in-service cables in the future.

2.4.1.4 Where spare conduits are installed along with the newly installed cables, the rating must include mutual heat of future cable installations. Ausgrid will determine the most appropriate conductor to be included in calculations for existing and future cables within 4m of the edge of the cable rating being assessed.

2.4.1.5 To address inclusion of the heat from future installation of 11kV feeders leaving a substation in the ratings calculation, Ausgrid may require a mutual heating factor be applied to the 11kV cables for the ratings assessment. A mutual heat factor reduces the maximum possible conductor temperature that is to be used in calculations for feeders near a substation. Ausgrid will provide the mutual heating factor if it is required for the rating calculation.

2.4.2 Cable Crossings

- 2.4.2.1 Cable crossings need to be included in calculations where the acute angle at the point of crossing is less than 45°.
- 2.4.2.2 Where cable circuits need to cross each other, the preferred crossing angle is 90° with a minimum vertical separation of 300mm.
- 2.4.2.3 Ausgrid will accept cables crossings between 45° and 90° (acute angle at the point of crossing) as being a 90° crossing and will not require mutual heating calculation for such constructions. In this regard, Ausgrid differs from IEC60287.
- 2.4.2.4 A crossing angle less than 45° needs to be justified and steps taken to mitigate the mutual heating impact at this location.
- 2.4.2.5 Where large duct banks (more than 4 ducts) or multiple feeders at 132kV (more than two) cross each other, further thermal overload mitigation strategies are to be used such as, a lower thermal resistivity bedding/backfill/TSB or increased horizontal spacing.
- 2.4.2.6 Ausgrid must provide approval of any mitigation strategy and supporting evidence for this strategy provided by the Designer.

2.5 Operational Conditions

2.5.1 Operational Ratings

- 2.5.1.1 Ausgrid must be contacted to determine the normal and abnormally switched (or emergency) configurations so the limiting case can be considered.
- 2.5.1.2 Ausgrid uses a summer and winter rating, and a normal and abnormally switched (or emergency) rating. The summer and winter rating use different ambient temperatures in the rating assessment (see 2.2.1). If only a summer normal rating is calculated, this will be applied to the summer emergency, winter normal and winter emergency ratings.
- 2.5.1.3 Normal and abnormally switched (or emergency) ratings shall be applied differently to different voltages and installations. The cable maximum operating temperature is the same, excepting transformer tails.
- 2.5.1.4 If a cable shares a trench, and all feeders are normally in service, the normal rating is the rating when all feeders are in service (or under load), while the abnormally switched rating is the rating when one cable is out of service (for maintenance or due to a fault), therefore, the mutual heat is reduced.
- 2.5.1.5 If a cable shares a trench with a standby feeder (with no load) the normal and abnormally switched rating would be the same (as the standby feeder would be in service if any other feeder was out of service).
- 2.5.1.6 The abnormally switched (emergency) rating for transformer tails can be applied under firm rating (N-1) conditions, that is, when a transformer is out of service due to maintenance or a failure. The emergency rating can be used for the duration of the emergency.

2.5.2 Continuous Versus Cyclic Ratings

- 2.5.2.1 Unless otherwise stated, cables shall be rated as continuous, this allows for a future change in the load profile.
- 2.5.2.2 Ausgrid will advise if a load cycle is to be applied in ratings calculations.

3 Maintaining Asset Ratings

- 3.1 New connections that are within 4m of the edge of existing Ausgrid assets works must ensure the thermal influence of the new connection is mitigated sufficiently to ensure that the rating requirements of the existing section of network is maintained.
- 3.2 A 'Rating to be Maintained' (**RTBM**) must be submitted and approved for all Ausgrid Assets that are within 4m of the new connection or other relocation works would de-rate an existing Ausgrid asset. Ausgrid will review the ratings of the entire asset when determining whether the de-rate is acceptable.

3.3 Ratings to be Maintained

- 3.3.1 An RTBM must be provided for the rating of Ausgrid's existing and future assets (all cables and conduits, including out of service cables, with a status other than abandoned) that are affected post commissioning of the proposed asset. An RTBM is a 'before and after' assessment of the proposed configuration. It shows the effect of the proposed assets on, and potential de-rating of, any Ausgrid assets. Ausgrid will provide feedback if the proposed 'before' loads are not correct.
- 3.3.2 Where a conduit is expected to carry a future cable, Ausgrid will specify the assumed cable details.

4 Ratings Software

- 4.1 Ausgrid uses CYMCAP software to perform ratings analysis. Where other software or models are used, sufficient detail of the model needs to be provided to enable verification of the ratings study by Ausgrid in CYMCAP. CYMCAP models can be submitted as a form of ratings calculation.
- 4.2 The data from CYMCAP or an alternative ratings software, provided by the Designer, must include exports and cross sections of the results to enable Ausgrid to review the rating calculation in accordance with IEC60287.
- 4.3 All individual cable models must be formally verified against the manufacturer's data sheets for the cables, regardless of the ratings software used.

5 Summary of Ratings Requirements

5.1 Cable Ratings – Ausgrid Design Review Requirements

- 5.1.1 The following list of requirements is to be used in conjunction with and attached to all electrical designs associated with cable ratings prepared by the Designer. Refer to NS104 for the certified design/design plan requirements.
- 5.1.2 Submission to Ausgrid shall include the following:
- Rating calculations, in the form of a CYMCAP model (database file) or other model that meets IEC60287 with version details. The calculation must include the following, Thermal Resistances (T_1 , T_2 , T_3 and T_4), Losses (W_c , W_d , W_s , W_A , λ_1 , λ_2) and Resistances (R_o , R , y_s , y_p) as defined by IEC60278,
 - Report summarising results from the ratings model and outlining the ratings methodology used (where there is a departure from the IEC60287 methodology). The report must include,
 - 1) Assumptions used in the ratings assessment (incl. use of worst-case parameters in lieu of available data) and justification of these assumptions.
 - 2) Loadings considered for ratings scenarios
 - 3) Any cable temperature violations that arise in the ratings model
 - 4) Cross sections of each case considered and shown
 - 5) Justification for any cable parameters in the rating assessment model that are not derived from the manufacturer's data sheet, such as appropriate 'averaging' of layers used where there is mismatch between the data sheet and the available layers in the model, and,
 - Certified Design/Design plan including detailed cross sections, (see NS104 for requirements)
 - Verification of cable models – see section 4 and manufacturer's cable data sheets.
 - Native soil TR test results (including TR dry out curves) shall be submitted to Ausgrid no later than six (6) weeks after sampling via TR_and_TSB_results@ausgrid.com.au for incorporation into Ausgrid's database.
 - Test certificates for all engineered bedding and backfills shall be submitted to Ausgrid as specified in NS130.
- 5.1.3 A 'Rating Assessment Submission Template (NS272)' can be found via the link below:
<https://www.ausgrid.com.au/ASPs-and-Contractors/Network-design>

Annexure A

A1 Reference table for the application of NS272 to various cable installations.