NSP/004/112 - (OHI 12) Guidance for the Inspection and Testing of Wood & Steel Poles

1. Purpose

The purpose of this document is to provide guidance on the inspection, testing, recording and classification of wood & steel poles for use on the Northern Powergrid Distribution System.

This document supersedes the following documents, all copies of which should be destroyed.

Document Reference	Document Title	Version	Published Date
NSP/004/112	(OHI 12) Guidance for the Inspection and testing of Wood & Steel Poles	4.0	June 2019

2. Scope

This document includes details on the inspection, testing, recording and classification of wood & steel poles. In addition, it provides guidance on the precautions to be taken prior to ascending wood poles.

The Inspection techniques detailed within this document are based around the best practise for testing of wood poles, ENA ER L9 - "*Structural testing of wood poles prior to climbing or use as a personal support*"

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3. Technical Specification

3.1. Testing of Wood Poles Before Climbing

Before a pole is climbed or relied upon for personal support, it is the duty of the person who is to climb the pole to verify that the pole is in a safe condition to climb. Sound external appearance does not necessarily mean that a pole is safe. Poles showing any signs of damage, significant decay or weakness as identified in this guidance note shall not normally be relied upon for personal support.

The following tests shall be applied to all poles before they are climbed:

a) Visual Examination

b) The HAMMER test, which consists of striking the pole a sharp blow.

c) The PRODDING test, which consists of prodding or probing the surface with the point of sharp tool.

d) ADDITIONAL EXPLORATION TESTS for possible below ground level decay on Specified Increased Risk Pole Categories

The condition of the pole shall be classified as follows, according to the symptoms indicated:

Condition	Test	Symptom
Safe	Visual	No damage
	Hammer	A good ring
	Prodding	No decay
Unsafe	Visual	Pole damaged or structurally unsafe
	Hammer	Very hollow sound (all round pole)
	Prodding	Prodding decay to a single depth point of >=50mm or when tested all around the pole >=12.5mm
	Decay level assessment test	CR4 or CR5 categorisation of the pole from any decay level assessment test e.g. Thor Hammer or Resistograph

<u>To ensure the safety of our staff, poles that fail any of the tests detailed in clause 3.1.2 (a-d) or without any pole age identifier must be identified with a 'D' notice as shown on Drawing Number 1091010228 and not climbed until the actual level of decay and remaining residual strength have been confirmed.</u>

<u>See clause 3.2 for further guidance on decay assessment, poles with residual strength levels of less than 70% shall be supported in accordance with clause 3.9 before being ascended or accessed using other non-climbing means e.g. MEWP's</u>

Note

It shall be noted that whilst a MEWP is the preferred method of gaining access to a suspect or decayed pole, the work that can be safely carried out from the MEWP is restricted to that which will not create any significant changes in mechanical loadings or changes in conductor tensions unless the pole has been supported or stayed against those forces.

If the tests taken as required by clause 3.1 indicate that the pole is safe to climb, then the linesman may climb as required for the work he is there to undertake. During the climb, ongoing attention should be given to the condition of the pole and further hammer tests made if considered necessary.

To correctly categorise the condition of a pole suspected of having decay for its suitability for continued use, the pole shall be subjected to a detailed test procedure using one of the decay level assessment test devices as detailed in Clause 3.2.1.

However where a test as described in clause 3.2.1 has not been carried out, a Condition Rating shall be assigned based on the results of the tests (a) to (d) in clause 3.1 as follows; a pole <5 years old that passes all tests will be assigned a CR1, a pole >=5 years old that passes all tests shall be assigned a CR2, a pole that fails one or more of tests (a) to (d) shall be ascribed a CR4, pending the results of a decay level assessment test) unless that pole has decay/damage that warrants a 159 report being raised – in which case it shall be assigned a CR5. Further details on the condition rating of poles can be found in the table in clause 3.3.

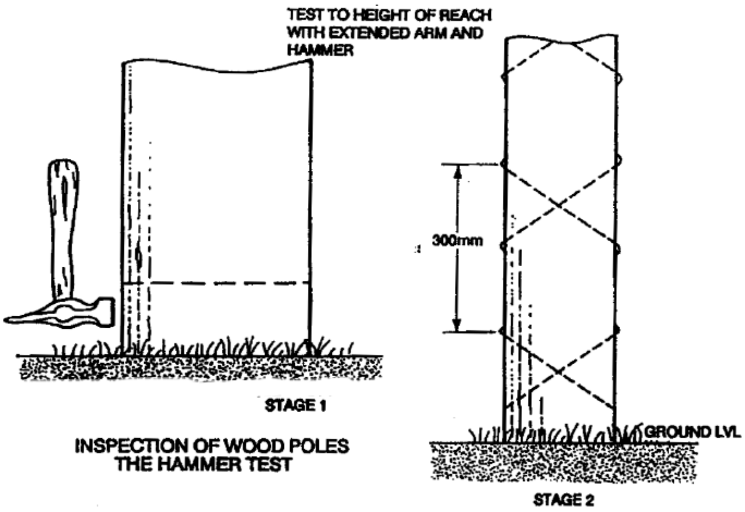
3.2. Routine Inspection and Testing of Wood Poles in Position

a) Visual Inspection

Poles shall be inspected visually from the ground over its entire length above ground for: -

- A sign of decay, such as wet crumbly wood, 'D' labels, fungal growth, or evidence that suggests the pole has been "PURL" tested, i.e. nails at ground, 1M and 2M levels.
- Where a pole is encountered with an existing 'D' label, this pole shall be re-tested above and below ground level using a decay level assessment device as detailed in clause 3.3 before any existing label may be removed or its status amended.
- Signs of damage or weakness, caused by Woodpeckers, vehicles or farm machinery, excessive animal rubbing. The bending strength of a pole is proportional to the cube of the diameter so particular attention should be paid to external decay or the effect of cattle rubbing on the pole which results in a reduction in the diameter. It is recommended that creosoted laggings be fitted to prevent cattle rubbing where this has occurred previously.
- Signs of splitting or cracks. Many poles suffer from large cracks due to drying out; these are not detrimental except that they may expose the untreated sapwood and heartwood.
- Fire Damage. Evidence of Pole top fire damage or burn marks adjacent to earthed steelwork lower down the pole are normally indicative of damaged insulators or insulation on pole top equipment resulting in leakage current through the wood down to ground. Damage of this type must be reported to Network Control immediately to allow the line to be made dead before any further work or contact with the support.
- Damaged insulators or steelwork. If the insulators are damaged the line must be made dead before any further work or contact with the support.
- Signs that suggest the pole may not be stable, such as recent excavations around the pole, dikes or trenches nearby, or the gouge mark/disc high above the ground suggesting the pole may not be planted to the correct sinking depth. In some cases, although relatively rare, poles may be found without any pole gouge marks or year of manufacture indications (it was not mandatory to provide a gouge mark before 1954). Where these circumstances are identified, the pole shall not be climbed without either supporting it in accordance with clause 3.9 or accessing it with a MEWP. If neither alternative system is appropriate due to the location of the pole then the pole shall be programmed for replacement.
- During a line inspection a note should be taken of any poles which are buckling or which have their pole head greater than two pole head diameters out of true. This sometimes occurs on 'light' poles fitted with 'tee off' stays etc. A pole buckling under normal conditions will break during heavy loading and should therefore be programmed for replacement if the buckling is due to load and not just a deformed pole.
- Poles located in dense vegetation such that the base of the pole cannot be accessed and inspected shall be reported to Vegetation Management to clear the obstructions allowing a proper inspection to be carried out.
- Poles located in areas of permanent standing water shall be recorded with a view to relocating the pole outside the affected area as the integrity of these poles cannot be guaranteed and access may not always be possible depending on the depth of the water.
- Signs that suggest a pole(s) may be suffering from pole top decay. This may be indicated by signs such as grass or other vegetation growing out of the pole top or a wet looking patch near the pole top. Overhead line routes subjected to helicopter inspections shall be vigilant for this type of issue as it will often be more prominent from this viewpoint.

b) Hammer Test



Strike the pole with a 2lb hammer and listen to the sound produced. The pole shall be struck with a series of sharp, but moderate blows with the hammer, listening for a good ringing sound as the hammer strikes the poles indicating solid timber. Sounding should commence at ground level and continue around the circumference at not more than 25mm spacing. Repeat the process spirally round the pole at vertical spacing of not more than 300mm to a height of normal reach is achieved. A change in tone will be heard when the hammer passes from sound to decayed wood.

A dull or dead tone indicates external or slight internal decay whilst a hollow note indicates extensive internal decay. Any areas of wood identified as suspect during the hammer test must be prod tested. Note this test will rarely identify below ground level premature pole shell rot on AC500 treated poles, hence they shall automatically be subjected to the additional below ground level exploration tests.

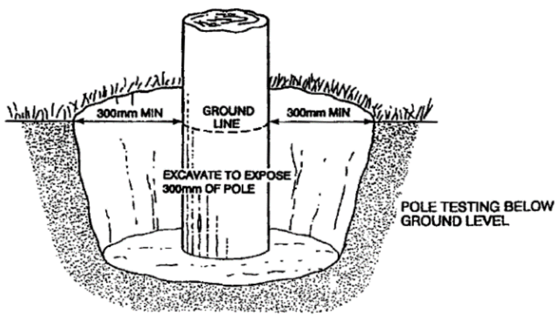
c) Prodding Test

Prodding the surface of a pole with the point of a sharp object, such as a bradawl or a long thin bladed screwdriver with the tip ground to a sharp bit will give an indication of any decay near the surface of the pole. The test shall be carried out at intervals around the pole immediately above the ground and at points of suspected decay. An indication that the pole is sound is given by the prodding test being resisted by firm fibre (neglecting shakes in the timber). Decayed wood will offer little resistance to the insertion and withdrawal of the sharp object. Prodding the pole with a screwdriver at a 45° angle to the pole just below ground level without excavation may indicate the presence of below ground level deterioration not previously evident from the above ground tests. Where deterioration is suspected at or below ground, then the pole shall be subjected to the additional below ground level exploration tests.

d) Additional Exploration Tests for possible below ground level decay on Specified Increased Risk Pole Categories

i) AC500 treated LV poles installed in the period 2007 – 2014

ii) Poles >50 Years Old



Any poles that fall into this category shall not be climbed unless the pole has been subjected to a below ground line inspection to check for any signs of hidden decay below the ground line. This shall typically involve the area surrounding the base of the Pole being excavated to a depth of 300 mm, and the section of pole exposed tested using the normal above ground line tests.

The requirement for mandatory below ground line inspections applies equally to foot patrol inspections and where a support will be relied upon for personal support activities.

As an alternative to excavating around the base of the pole for example where the pole is located in an area with "finished ground" and this test would involve complicated excavation and re-instatement works, it is permissible to use the "Thor Hammer" or a "Micro Drill Resistograph" tester applied at a 45° angle into the pole at ground level.

Notes

The "Thor Hammer" is the preferred instrument to be used as part of routine pole inspections as this device is capable of testing the pole both above and below ground level in a single test applied from an above ground position.

AC500 treated LV poles - installed between 2007 and 2014 have been found to suffer from sapwood / outer shell decay below ground level caused by a premature failure of the protective treatment system for poles installed in this period. As such this form of decay is rarely identifiable using the standard above ground level hammer test.

As a general rule the use of AC500 treated poles ceased after 2014 with the exception of new or replacement poles installed near schools, parks and playgrounds where the REACH regulations do not allow the placement of Creosote treated poles.

Any doubts about the integrity of pre- 2014 treated AC500 treated poles located in the vicinity of these high-risk sites shall result in the pole being replaced with a new AC500 treated pole (installed in a protective pole liner) or with a non-creosote based equivalent pole. AC500 treated poles installed post 2014 do not suffer from the same high levels of premature below ground level rot due to changes in the treatment retention levels after this date.

Poles >50 Years Old

It is recognised within the industry that poles shortages in the periods 1939 to 1945, and during the rural electrification period of the 1950's resulted in inadequate pole seasoning prior to the application of preservative treatments. As a result, poles installed in these periods may have a higher incidence of below ground level decay similar to that detailed for AC500 as such we have decided to apply the same enhanced below ground level inspection activities to be applied to all poles greater than 50 years old.

3.2.1. Decay Level Assessment and Approved Test Devices

Decay of pole timber is mainly caused by fungal attack at ground level or below where soil can readily contribute fungi and destructive bacteria. Moisture which is vital for the development of the fungal spores is present in the wood cells for considerably longer periods at ground level than above and hence it is here that the pole will be most intensely attacked.

The residual strength of a pole affected by decay depends not only on the extent of the decay, but also on its position in the pole. For example, decay in the centre of a pole with a substantial sound outer ring reduces the strength by a negligible amount whereas conversely decay or damage in the outer ring of a pole significantly impacts its remaining residual strength. It is sometimes difficult to decide whether identified decay is sufficiently extensive to necessitate pole changing. To assist with this assessment process in terms of the remaining residual strength, then the effected poles shall be subjected to a series of further tests using an approved test device. Currently the Northern Powergrid approved tests devices include the "Thor Hammer", the Micro Drill "Resistograph" and the "PURL Tester" each used in conjunction with their associated software assessment packages.

Information on the correct use of these test devices can be found in Appendices 1-4.

3.3. Condition Rating of Wood Poles and Urgency for Replacement

Where poles are inspected as part of the MNT/004, foot patrol inspection requirements, the poles shall be condition graded using the condition rating table below for inclusion into the company's asset condition register.

Condition Rating	% Residual Strength Value (RSV)	Condition Description	Comments
1	100%	Good Hammer Ring - No signs of decay or damage - generally assigned to a new or recently replaced pole	Pole OK to be retained and climbed
2	99% - 90%	Good Hammer Ring - Minor visual damage or slightly reduced residual pole strength but within acceptable tolerances	Pole OK to be retained and climbed
3	90% - 70%	Increased level of visual damage or the reduced residual pole strength is no longer within acceptable tolerances without the need for additional monitoring. Normally associated with early pole decay or loss of pole fibre strength	Poles are still fit to be climbed; however, the poles shall be re-scheduled for a re-inspection in 5 years. (However, where poles are being tested as part of a line refurbishment scheme, then the pole should either be retrofitted with a pole support system to provide a minimum of 10 years life extension or be entered into a pole replacement programme rather than being entered into a re-inspection programmes).
4	70% - 60%	Increasing level of visual damage or continued reduction in residual pole strength. Unacceptable level of pole residual strength or damage, pole requires replacement.	Poles shall be identified with a 'D' notice and can no longer be climbed. The pole shall be placed into a pole replacement programme and be prioritised based on the RSV result and criticality of the pole.
5	<60%	Severely decayed or damaged pole – *Generally poles in this status will be reported through the 159 scheme to ensure timely replacement.*	Poles shall be identified with 'D' notice, not safe to climb and must be removed off the system, the replacement shall be prioritised based on the RSV and criticality of the pole.

- Where a decay assessment test as described in clause 3.2.1 has not been carried out to provide a %RSV rating, then a Condition Rating shall still be assigned but instead based solely on the results of the tests (a) to (d) in clause 3.1 as follows; a pole <5 years old that passes all tests will be assigned a CR1, a pole >=5 years old that passes all tests shall be assigned a CR2, a pole that fails one or more of tests (A) to (D) shall be ascribed a CR4, pending the results of a decay level assessment test unless that pole has decay/damage that warrants a 159 report being raised – in which case it shall be assigned a CR5.
- Where practicable the results from the decay assessment devices shall be analysed and the pole condition graded accordingly before leaving site, thus allowing any incorrectly previously applied 'D' notices to be removed from healthy poles, or new 'D' labels to be applied to unhealthy poles. However, where this is not achievable the recordings shall be returned to the supervising engineer to enable residual strength calculations to be carried out and a further visit planned to remove or install the required warning labels.

During any activities, poles identified to present an immediate risk to safety or network integrity shall be reported via the 159 scheme to allow tracked and timely intervention.

Notes:

Where poles are inspected as part of the preliminary works stage of an overhead line rebuild or refurbishment program, ahead of the main site works (which often happens at least 12 months ahead of any proposed site works) this may result in the identification of severely decayed poles and a dilemma as to whether the pole should be replaced immediately upon discovery or delayed until the main site works.

Such poles shall be subjected to further risk assessment to quantify the risk of temporarily leaving the decayed poles on the system until the main scheme starts. Poles may be retained in situ providing they have not been identified as CR5 poles, are not located adjacent to high-risk sites as defined in MNT/001/004 and are fitted with 'D' notices to stop further climbing activities. In carrying out this risk assessment to decide upon the level of immediacy for replacement, a higher level of risk must be applied to those sites where multiple decayed poles are found adjacent to each other as the consequences of failure at such a site will substantially increase the return to service period under fault conditions. Where information about a line's future up-rating requirement is not known, the replacement poles shall be replaced with stout grade poles of the equivalent height as a default.

3.4. Testing Cobra Treated Poles with Aluminium Bandages

The Cobra treatment process was a post installation site treatment that was claimed to increase the pole life by a further 10 years. The treatment involved injecting a bonded mixture of Sodium Fluoride, Dinitro-Phenol and Arsenous Acid into the pole using a hollow needle. The Injections were applied 300mm above and below the groundline. Poles treated with this process where then protected with an Aluminium Bandage to stop livestock licking the treatment and to aid the future identification of treated poles.

Cobra treated poles shall be tested as follows:

- Carry out the standard inspection tests as detailed in clause 3.1.2 a-d (If the pole is being tested with the Thor Hammer it may be tested in the usual way but with all tests carried out above the bandage).
- Otherwise excavate around the pole to just below the bandage (approx. 150mm) and without removing the bandage, test the pole for indications of decay using the Purl Tester or the Micro drill, Resistograph. (The transmitter may be applied to the pole above the aluminium bandage. The receiver shall then be placed at points around the circumference of the pole below the bandage to check for signals)
- Provided signals are received in all locations or the Microdrill does not identify any suspect areas, the bandage can be retained in position.
- If no signal is obtained in any location, the bandage shall be removed and the degree of decay diagnosed in the normal way.
- After testing, the existing bandage shall be replaced back into its original place.

3.5. Boron Rod Treated Poles – Identification and Replacement

In the early 1990's a program of pole treatment with Boron Rods took place on the Northern Powergrid network. It is estimated that circa 60,000 poles were treated in the Northeast licence area and 1,000 poles in the Yorkshire area.

Poles previously treated with Boron Rod preservative treatment are identifiable by a series of 3 or 4 (depending upon the pole grade) plastic 12mm angled plugs inserted at the base of the pole together with a last treatment date label. Once boron rod treatment has been applied to a pole its application shall be re-applied on a 10 -12 year repeat cycle. Re-application of the rods shall be achieved by removing the previous plastic plug and re-inserting the rods. Due to the current restriction on the use of Boron Rods, then Boron Paste may be injected into the holes as an alternative, it is estimated that a typical 400ml tube of paste will protect on average 6 poles.

Care must be taken when re-inserting the plastic plugs into the holes to ensure that it achieves a tight fit. Failure to do so will result in the plug being ejected from the hole as the paste will expand when it gets wet forcing the treatment out of the hole instead of into the pole, and thus negating the protective benefits given by the Boron.

Note – where a pole has been identified as a CR3 support due to its %RSV and goes into a new 5-year repeat inspection cycle, then the pole should still be treated with boron rods or boron paste to minimise the decay process in the pole.

3.6. Poles Suspected of being Subjected to Shock Loading

Poles suspected of being subjected to shock loading (i.e. pole or stay being struck by a vehicle, conductors being struck by falling trees or substantial tree limbs, poles where some but not all conductors have snapped and the remaining conductor will be unbound to effect repair) must be approached with caution.

In these circumstances the suspect pole shall be checked by applying leverage by means of a guy rope attached near the top of pole. The guy rope should be attached from the ground by means of J & P rods fitted with a positive grip head attachment and a guy rope applicator as shown on Drawing No 1091450203. The rope should be long enough and the staff pulling on it so placed to preclude any danger should the pole being tests collapse. If, following this test, the pole is still suspect, then before it is climbed temporary stays shall be attached. The stays should be attached to the pole by means of the guy rope applicator as shown on Drawing No 1091450203.

If it is not practicable to carry out the check outlined above because of the pole arrangement, i.e. an existing stay, the ground around the base of the pole shall be excavated to a depth of 600 mm and the section of pole thus exposed cleaned and visually inspected. If no signs of fracture are visible, hammer and prod tests should be applied to the exposed area. Only after all three tests have indicated that the pole is sound may it be climbed having first backfilled the excavation at the base of the pole.

Tests which indicate that the pole is unsound must be reported to a supervisor and fitted with a D label as shown on Drawing Number 1091010228.

3.7. Reinstated Poles using Retrofitted Pole Support Systems

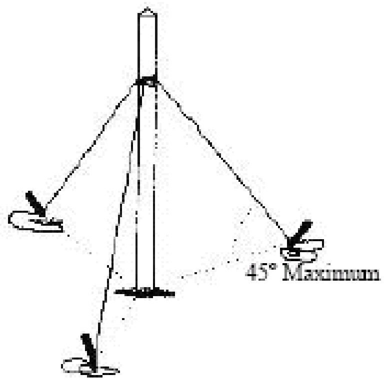
Retrofit pole support systems are now available whereby an existing damaged or decayed pole may be strengthened in situ. These systems are ideal for repairing and extending the life of an existing decayed or damaged support, especially where these issues occur on only 1 leg of a multi legged support or supports carrying HV or EHV cable terminations. Northern Powergrid assessed systems are capable of returning a sub-standard support back to its original support capability and as such a repaired pole shall be deemed to be fit for climbing and use on the network for 10-20 years from the date of installation providing that the following additional checks are made: -

- The “Multi-Tube Repair Splice” **or equivalent Northern Powergrid assessed system** has been inspected for obvious damage or deformation that may have occurred due to vehicular or farm equipment damage. Deformation could also occur due to stress loading following severe weather. If either case is observed the “multi-Tube repair splice shall be replaced.
- The Multi-Tube is 2400 mm in length with 1200 mm of exposed tube above ground level. A tolerance of +/- 150 mm from the 1200 mm will be accepted due to typical backfill and ground conditions.
- Ensure that no cables or earth wires are obscured or interfered with by the installation of the system.
- Confirm that the multi-Tube is pulled up as close to the pole as possible
- The Multi-Tube repair splices can be fastened to the pole with either M20 bolts or steel straps and a tensioning buckle. When the Multi-Tube is fixed to the pole with bolts, ensure that the wood surrounding them is free from decay and that the wood between the top and bottom restraining bolts is sound.

3.8. Making a Suspect Pole Safe to Ascend using Guy Ropes:

- Pole's that show minimal signs of damage or decay can be made safe to ascend by securing the pole with guy ropes after which only one person may ascend.
- Using a MEWP, or rope support and live line tapping rods, secure a minimum of three preferably four guy ropes to a point at least two thirds up the pole.
- Install bars, or ground anchors, a distance of at least the height of the ropes away from the pole. These anchors must be positioned equally around the pole. Remember to check for underground apparatus before knocking in the bars.
- Secure a guy rope to each anchor, take up the tension in all the ropes at the time and tie off securely.

Example using three guy ropes.



3.9. Assessment of Steel Poles

Corrosion of steel poles is generally concentrated around ground level, at the joints where the pole changes diameter and at collar positions.

Note

It will be necessary to excavate 100mm below ground level (to the top of the concrete foundation) to carry out these tests correctly, being observant for signs of previous changes in ground level. Upon completion of the testing and before the excavated area is re-instated, the exposed below ground area and the area up to a height of 300mm above ground level shall then be repainted with a single coat of Black micaceous oxide paint

Where cement weather seals are encountered, these shall be removed to allow a proper assessment of the pole to be carried out.

The opportunity shall be taken while this testing is taking place to ensure that all steel poles are effectively earthed. For further guidance in this area see NSP/004/041 clause 3.7.2

3.9.1. Condition Rating of Steel Poles and Urgency for Replacement

Condition Rating	% Residual Strength Value (RSV)	Condition Description	Comments
1	100%	No signs of damage or rust - generally assigned to a new or recently replaced pole	Pole OK to be retained and retested on standard 10-year Frequency
2	99% - 90%	Minor visual damage or evidence of surface rust but within acceptable tolerances.	Pole OK to be retained and retested on standard 10-year Frequency
3	90% - 70%	Increased level of visual damage or / the reduced residual pole strength is no longer within acceptable tolerances without repeat monitoring.	Poles OK to be retained, however the inspection frequency shall be amended to every 5 years. (Where poles are identified as part of a line refurbishment scheme, then they shall be planned for automatic replacement rather than being re-inspected every 5 years
4	70% - 60%	Severe loss of steel section Increasing level of visual damage. Unacceptable level of pole residual strength or damage, pole requires replacement.	Pole to be Marked with a Red D label The pole shall be placed into a pole replacement program and be replaced within a minimum of 5 years.
5	<60% or hole in pole	Hole in pole or evidence of pole buckling at Joints – *Generally poles in this status will be reported through the 159 scheme to ensure timely replacement.*	Pole to be Marked with a Red D label The pole to be removed off the system within 6 months.

Notes

Corrosion of steel poles is generally concentrated around ground level, at the joints where the pole changes diameter and at collar positions.

It will be necessary to excavate 100mm below ground level (to the top of the concrete foundation) to carry out these tests correctly, being observant for signs of previous changes in ground level. Upon completion of the testing and before the excavated area is re-instated, the exposed below ground area and the area up to a height of 300mm above ground level shall then be repainted with a single coat of Black micaceous oxide paint.

Where cement weather seals are encountered, these shall be removed to allow a proper assessment of the pole to be carried out.

The opportunity shall be taken while this testing is taking place to ensure that all steel poles are effectively earthed. For further guidance in this area see NSP/004/041 – "*Code of Practice for the Construction of LV ABC Overhead Lines*" clause 3.7.2

Further detail on the use of reporting poles through the 159 scheme – "This is where network assets are deemed to place the safety of the public or the integrity of the network at risk, they shall be reported via the 159 scheme to allow a tracked timely intervention to be carried out.

3.9.2. Inspection Procedure for Steel Poles

- Carry out a site-specific risk assessment
- Carry out an overall visual safety examination of the pole AGL (Above Ground level) for signs of damage or distress recording the following details: -
  - Pole Asset ID Number
  - Pole site ID No.
  - Pole Class (using chart in clause 3.10.5)
  - Base circumference
  - Base diameter
  - Pole manufacture date if marked
  - Assign a corrosion HI to the pole (worst remaining thickness value) , noting any particular issues like holes or damage
  - Where possible record the number and size of conductors attached to the pole i.e. 4 x .05" HDBC, 120mm ABC
- Record condition photos of the pole, a min of three photos showing the following: -
  - An overall photo of the pole showing its pole type i.e. inter, angle or terminal and equipment located on the pole
  - A photo showing the condition of the Pole safety signage and pole number
  - Condition Photo(s) of the pole base area (if holes are present in the pole, then provide an extra photo to allow the location of the hole to be orientated on the circumference of the pole to allow the immediacy of pole replacement to be assessed).
- Determine the pole reference thickness – see detail below for details
- Determine the pole thickness at the 1.5m test height and compare this against the ref thickness to assess the loss of thickness at this point
- Determine the pole thickness at GL (Ground level) test height and compare this against the ref thickness to assess the loss of thickness at this point.
- Determine the pole thickness BGL (below ground level) by excavating to a point just above the concrete foundation (normally 75-80mm below GL. (**This test shall only be carried out if the pole appears to be sound at ground level** i.e. no visible holes in the surface of the pole).
- All data to be recoded in a spreadsheet and indexed via the asset ID number.
- Repaint the BGL area with a single coat of Black micaceous oxide paint (YF602 Black Brush Coating) to a level of 300 mm AGL – Cat 342568
- Touch up any poles with paint where the paint has been removed with the grinder with a paint colour similar to the original paint (normally Green Micaceous Iron Oxide Paint) see NPS/001/021 for details – cat number 342597
- Make good the excavated ground around the pole circumference

Further guidance notes / descriptions

Test Value	Comments
Assessment of Pole Class	A pole class assessment shall be taken at each pole to assign the pole into one of the historical pole class groups as detailed in the "decision table for the assessment of steel poles" in clause 3.10.5. This assessment shall be taken in conjunction with the pole reference thickness tests to determine the best fit to the original class descriptions.
Pole Reference Thickness	Several ultra-sound test readings shall be taken at chest height to determine the average steel thickness of the pole in its bottom section. The tests shall be applied at several points around the poles circumference to identify an area that is deemed to offer a representative value of the pole original steel thickness. These measurements shall be carried out on points of the pole surface where the pole appears to be in sound condition.
1.5m Height tests	4 ultra-sound test values A, B, C & D shall be recorded at a level circa 1.5m from the pole base. The pole shall be scraped of rust and pitting at the selected point to ensure an accurate reading. Where necessary a mini portable hand grinder may be applied to assist in this process taking care to not excessively damage the integrity of the pole. These results shall be compared against the original pole reference thickness value to determine the % remaining thickness.
Pole base AGL tests	4 ultra-sound test values A, B, C & D shall be recorded at the base of the pole. The pole shall be scraped of rust and pitting at the selected point to ensure an accurate reading. Where necessary a mini portable hand grinder may be applied to assist in this process taking care to not excessively damage the integrity of the pole. These results shall be compared against the original pole reference thickness value to determine the % remaining thickness.
Pole base BGL tests	4 BGL (Below Ground Level) test values A, B, C & D shall be recorded at the base of the pole. The pole shall be scraped of rust and pitting at the selected point to ensure an accurate reading. Where necessary a mini portable hand grinder may be applied to assist in this process taking care to not excessively damage the integrity of the pole. These results shall be compared against the original pole reference thickness value to determine the % remaining thickness. Note this test is not required if any visual signs of holes in the pole are observed.
Orientation of test points	To enable future pole test comparisons to be carried out, all tests shall be carried out in a clockwise sequence and 90° apart starting at point A and moving round to point D. Point A shall be located at a point on the pole directly below the conductors with the operators back towards the lower pole numbers in the overhead line route.
Condition Rating based on assessment of remaining Steel Pole thickness	The worst % remaining thickness reading shall be compared with the reference thickness value to determine the poles "as found residual strength. See clause 3.8.1 for a summary of the assigned condition rating against the original thickness
Asset ID	The asset ID number of each pole shall be appended to the pole observation data

3.9.2.1. Approved Ultrasonic Thickness Tester

Meritronics Digital Ultrasonic Thickness Meter used in conjunction with the UCA-2 couplant or a DMV UK, MT600 Multi-mode Ultrasonic thickness gauge with associated couplant.

3.9.3. Painting Requirements for Steel Poles

The visual inspection of the pole will indicate the need for painting. Repainting should be carried out before the existing coat has completely broken down, but it is anticipated that this will generally be undertaken on a 20-year cycle. Steel poles shall be painted with a two-coat paint system generally in accordance with MNT/001/004 – "*Technical Specification for Tower Painting using paint systems"* in accordance with NPS/001/021 – "*Technical Specification for Overhead Line Tower, Steel Pole and Substation Plant Paint Systems"*. The colour of the finishing coat may vary depending on local authority requirements.

Modern galvanised steel poles supplied in accordance with NPS/001/018 are provided with a 120 Micron layer of galvanising providing them with a protective coating for a minimum of 30 years before the galvanising layer is damaged. As such poles of this type do not require testing with the Ultrasonic testing device until their 30th anniversary.

3.9.4. Steel Pole Manufacturing Dates

The manufacturing date shall be marked on modern galvanised steel pole at the pole depth mark. Where this is missing then the poles shall be treated like traditional painted poles unless other collaborating evidence exists to confirm the true age of the poles.

3.9.5. Ultrasonic Testing of Steel Poles

Decision table for the identification of Steel Poles												Calculated Minimum Thickness values for each condition rating				
Base Diameter (mm)	Base Circ. (mm)	Pole Type	Pole Length (M)	Section Length			Base Section Wall Thickness (mm)			Safe Working Load	Original Design Factor of Safety	CR1 Min Allowed Thickness (100%)	CR2 Min allowed Thickness (-10%)	CR3 Min allowed Thickness (-20%)	CR4 Min allowed Thickness -30%	CR5 -40% or Hole in the pole
				Top	Middle	Bottom	Post 1968	1952 - 68	Pre 1952							
168.3	528.7	A	9144	N/A	N/A	N/A	N/A	N/A	N/A	476	2.5	Not Available				
190.5	598.5	B	9750	Not Available					6.3	517		6.3	5.7	5.1	4.4	
193.7	608.6		9144	2134	2134	4877	7.1	8.0				7.1 or 8.0	6.4 or 7.2	5.7 or 6.4	5.0 or 5.6	
			9750	2438	2438	4877	7.9	8.0				7.9 or 8.0	7.1	6.4	5.5	
		E	9750	2850	1760	5340	10.0			476		10.0	9.0	8.0	7.0	
241.3	758.2	C	Not Available						7.9	1088		7.9	7.1	6.4	5.5	
244.5	768.2		9144	2134	2134	4877	9.5	8.0				9.5 or 8.0	8.6 or 7.2	7.6 or 6.4	6.6 or 5.6	
			9750	2438	2438	4877	10.3	9.5				10.3 or 9.5	9.3 or 8.6	>8.3 or 7.6	7.2 or 6.6	
		F	9750	2810	1910	5030	12.5			952		12.5	11.3	10.0	8.7	
266.7	838	D	Not Available						9.5	1497		9.5	8.6	7.6	6.6	
273.0	857.8		9144	2134	2134	4877	11.1	9.5				11.1 or 9.5	10 or 8.6	8.9 or 7.6	7.8 or 6.6	
			9750	2134	2134	5486	11.1	11.1				11.1	10.0	8.9	7.8	
		G	9750	2240	2390	5120	16.0					10.0 (16.0)	10.0 (14.4)	8.9 (12.8)	7.8 (11.2)	
		K	9750	3000	2600	4150	13.5					10.0 (13.5)	10.0 (12.1)	8.9 (10.8)	7.8 (9.5)	
		K	10750	4140	3100	3500	13.5									
		L	9750	3000	2600	4150	10				1.6	10	9	8	7	
		L	10750	3000	2600	5150	10									

Decision table for the identification of Steel Poles										Safe Working Load	Original Design Factor of Safety	Calculated Minimum Thickness values for each condition rating				
Base Diameter (mm)	Base Circ. (mm)	Pole Type	Pole Length (M)	Section Length			Base Section Wall Thickness (mm)					CR1 Min Allowed Thickness (100%)	CR2 Min allowed Thickness (-10%)	CR3 Min allowed Thickness (-20%)	CR4 Min allowed Thickness -30%	CR5 -40% or Hole in the pole
				Top	Middle	Bottom	Post 1968	1952 - 68	Pre 1952							
		M	9750	4750	2-piece pole	5000	16					10.0 (16)	9 (14.4)	8 (12.8)	7 (9.5)	
		M	10750	5750	2-piece pole	5000	16									

The table above indicates the original minimum design thickness of the various types of poles.

The following decision sequence shall be used to identify the original steel pole type:

1. Measure base diameter or circumference of pole.
2. Locate base diameter or circumference in table.
3. If only one pole type associated with base size, identify required wall thickness shown on right hand side of table.
4. If more than one pole type indicated, measure length of middle section or bottom section as indicated in the table to identify exact pole type.
5. Use ultrasonic tester to obtain existing wall thickness of pole.
6. Where the min calculated thickness value includes a value in brackets i.e. pole types G, K &M then the bracketed figure is the calculated value but the min value to use shall be the un-bracketed value. (The steel tube thickness is larger due to tube availability rather than strength requirements).

4. References

4.1. External Documentation

Reference	Title
ENA ER L9	"Structural testing of wood poles prior to climbing or use as a personal support"

4.2. Internal Documentation

Reference	Title
MNT/001/004	Technical Specification for Tower Painting
MNT/004	Policy for the Inspection and Maintenance of Overhead Systems
NPS/001/018	Technical Specification for Steel Poles
NPS/001/021	Technical Specification for Overhead Line Tower, Steel Pole and Substation Plant Paint Systems
NSP/004/041	Code of Practice for the Construction of LV ABC Overhead Lines

4.3. Amendments from Previous Version

Reference	Amendment
Clause 2, Scope	Addition of a reference to testing of wood poles in accordance with, ENA ER L9 - "Structural testing of wood poles prior to climbing or use as a personal support"
Cluse 3.1. -Testing of Wood Poles Before Climbing	Amendment to the maximum allowed prodding depth. This follows changes to ENA ER L9 where the pervious maximum prodding depth value of 25mm all around the pole has been reduced to 12.5mm. A pole categorisation of CR4 or CR5 as a result of any decay level assessment test has been added to "do not climb" pole test status Additionally, an additional para has been added to provide guidance on how a pole shall be assigned a default condition rating when it has not been subjected to a proper decay assessment test to determine it actual %RSV
Clause 3.2 - d) Additional Exploration Tests for possible below ground level decay on Specified Increased Risk Pole Categories	The notes section of this clause has undergone minor rewording to specify the Thor Hammer as the preferred device for carrying out additional tests below ground level on specified increased risk poles
Clause 3.3. - Condition Rating of Wood Poles and Urgency for Replacement	The existing condition rating table and associated guidance notes have been updated to align with a similar table and notes more closely in MNT/004.
Clause 3.9.3.5. - Boron Rod Treated Poles – Identification and Replacement	Additional note has been - where a pole has been identified as a CR3 support due to its %RSV and goes into a new 5-year repeat inspection cycle, then the pole should still be treated with boron rods or boron paste to minimise the decay process in the pole.
Clause 3.9.1 - Condition Rating of Steel Poles and Urgency for Replacement	The existing condition rating table and associated guidance notes have been updated to align with a similar table and notes more closely in MNT/004.
Clause 3.9.2.1 – Approved Ultrasonic thickness tester	Additional approved tester added
Appendix 4 -THOR Hammer Testing of Wood Pole using V3.0 Tools	Additional Appendix 4 added to introduce the THOR Hammer V.3.0 tools and the way the new test equipment is used. Detail on the uploading of test data from the filed into the cloud-based portal has been removed as this process takes placed automatically using the cellular connectivity of the users Bluetooth connected smart phone or a standalone tablet.

5. Definitions

Term	Definition
CDS	Controlled Document System
Cobra	Pole butts treated with Arsenic preservative treatment
PURL	Pole Ultrasonic Rot Locator
% RSV	% Residual Strength Value
Resistograph	A test device which relies on the motor force required to drill a 3mm hole into the pole with the output plotted on an electronic graph. From which a calculated residual strength is generated.
Steel pole	A Steel Pole shall be classified as a tubular or circular folded plate galvanised steel self-supporting structure designed to accommodate 1 or more broken wire conductors.
Thor Hammer	Pole test device manufactured by Groundline which is capable of testing the complete pole, above and below ground as part of a single test procedure.

6. Authority for Issue

6.1. CDS Assurance

I sign to confirm that I have completed and checked this document and I am satisfied with its content and submit it for approval and authorisation.

		Date
Liz Beat	Governance Administrator	03/11/2022

6.2. Author

I sign to confirm that I have completed and checked this document and I am satisfied with its content and submit it for approval and authorisation.

Review Period - This document should be reviewed within the following time period;

Standard CDS review of 3 years?	Non Standard Review Period & Reason	
Yes	Period: n/a	Reason: n/a
Should this document be displayed on the Northern Powergrid external website?		Yes
		Date
Ged Hammel	Senior Policy and Standards Engineer	03/11/2022

6.3. Technical Assurance

I sign to confirm that I am satisfied with all aspects of the content and preparation of this document and submit it for approval and authorisation.

		Date
Steven Salkeld	Policy and Standards Engineer	03/11/2022
Joe Helm	Policy & Standards Manager	03/11/2022

6.4. Authorisation

Authorisation is granted for publication of this document.

		Date
Paul Black	System Engineering Manager	04/11/2022

Appendix 1 - PURL Testing Wood Poles

Background

A PURL uses an ultrasonic signal to identify the presence and locate the position of decayed timber in wood poles. The transmitter of the PURL is fixed to the pole and when turned on gives out an ultrasonic signal that can only travel through sound timber. The receiver is then held against the pole at the various positions to test for the transmitter signal. When turned on the light on the receiver should flash in unison with the transmitter “clicks”. If there is decayed timber between the transmitter and the receiver, then there will be an out of unison or “No Signal”.

General: -

Visually inspect the pole for signs of damage such as decay fungal growth, splitting, etc. Or weakness caused by woodpeckers, vehicles, farm machinery, excessive animal rubbing, etc.
Clear away any raised ground at the base of the pole to reveal the true ground level.
Before starting work check that the PURL testing kit contains one of each of the following items of equipment; - Transmitter, Receiver, Ratchet drilling device, Drill 7/64", Measuring Tape, “D” marker plate, Calibration block (Go), Calibration block (No Go), Elastic marker band (small poles), Elastic marker band (large poles). Results form 1190 4/82 and the Carrying case.
When turned on and applied to a pole the light on the receiver should flash in unison with the transmitter “clicks”. If there is decayed timber between the transmitter and the receiver then there will be no flashes, or the flashes will be out of unison with the clicks from the transmitter.
Complete a “Scan test” first to determine the condition of the pole. If you fail to get a signal or you get a signal which is out of unison you must complete a “Full test” and record the results using form 1190 4/82 as shown on page 4.
The transmitter and receiver must be checked for correct operation before and after use.

Checking the PURL Equipment

Stand the PURL on its end with the screw uppermost and screw on the “Go” test block.
Switch on the transmitter by turning the control switch clockwise. A series of “clicks” should be heard.
Switch on the receiver to position 1 and apply the receiver to the test block at the opposite end to the transmitter, a signal should be obtained.
Unscrew the “Go” test block and screw on the “No go” test block. Apply the receiver to the test block; a signal should not be obtained.
If either the transmitter or receiver fails to operate the batteries may need changing. Access to the batteries is obtained by unscrewing the end cap. If either device still fails to operate correctly return them to your supervisor.

Scan Test

1. Drill a pilot hole in the pole at ground level and in line with one set of conductors using the ratchet drill. Screw the transmitter into the pilot hole to the full extent of the thread and turn back half a turn. Turn on the transmitter.

2. Switch on the receiver by turning the control switch to the required sensitivity setting. The setting is determined by measuring the diameter of the pole using the tape measure at a height of 1m from the ground. The tape gives a reading of the setting to be used. Care must be taken if there are cables fixed to the pole.

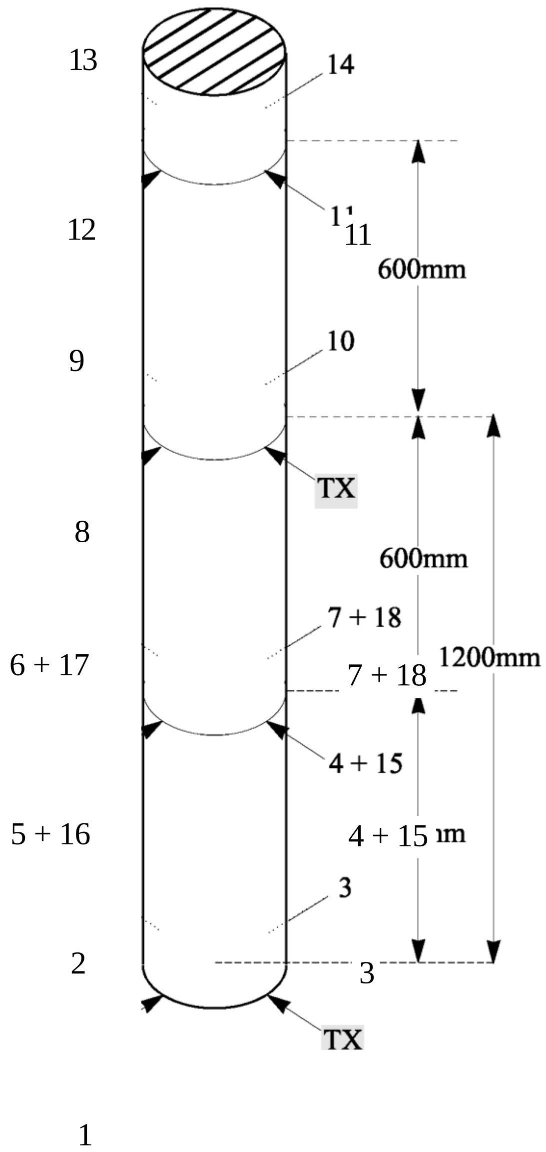
3. Apply the receiver at points 1, 2 and 3 shown on the illustration.

4. Leave the transmitter in place and test using the receiver at 600mm above ground level at points 4, 5, 6 and 7 shown in the illustration.

5. Re-position the transmitter directly above the first position at 1200mm above ground level. Test using the receiver at points 8, 9 and 10 shown on the illustration.

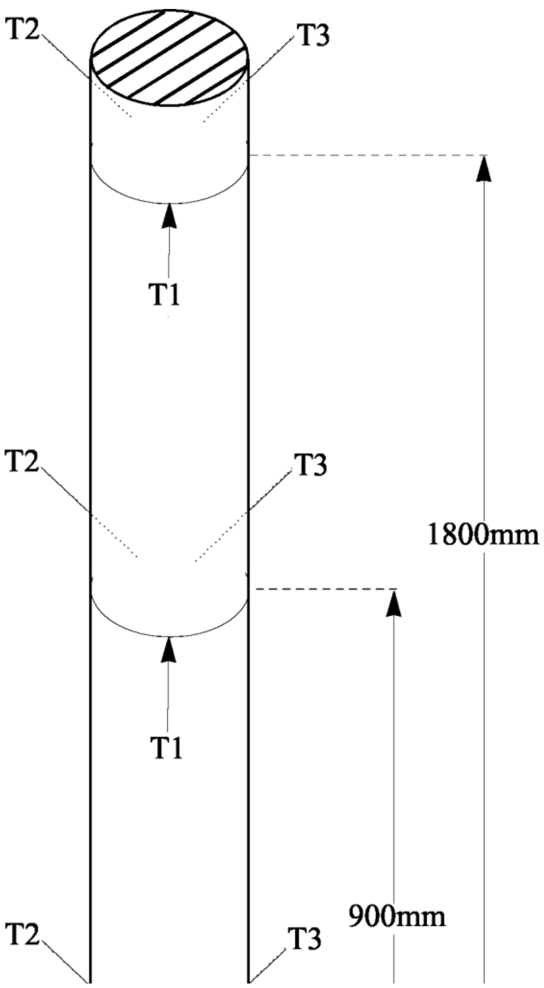
6. Leave the transmitter in place and test using the receiver at 600mm above the transmitter at points 11, 12, 13 and 14 shown in the illustration.

7. Leave the transmitter in place and test using the receiver at 600mm below the transmitter at points 15, 16, 17 and 18 shown in the illustration.



Full Test

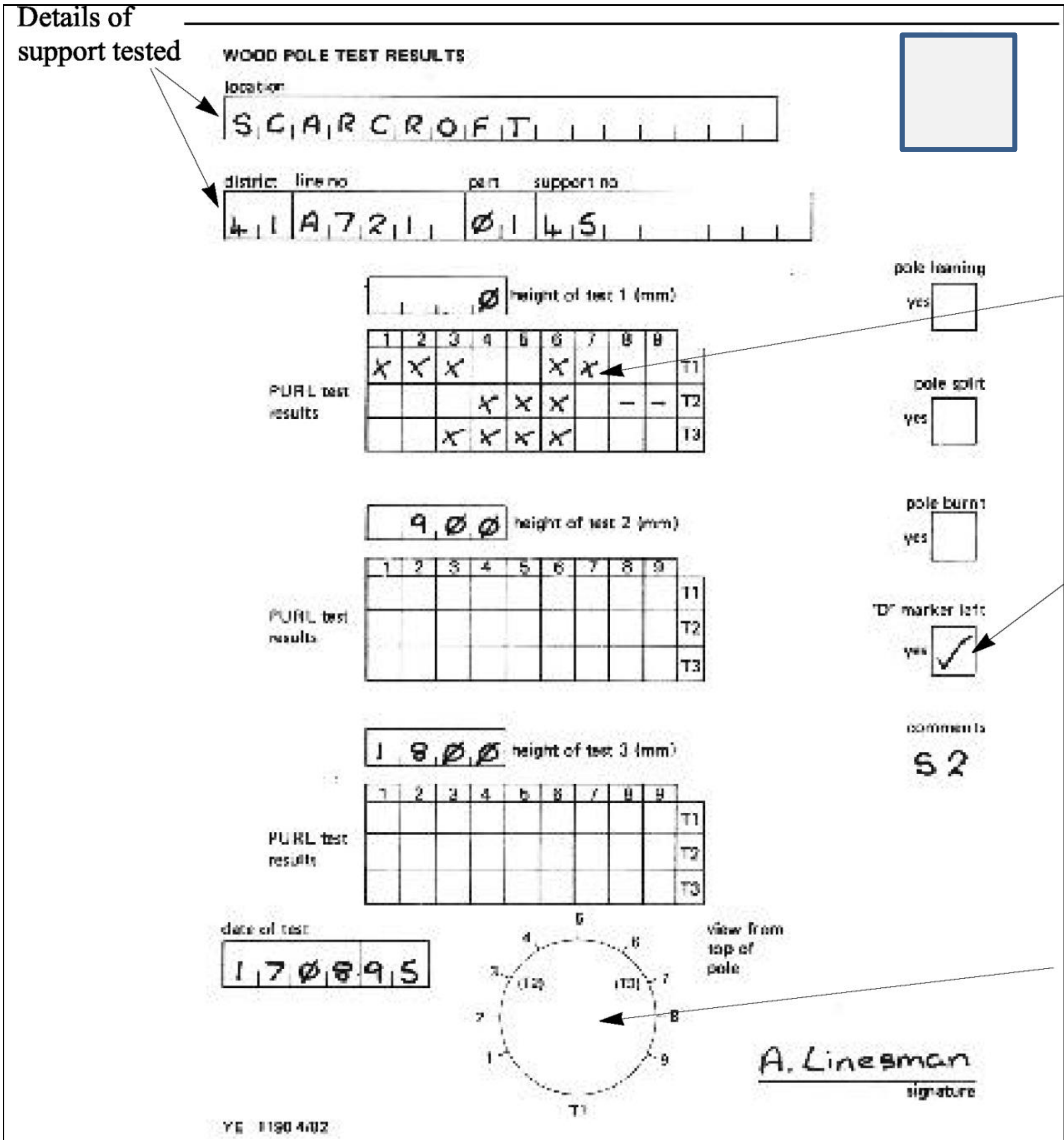
1. Fix the transmitter to the pole, in line with one set of conductors at a height of 1800mm from the ground. This is the Transmitter "T1" position.
2. At the same level but 120 degrees (1/3rd) around the pole in a clockwise direction around the pole chalk mark the Transmitter "T2" position and at a further 120 degrees (1/3rd) around the pole in a clockwise direction around the pole chalk mark the Transmitter "T3" position.
3. Fix the appropriate size elastic marker band around the pole at the same height as the transmitter.
4. Using the receiver, test for signals at 9 equally spaced positions as indicated by the marker band moving in a clockwise direction around the pole.
5. Move the transmitter to the T2 position and repeat step 4.
6. Move the transmitter to the T3 position and repeat step 4 again.
7. Repeat steps 1 to 6 with the transmitter at 900mm from ground level.



8. Repeat steps 1 to 6 with the transmitter at ground level.
9. Permanently mark all T1 positions using marker nails. Use 1 nail at ground level, 2 at 900mm and 3 at 1800mm above ground level.

Recording and interpreting results

- Fill in a "Wood Pole Test Results" form 11904/82 for each pole on which you complete a Full Scan. A sample of a completed Wood Pole Test Results form is shown overleaf.
- The receiver positions are numbered 1-9 from the present transmitter position moving clockwise around the pole.
- Enter "X" for every position where you fail to get a signal or receive an out of unison signal.
- Enter "–" for any position where the receiver cannot be applied because of an obstruction or damage to the pole.
- If any of the boxes have 10 or more crosses then a red "D" marker plate must be fixed to the pole under the number plate at the highest point that can reached from ground level.



"X" indicates no signal or out of unison signal at this receiver position

Tick if "D": marker plate fitted

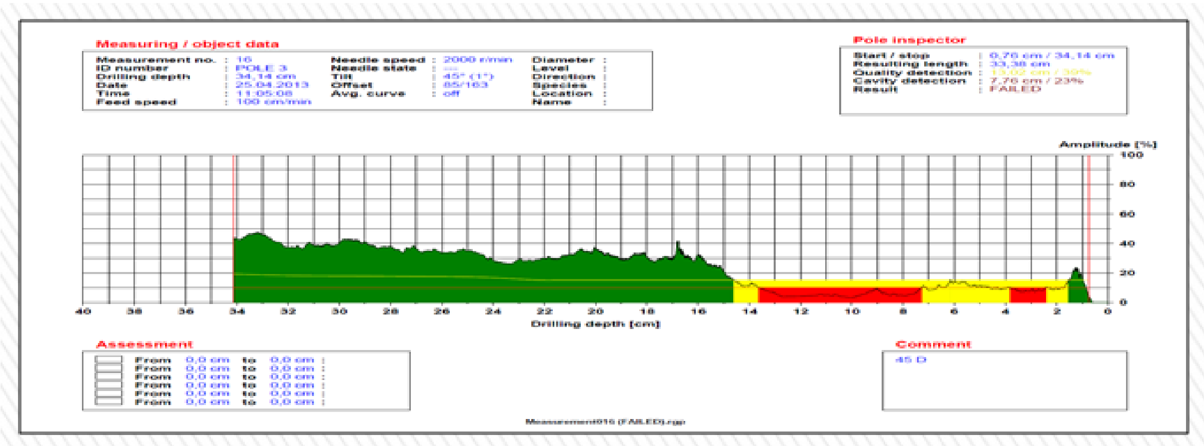
Difficult Situations

Where a pole is situated close up to an obstruction it will normally be possible to select 3 approximately equally spaced positions for the transmitter. In these situations, the T1 position does not have to be in line with the conductors if it is not possible. The receiver must be used in as many of the positions as it is physically possible to reach.

Appendix 2 – Resistograph Testing Wood Poles

Test procedure

1. Measure the pole diameter.
2. Enter Pole number, feeder number and any observation notes into the drills electronic display together with the maximum drill length of the pole -5mm such that the drill does not exit the other side of the pole.
3. A minimum of 4 holes shall then be drilled around the circumference of the pole with the tester held 90° to the pole at a height of .05m above GL.
4. The tests in point 3 shall then be repeated at 1.2m above GL and then again at GL but with the drill at 45° downwards below ground level.
5. After each test is completed, the device creates an electronic graph together with a pass/failure result



6. To calculate the remaining residual strength in the pole, the readings are then entered into a handheld device which takes the worst reading and provides a calculated residual strength as shown below. From this reading the pole condition can then be provided with its condition rating as detailed in clause 3.5.

Type of pole	stout 12	Standard pole values
Length of pole in metres	12 metre	
Diameter at top of pole	190 mm	
Diameter at 1.5m from butt	305 mm	
Plant depth	1.8 metre	
Angle of drilling	0 degrees	
Start of rot	35 mm	
End of rot	125 mm	
Diameter at ground level	302 mm	
Man's weight in kg =	100 kg	
Wind load at cross arm	1000 N	
Design load at cross arm	2000 N	

Factor of safety is a minimum of 2.1 kN
The higher factor of safety applies where people are involved.

Breaking load of pole if perfect:	15.09	Breaking load of rotten pole:	13.09
Residual strength of perfect pole:	100%	Residual strength of rotten pole:	87%
Factor of safety if perfect:	7.54	Factor of safety of rotten pole:	6.54

Appendix 3 – THOR Hammer Testing of Wood Poles using V1.0 Tools

1. Introduction to the THOR Pole Tester

The THOR Pole Tester is an instrument designed for a fast and effective safety assessment of timber power poles. It is designed to test from essentially the top of the pole through to the base in a matter of seconds, providing the operator with a simple response as to the fitness to climb or the need to subsequently test further with other equipment.

The equipment comprises:
- The Handheld electronics unit
- Unit data cable to upload the test results to THOR portal
- An Impulse Force Hammer
- A Geophone
- AC Power Adaptor
- A carrying case

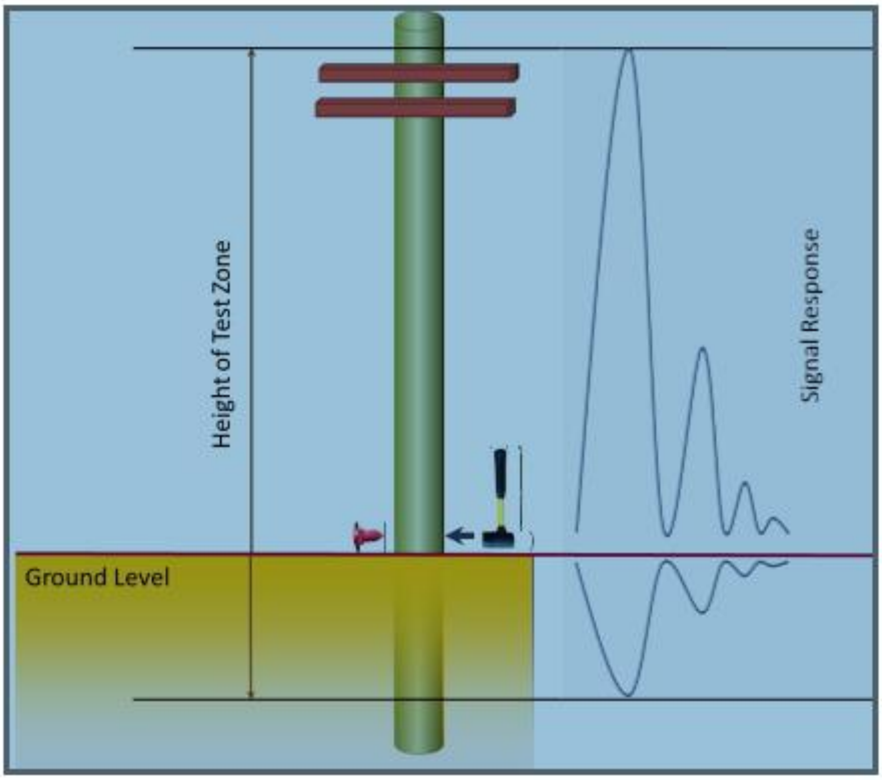
2. Principle of the THOR Pole Tester

The instrument detects, analyses and records the signal of a series of stress waves entered into the pole by the hammer. On board processors analyse the signal based on the duration of the wave form against the impulse force and provides the operator with a visual indication as to the state of the pole.
When the force is applied to the pole from the impulse hammer, the stress wave travels up to near the top of the pole and down to near the base. The location of the test is important so that the waveform for the signal results in the most effective analysis. It is ideal to have the hammer hit location and the geophone as close as to the ground. Further, try to place the geophone firm and sturdy to the other side of the hammer impact location on the pole. If it is not possible the geophone can be held on the same side of the hammer impact location.

Where the expected duration of the wave signal relative to the force is within a particular range, the THOR unit provides the operator with a ‘traffic light’ signal response of green, amber or red to confirm the test is valid. The unit then displays the pole health in terms of Equivalent Diameter against to its target diameter at ground, both as a value and a percentage.

Additionally, the THOR Pole Tester assesses the pole to soil interface i.e. the quality of the foundation that the pole is sitting in. These results display as a Foundation Target %. Although not currently available as a site displayed value, the Thor Hammer has the potential to use this value to calculate the pole embedment depth. Currently the Embedment Depth must be calculated by an engineer as a post inspection analysis of the on-site capture information. In order to calculate the embedment depth the tester MUST supply the above ground height. This can be determined using a range finder, to measure this value.

Note
It is proposed that further development of the product will result in the embedment depth being supplied as an onsite value via the automation of the manual calculation



3. Setting Up

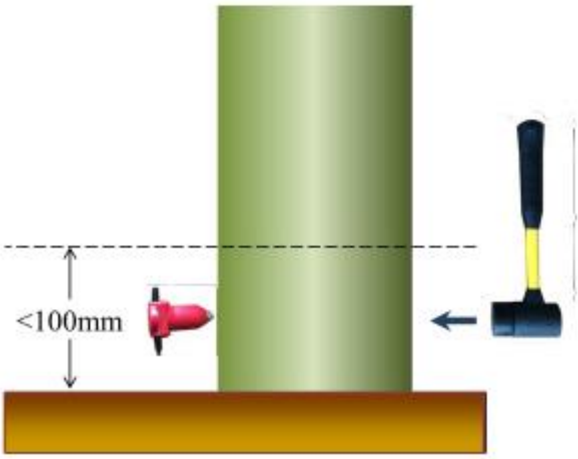
There are several items that need to be completed before an operator is able to progress to using the THOR Pole Tester in the field. Once set up there is limited requirement to maintain these files (see Section 6).
Charge the unit prior to operation using the power adaptor provided for this purpose. It generally takes an hour or so to fully charge and the unit will advise when charging is complete. With an efficient power management system on board, a fully charged THOR unit will operate several days.

3.1 Connecting Components

First make sure that the rubber impulse tip of the hammer is attached firmly. Continue to tighten every 4 or 5 poles to make sure the energy transfers properly through the bolt. The components provided with the THOR Pole Tester are straightforward, with the cables from the geophone and the hammer fastened into the base of the unit into the respective colour coded adapters. These are not interchangeable between the hammer and geophone and no forcing is required. Each of the LEMO connectors have one or more pins that fit within slots on the port, with the red dots lining up to help position the two components.

Note the raised bumps at the end of each connector. These are specific to each socket and grooves are located that match the pattern of the connector. The cables are also colour coded to the sockets (yellow for Hammer and red for Geophone). There is a red dot on both the socket and the connector to line up the grooves to the raised bumps.

With the hammer tip, it screws into the hammer head but occasionally comes slightly loose. Occasionally check for tightness and, if loose, just tighten until no longer slack – but don't overtighten.



4. Application

The general rules of applying the THOR Pole Tester are to:

• Place the geophone on one side of the pole within 100mm of ground level where possible. For reinforced poles, place the geophone at the top of the steel when it is not possible to access close to the ground.

• Choose an area of the pole that is solid and has no sapwood separation or loose material.

• In general the hammer is used on the opposite side of the pole to the geophone. If unable to reach around then go as far as possible so that the hammer blow is not affected by the shortness of the cable.

• It is not important what orientation you use the geophone and hammer around the pole although inline is preferred.

• When swinging the hammer only go back about 40-50cm and swing at the pole with only moderate force. Generally the force applied to swing the hammer should be roughly enough to bounce back the hammer to the original position with a loose hand.

• Any force applied that is too hard or too soft will result in flawed result (Hammer value indicates too soft). Hard hammer strikes will not result in an Equivalent Diameter percentage.

• Make sure the geophone is held tightly and firmly in position against the timber horizontally levelled – pointing to the centre of the pole - whilst swinging the hammer.

• Keep the geophone and hammer strike at the same level when testing the pole.

• If you are unable to test on either side of the pole then place the geophone in the appropriate location and use the hammer as close to 180° as you can.

5. Testing Procedure

For routine testing follow below operating procedure:

1. Connect the components and turn on the THOR Pole Tester by pressing the power button.

2. The firmware loads and the introductory information displays. Press any key on the keypad to progress to the Main Menu.

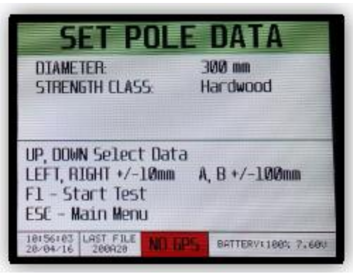
3. The current user and the menu options available are displayed. Note the serial number for the Hammer and the Geophone – these should match the items that come with the kit.

4. Wait until the GPS position is determined.

5. If you want to see the progress of the satellite connections, press the “A” button and go back to main menu by pressing “ESC”

6. To begin testing, press the F1 button (Continue to Test).

7. The reading will ask the user to enter the Diameter and select the Strength Class as “Softwood” or “Hardwood”. For the purposes of testing poles on NPG’s network, Softwood is to be selected.



Measure the diameter of the pole at the point of test, by using the provided diameter tape. Do this by using the UP/DOWN arrows to move between the two selections, the LEFT/RIGHT buttons to progress the Diameter by -10mm/+10mm respectively and the A and B buttons to progress the Diameter by -100mm/+100mm respectively. To change the Pole Species (Softwood or Hard wood) select the item using the UP/DOWN arrow and use the LEFT/RIGHT buttons to cycle through.

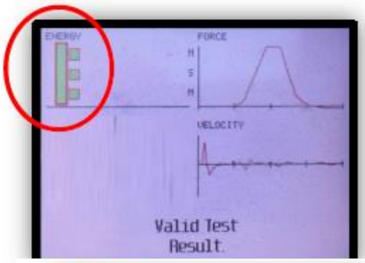
8. Press “F1” and the reading will display “HIT POLE WITH HAMMER”.

9. Position the geophone in the appropriate location.

***Technique**: Place the geophone firmly against the pole pointing straight to the centre and level or parallel to the ground using the bubble level at the top of the geophone. Also make sure the timber is not laminated as it needs to be placed on a good, clean and firm surface. Place about 50-100mm from the ground and if on a slope then place in a situation where the geophone is on the same level as the hammer strike level. Having the geophone horizontal and firm during the inspection is crucial for the accuracy of the data. Also keep the geophone away from splits and cracks.*

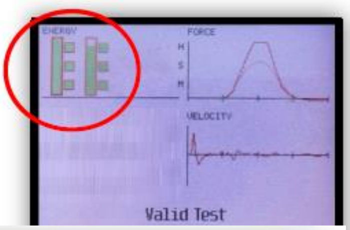
10. Swing the hammer against the pole *Note that you don’t have to hit the pole hard, but squarely*. You will quickly come up with a result and each result will display along the top left of the screen. The vertical bar that has the green area displayed is the amount of energy recorded by the hammer blow.

Technique: Swing from about 300-400mm out from the pole so that the round rubber end of the hammer hits the surface as perpendicular as possible. The display will show you how hard you have hit and use this to gauge whether you need to go softer or harder on the swing.



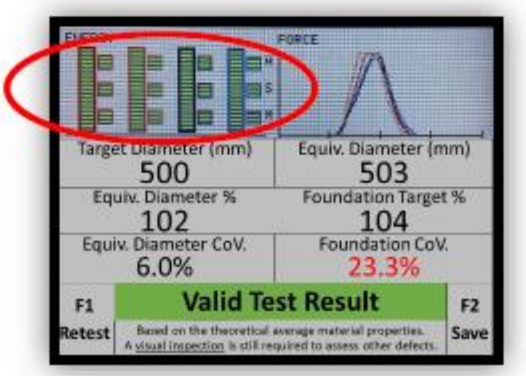
Each of the three vertical squares will display green, amber or red for Hammer (H), Foundation Target (S) and Mobility (M) from the top down respectively. If the hammer blow is insufficient then the words “Soft Hit. Striker Harder” will display and a message “Hold Geophone” when the geophone is not held firm against the pole.

You have 4 attempts for each of the 4 recorded readings to obtain a valid result. If the hammer blow is insufficient or not ideal, hit the ‘ESC’ key and start again.



11. A result that can be analysed will show as “Valid Test Result” and you will then be progressed to the next reading.

12. Continue through the remaining hammer strikes and each will give you an output summary for the reading with additional graphs for Force, Velocity and Mobility that show each of the results.



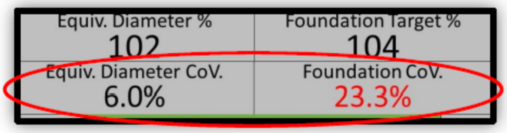
13. Once the four readings are successfully returned the THOR Pole Tester will advise the overall result and indicate whether anomalies are detected or not e.g. “FLAWS DETECTED”.

During the 3rd hit, THOR will record your GPS location.

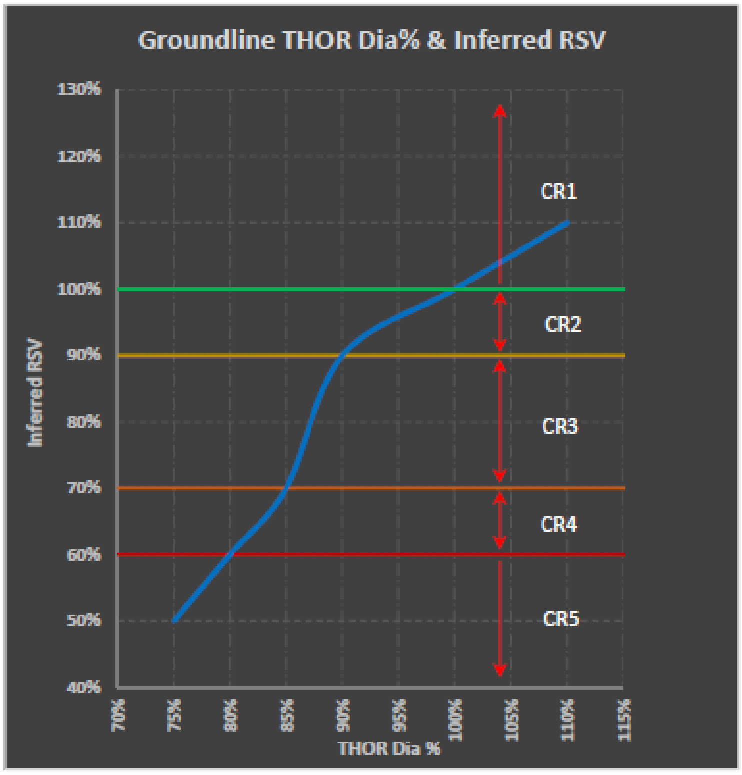
6. Understanding the Readings

To understand the readings, there are two main results that are relevant to determine what happens next. These are the average of the Reported Equivalent Diameter (Residual Strength Characteristic) and the percentage related to Target Diameter and Foundation Target (Foundation Condition)

Next to the values are numbers that assist in advising that the readings are valid across all four measurements i.e. consistency for analysis. These are Coefficients of Variation or COV and they should be ideally less than 15 but up to 20 is acceptable if it's too challenging to record a lower number. If your end result is over 20 then re-test and sometimes this means slightly changing the location of the geophone and/or hammer strike area.



To convert the "Reported Equivalent Diameter" into a Residual Strength Characteristic for the pole the following procedure shall be followed:



i) Locate the matching "Thor Dia %" on the horizontal axis of the graph.
ii) Project this value vertically until it intersects with the blue curve on the graph.
iii) Project a line horizontally towards the vertical axis to show the corresponding "inferred RSV" (residual strength value" for the pole.

Note

The graph has been calibrated to show the "as found" condition rating that shall be applied to the pole and thus any required safety labelling that needs to be applied to the pole.

This graph has been re-created on the rear of the "Thor Hammer handheld electronics unit" for convenient site reference.

Where the pole is being inspected as part of a foot patrol project, then currently the "as found RSV" shall be manually entered into the associated data capture device alongside the other collected pole data e.g. the pole manufacture date, pole grade, height etc. In the future as a result of further development work it is planned that the Thor hammer will be able to show this value as a calculated value.

Press the 'ESC' key to return to the Main Menu or the 'F2' key to save the result. You can then choose to retest the pole or move to the next pole and start the process again.

7. Capturing the pole Embedment Depth

Currently Embedment Depth must be calculated by an engineer as an off-site, post survey process, through analysis of the on-site capture information. In order to calculate the actual embedment depth the tester MUST also supply the "above ground height value" as an independently collected value.

This value can be determined using a range finder to measure the pole height, (not supplied as standard within the THOR kit) or if the pole contains a 3m gouge mark the assumed sinking depth can be calculated and deducted from the marked pole height. The assumed sinking depth value will be entered into the data collection records as normal.

The off-site tests compare the speed of the signal response through the pole and its reflections to calculate the actual length of buried timber or embedment depth. Automating this process is currently in development to allow a user to confirm this value whilst still on site.

8. Uploading the results to the On-line Data Portal

Flash memory is stored within the THOR Pole Tester and this is where the configuration and data files are stored. The only files that require copying are the data files, which are in the format .DAT (e.g. "197A41.DAT", "197A42.DAT"). Plug the USB data cable into the port at the top of the THOR Pole Tester and the other end into a computer.

When the USB cable is plugged into both the computer and the THOR Pole Tester the flash memory will appear as a drive – initially it may load a device driver to recognise the unit. The flash memory then appears in the Windows Explorer as a directory (SD Card). Click on the drive and you will see the list of data files in the main window.

They are quite sizeable (several hundred kilobytes) so copy them from that directory and paste them into one for backup and compression. Do not delete the original .DAT files from the THOR unit as there is enough capacity hold significant number of tests. In a situation to clear the files to create space in THOR unit, user must leave the very last tested pole data (XXXXX.DAT). From the new directory select the data files you want to send then right-click over them to show a pop up menu.

Select Send To >> Compressed (zipped) folder and a new folder appears in the file list that can be renamed if required.

Upload the zipped file into the Pole Test Portal at https://portal.poletest.com/ with your Groundline provided Portal log in details.

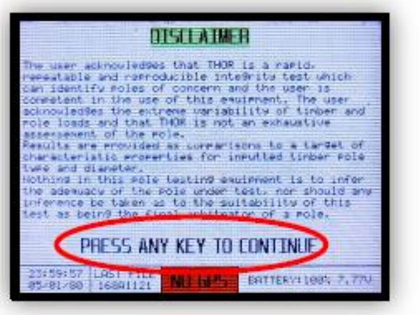
9. User Setup on Device

There are several items that need to be completed before an operator is able to progress to using the THOR Pole Tester in the field. Once set up there is limited requirement to maintain these files. *Do not delete any of the system .CSV files as all are critical to the operation*. To change User and Project items first plug the THOR Pole Tester into your Windows computer using the 4 pin LEMO connector provided (it has a USB adaptor on one end of the cable). When it's plugged in, turn the THOR Pole Tester device on and a message will display on its screen to say it is USB CONNECTED. A device driver is installed (doesn't always happen but it is common) prior to a Windows Explorer screen displaying. When this happens, there are several .CSV files displayed in the list and the two main ones are user.CSV and project.csv. You can edit either of these by double-clicking them.

9.1. User and Project data

User and project data is kept in a comma separated value (CSV) format and is able to be changed but the format and sequential numbering must be kept the same. Any variation to the file will corrupt the operation of the THOR unit. Once these files are saved, disconnect the THOR Pole Tester device.

When the start-up screen and the introductory information displays press any key on the keypad to progress to the Main Menu.



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9.2. Changing User

When the THOR Pole Tester is first loaded, on the Main Menu screen it shows the current user selected. To change the user, press the F2 button to edit the Sample Configuration.

It will display the SELECT USER item first with the following menu items.

To run through available users, press the UP and DOWN buttons. A new user is displayed similar to the above.

If you want to select this user, press the F1 button. Select F2 to progress to the next item for editing or otherwise the “ESC” button to return to the Main Menu without making any changes. Keep selecting F2 until you reach the SELECT PROJECT screen and use the same process for cycling through the available list and select F1 to save or ESC to return to Main Menu.

If ever you need to change the geophone or hammer serial numbers, use this process in the same way, but if the item isn’t in the list, contact us and we will work through the process with you.

10.0. Downloading Thor Data & Uploading to Portal

Flash memory is stored within the THOR Pole Tester and this is where the configuration and data files are stored. The only files that require copying are the data files, which are in the format .DAT (e.g. “197A41.DAT”, “197A42.DAT”). Plug the USB data cable into the port at the top of the THOR Pole Tester and the other end into a computer.

When the USB cable is plugged into both the computer and the THOR Pole Tester the flash memory will appear as a drive – initially it may load a device driver to recognise the unit. The flash memory then appears in the Windows Explorer as a directory (SD Card). Click on the drive and you will see the list of data files in the main window.

They are quite sizeable (several hundred kilobytes) so copy them from that directory and paste them into one for backup and compression. Do not delete the original .DAT files from the THOR unit as there is enough capacity hold significant number of tests. In a situation to clear the files to create space in THOR unit, user must leave the very last tested pole data (XXXXX.DAT). From the new directory select the data files you want to send then right-click over them to show a pop up menu.

Select Send To >> Compressed (zipped) folder and a new folder appears in the file list that can be renamed if required.

Upload the zipped file into the Pole Test Portal at https://portal.poletest.com/ with your Groundline provided Portal log in details.

The submitted files can be reviewed on the portal for subsequent analysis.

Appendix 4 – THOR Hammer Testing of Wood Poles Using V3.0 Tools

1. Introduction to the THOR Pole Tester

Thor Poletest™ is a proprietary non-destructive timber utility pole testing technology and data capture system that uniquely assesses strength and serviceability of an entire pole from tip to base in a single test.

Thor Poletest™ is a secure and complete integrated system comprising a field kit combined with data transfer and cloud-based portal services.

Thor Poletest™ produces **PRIMARY** data outputs as well as **SUPPLEMENTARY** data outputs:

PRIMARY DATA

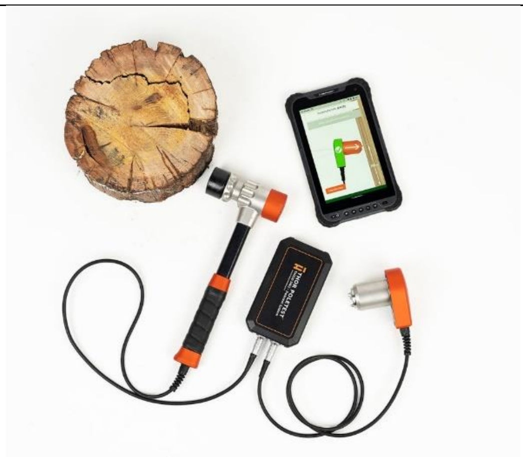
PHI™ (Pole Health Index)

SUPPLEMENTARY DATA

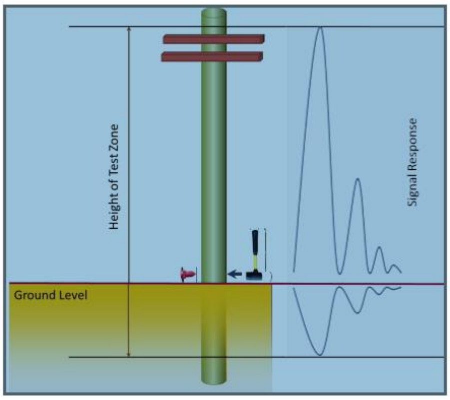
FHI (Foundation Health Index)

RSV% (Residual Strength Value)

Embedded Pole Depth

The equipment comprises: • Sensor Hub • Impulse Hammer • Geophone • Tape Measure (cm) • Impact resistant carry case • Bluetooth and GPS enabled mobile device * • Android/IOS Mobile App* • Thor Poletest Cloud Portal Access (InsightPro) • USB-C Charging cable Note. Thor Hammer can be controlled via a mobile app running on the users Bluetooth enabled smart phone or via a tablet provided as an optional extra.	

2. Principle of the THOR Pole Tester

The field kit detects, analyses and records the signal of a series of stress waves entered into the pole by the impulse hammer. The proprietary algorithms (internal firmware) analyse the signal based on the duration of the wave form against the impulse force and provides the operator with a visual traffic light colour coded indication as to the integrity of the pole. The algorithms analyse the stress waves as they travel to the top and bottom of the pole. The field kit uses analysis of the stress wave data to calculate pole health index (PHI™) and a foundation health index (FHI). PHI™ and the foundation health index values are then indicated on the Thor unit by a traffic light colour coded graphic of a 'utility pole' and 'ground'. These visualisations are commonly used to guide Health and Safety practices. Detailed test data is encrypted on the field kit and can be viewed once unencrypted at the Thor Poletest™ portal. This information is used to guide asset management practices.	

3. Preparing for use

Users of the field kit are required to be aware of, understand and prepare using the following requirements to ensure they perform the test safely, that the unit is set up correctly and to ensure the field kit is in good condition.

3.1 Safety of the User

Personnel using the field kit are required to adhere to their company risk assessment policies prior to using the field kit to ensure all site hazards are mitigated.

3.2 Protecting the Thor Field Kit

3.2.1 General

The field kit is housed in an impact resistant carry case. The carry case has internal foam padding and specific slots for each component of the field kit.

3.2.2 Geophone

The geophone is a delicate instrument that contains a magnet. It can be damaged by prolonged movement or rough handling.

Consideration is to be given to storage and positioning of the Thor field kit while being transported in a vehicle and between test locations to minimise wear on the geophone.

The geophone spikes/tips are secured using Loctite but under prolonged use the tip of the geophone may loosen.

Users are required to regularly check the tips to ensure they are not loose. A loose tip may affect the test result.

3.2.3 Hammer

Hammer tips are secured using Loctite but under prolonged use the tip of the hammer may loosen.
Users are required to regularly check the tip to ensure it is not loose. A loose tip will affect the test result and can damage the hammer

3.3 Connecting the Components

The field kit components are connected to the unit with special push/pull connectors.

The connectors are interchangeable into the sensor hub. I.E. Either cable can be connected into either port on the sensor hub

3.5.2 SETTING UP THE APP

1. Open app
2. Allow Bluetooth and location access (Bluetooth pairing PIN: 123456)
3. Read and Accept disclaimer
4. Login with Portal email address and password

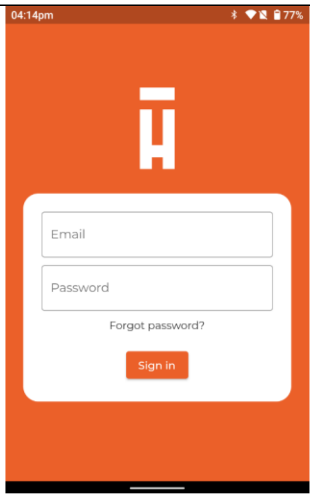
Ensure the corresponding red marks align with each connector's corresponding connection point on the sensor hub.

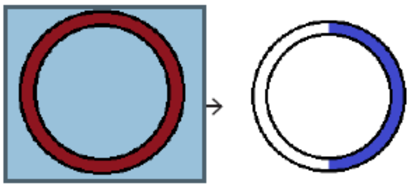
The connectors do not have to be forced and should insert easily. Users are also to confirm the connectors are fully inserted.

To disconnect a connector, pull back on the serrated sleeve on the connector and the connector will slide out of the connection

3.4 Turning on the Sensor Hub

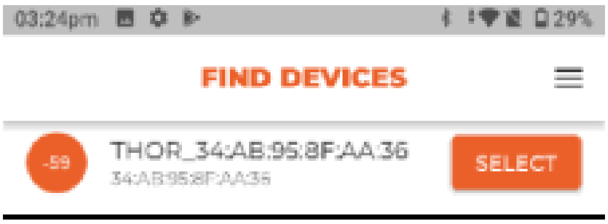
Turn the sensor hub on by pressing and holding the circular power button for two (2) seconds. The button will colour will change from 'red' to 'blue' slow flashing.

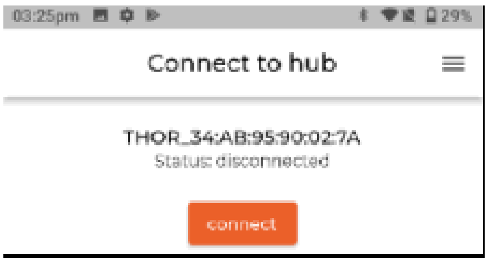




3.5.3 System Connection and Firmware Updates

5 Select Thor device from selection screen, press 'Connect' then 'Proceed to testing'.

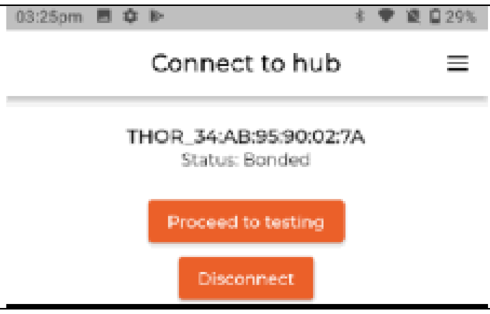




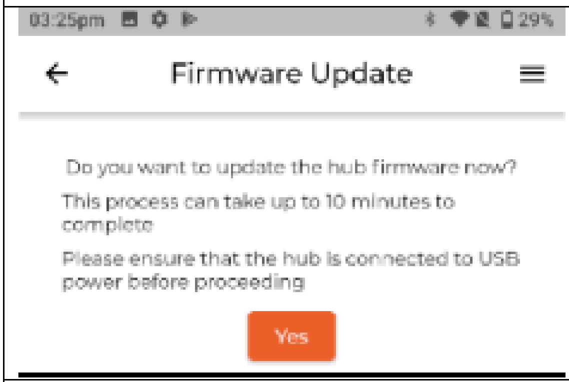
3.5 Setting Up Your Mobile Device

3.5.1 MOBILE DEVICE SET-UP

1. Download and install Thor Poletest App from Google Playstore or Apple.
2. App version is displayed when app is opened
3. Ensure device has the following enabled:
   a. Bluetooth
   b. Location services (GPS)
   c. Wi-Fi
   d. Mobile Data (if available)

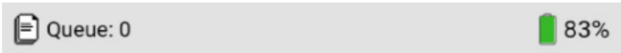


6. If requested to update Firmware, plug in USB-C cable and select 'Yes'. If firmware is updated, ensure the hub is power cycled and the app is restarted.



3.6 Battery Life and Charging of Sensor Hub

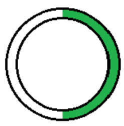
Battery charge level of the sensor hub is displayed at the bottom right-hand corner of the app screen.



Charging;

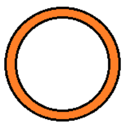
7. To Charge the sensor hub, plug in USB cable to the USB-C port on the sensor hub and the other end to an appropriate USB certified power supply. Note: The Sensor hub does not need to be powered on to charge.
8. A one (1) second press of the button with the USB cable plugged in, will enable the sensor hub to go into 'charge monitoring' mode. The button will be illuminated dependent on the level of charge as shown below.

Solid Green
Battery 100%



Slow Flash Green
86%<Battery<99%

Slow Flash Orange
Battery <85%



Solid Orange
Battery Flat

9. Daily charging of the Thor battery is recommended.

4. Testing

There are several key pieces of information that need to be considered / obtained in order to provide an accurate result. The following section provide an explanation on this information.

4.1 Acquiring the Global Positioning Satellite (GPS) Signal

The Thor unit needs to acquire a GPS satellite signal to allow testing. This is to allow recording of the location of the pole being tested.

Assuming the Mobile device has Google location services enabled, the GPS positioning will be taken in the background of the App and generally no user input is required.

It should also be noted that GPS acquisition can be extremely difficult to initiate when the unit is located inside a building or undercover.

GPS acquisition is typically completed with access to 3 or 4 satellites which allows accurate location points to be aligned to each Thor Poletest™. Location points aligned to Thor Poletest™ results are typically accurate to a five (5) metre radius

Thor Poletest™ results on structures within a 5-metre radius of each other are unlikely to be able to be uniquely identified. The remedial action to this issue is to ensure the unique pole identification number or details is/are entered in the Pole Setup section of the test screen and any additional clarifications are entered into the Observation field (Explained further in this document).

4.2 Pole Material / Class

Different species and classes of timber have varying properties which directly impact the strength and integrity of timber poles. Timber poles are categorised into two general strength categories including:

Hardwood
Softwood

Hardwood, as the name suggests, typically includes stronger timber pole species such as messmate, tallow wood and black butt.

Softwood, as the name suggests, typically includes lighter timbers with lower density including species such as Pinus Radiata, Scotts Pine and Douglas Fir

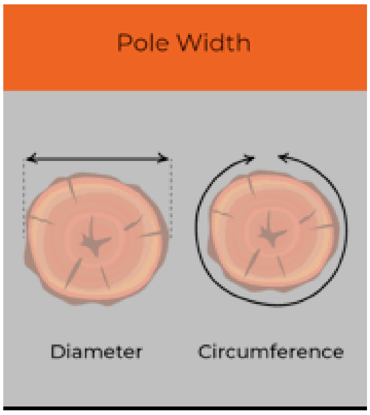
While most pole Networks typically have a predominant timber type, Thor users are required to be aware of and correctly enter the specific timber type of each pole being tested.

Correct entry of timber type is important in the production of an accurate pole health index value by the Thor unit.

4.3 Pole Width

It is important to correctly capture and input the width of the pole being tested to ensure accurate results.

The width of the pole can be entered either as diameter or circumference in either millimetres or inches.



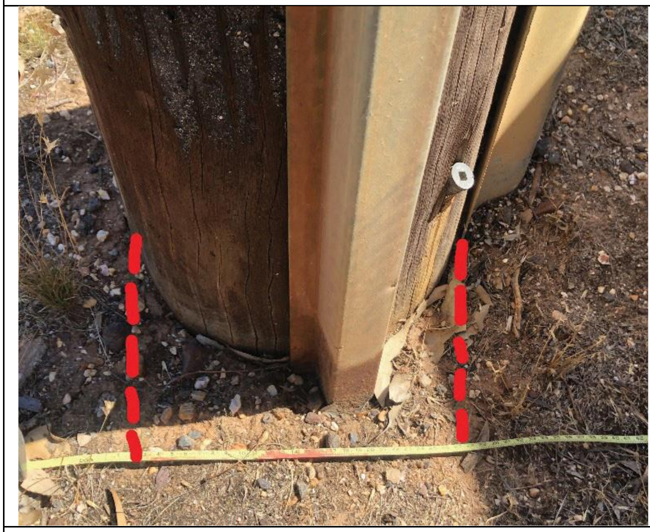
Typically, poles are between 100 and 500mm in diameter. Where the input is outside of this range the app will prompt the user to confirm if the correct measurement has been entered.

4.3.1 MEASURING THE DIAMETER

The measurement of the pole width is to be taken at ground level and while the exact dimensions can be entered, dimensions to the nearest 10mm are acceptable.
There are several acceptable methods to accurately measure the width of a pole including:

- A flexible measuring tape as included with the Thor field kit, or
- Commercially produced diameter measurement tools including callipers.

Note 1: Where the pole is an odd shape (e.g. oval) the use of a measuring tape is preferred over callipers to allow calculation of an average width.



Typically poles are between 6 and 25 metres in length. Where the input is outside of this range the app will prompt the user to confirm if the correct measurement has been entered.

The exact measurement of the pole height can be entered, however; dimensions to the nearest 0.2meters are acceptable. Where the height is being measured manually, the use of an approved / safe measuring device or method is required. Height estimation by eye does not provide suitable accuracy.

4.5 Pole Identification

Typically, timber distribution poles have a unique identifier associated to the pole itself. For data integrity it is beneficial to record this identifier at time of testing.

Note 2: Where cover guards or other obstructions prevent accurate measurement around the pole, a standard measuring tape can be used to measure from the estimated edges of the pole as a last resort. Callipers are also an option

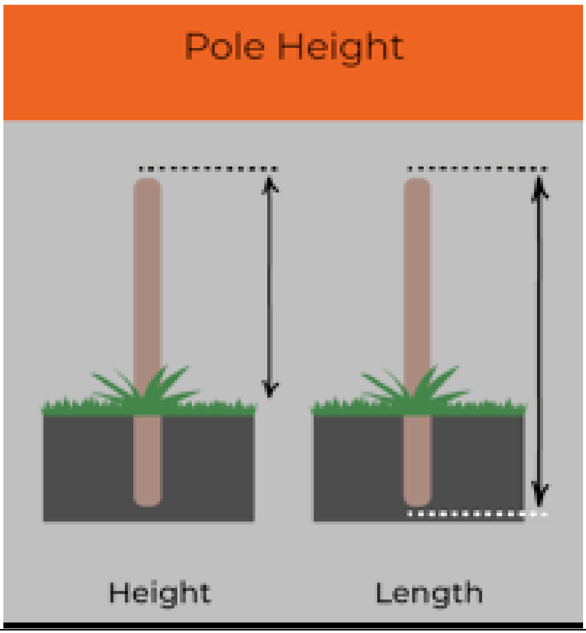
4.6 Observations

Where there are unique or interesting observations about a pole, it's location or the intended test method, it is recommended these things are associated and recorded with the test data.

4.4 Pole Height

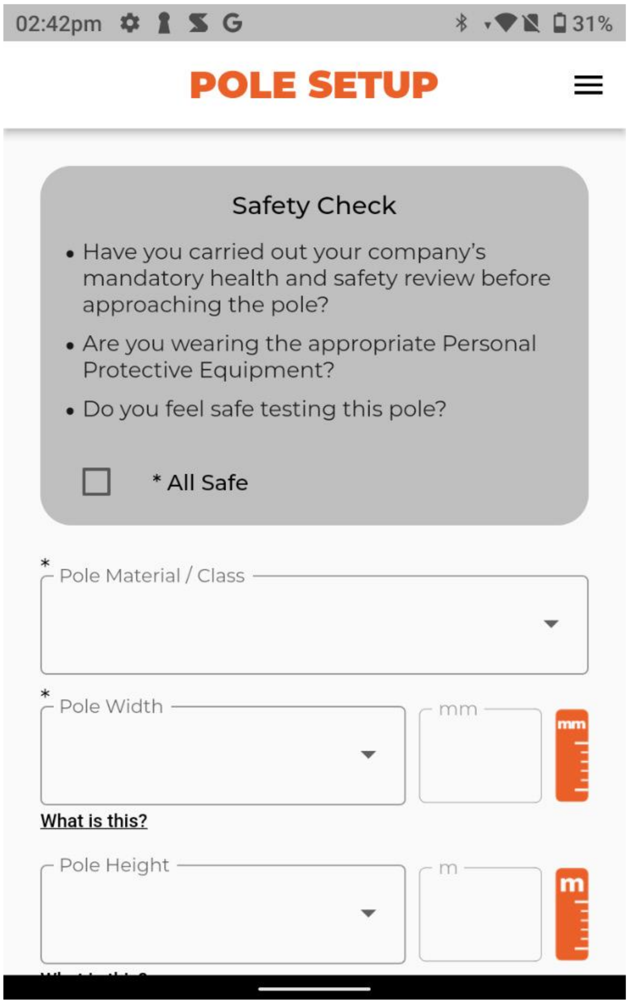
The pole height measurement field is discretionary and if entered can be used for advanced calculations, e.g. embedment depth and anomaly location.

The Pole Height can be entered either as above ground 'Height' or total 'Length' depending what information is available / known. The pole length can be entered in either metres or feet.



5. TEST PROCESS

Once ready to procced with testing a pole and the "Pole Sup" page on the App is ready, proceed with completing the required information:



A full test requires four (4) successfully repeated hammer hits to obtain a valid result. The App provides feedback to ensure these hits are consistent and the geophone is held correctly.

1. Setup near base of the pole, recommended to have Mobile device on hammer side of the pole (dominant hand).
2. When prompted, place geophone on the pole <100mm from groundline (using non-dominant hand).

The App will provide visual and audible feedback to ensure the Geophone is being held level and with appropriate force against the pole

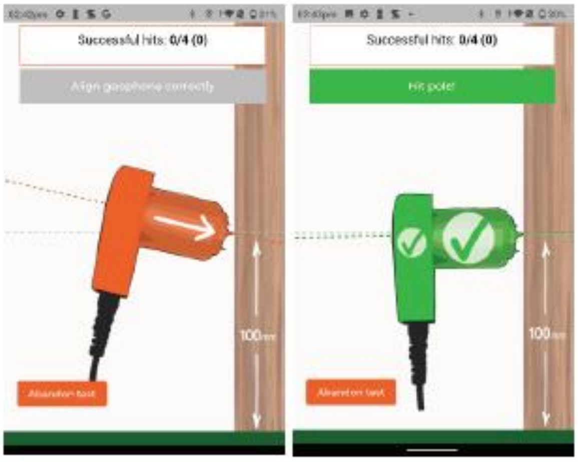
Once the visual representation of the geophone is all green and an audible tone is heard, the hammer can be struck against the pole

After acknowledging you have completed the required Safety Check, enter the following information:

1. Pole Material / Class
2. Pole Width measurement type
3. Pole Width measurement value
4. Pole Height measurement type and measurement value (if known) – non-mandatory field
5. Pole Identification – non-mandatory field but highly encouraged for data integrity
6. Observation – if any – non-mandatory field

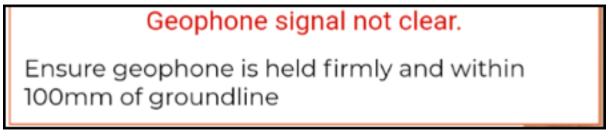
Once all mandatory fields are entered the Begin Test option is available to proceed to testing.

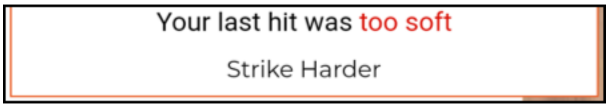
The actual test can now commence.



Firmly hit the pole with the hammer against the opposite side of the pole you are holding the geophone.

The App will provide feedback if the hammer hit was good or if the hammer hit was too soft or too hard. It will also provide feedback if the Geophone moved during the hit.

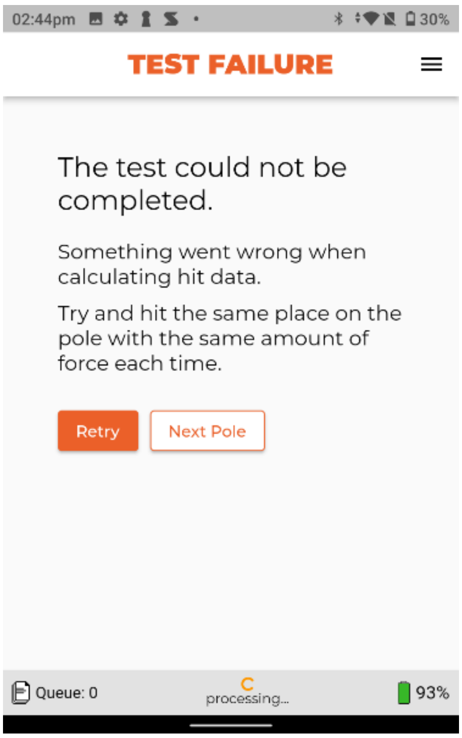




The Hit count is displayed, with the number in brackets being the total number of hits (Max 8 per test) and the count out of 4 of successful hit

A successful test requires 4 hits with a hammer hit peak force and calculated pole health within an acceptable range of variation (COV).

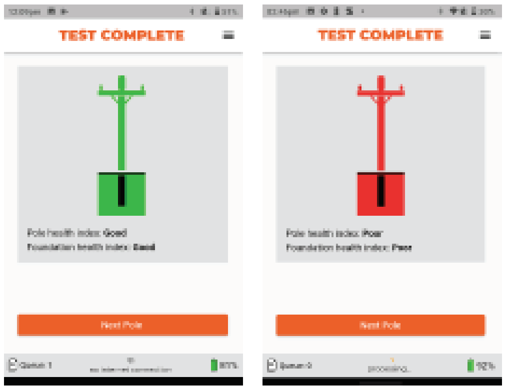
If an acceptable range of variation has not been achieved after a total eight (8) hits, 'Test Failure" will be displayed with the option to 'Retry' or 'Next Pole' .



At the completion of a successful test, the 'Test Complete' screen is displayed with both the traffic light colour coding and relevant text for the ratings for both the Pole Health Index (PHI™), and the Foundation Health Index (FHI).

When ready, proceed to the next pole or next test. In either circumstance the information is required to be entered again to ensure correct information is aligned to every test

TEST RESULTS



5.3.1 Pole Health Index (PHI™)

For Health and Safety applications, the pole health is conveniently displayed on the screen by a simple Green, Amber, and Red colour coding. The colour coding results refer to the range of Pole Health Index (PHI™) from tip to base of the pole and not just the above ground portion.

Green – >95% PHI™
Red – ≤ 80% PHI™

Note: For asset management purposes, the actual PHI™ for each test can be viewed and analysed in the portal.

5.3.2 Foundation Health Index (FHI)

For Health and Safety applications, the foundation health is conveniently displayed on the screen by a simple Green, Amber, and Red colour coding. The colour coding results refer to the range of Foundation Health Index (FHI) that relate to the compactions levels of the ground in which the pole is standing.

Green – >95% FHI
Amber – >80% and ≤ 95% FHI
Red – ≤ 80% FHI

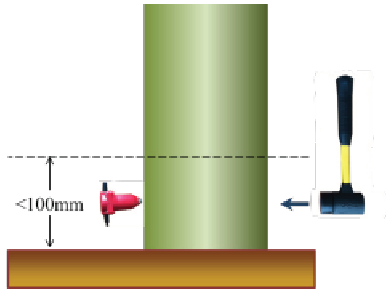
Note: For asset management purposes, the actual FHI for each test can be viewed and analysed in the portal.

UPLOADING DATA TO THE THOR PORTAL;

When a test is completed the test data will automatically be uploaded to the Thor Portal where the Mobile device has internet access.

If no internet access is available, the test results will remain stored on the Mobile device until access is obtained. Tests awaiting upload will be displayed in the bottom left of the device screen in the queue.

Tests will automatically start uploading to the portal when the app is open and an internet connection is available. Tests uploaded to the portal will be associated/aligned via the email address and log in of the user utilizing the device.



While any selected contact points approximately 180 degrees apart will provide suitable Thor results, where the user has the option, selection of contact points as close to, or in line with the through conductors is preferred.

6. APPLICATION AND TECHNIQUE

6.1 Tester Physical Requirements

Managers and Thor users are required to be aware that use of the field kit can be a physically demanding task when undertaking testing at multiple sites or for all or part of a shift. Personnel undertaking testing will need to have a reasonable level of fitness and agility to successfully complete the task. Ease of use may be improved for some users through the use of a mat to kneel on or knee pads.

6.2 Selecting Contact Points

GENERAL

At each pole to be tested, the user is required to visually assess the pole at ground level for suitable contact points for the hammer and geophone.

Suitable contact points are:

- Two flat surfaces on the timber pole that are approximately 180 degrees apart
- Less than 100mm above ground level
- Free of deformities or large cracks (small cracks are acceptable)
- Free of obstacles that will prevent a hammer swing
- Free of obstacles or hazards for the user

Note 1: Thor Testing with the hammer and geophone more than 100mm above ground will adversely affect the accuracy of the test results.

Note 2: Refer to 'Restricted Access Test' section below, where only one suitable contact point is available.

CRACKS AND DEFORMITIES

Contact points on large crack or deformities may adversely impact the integrity of the results.

While it is preferred to have contact points away from any cracks, it is understood that many poles have existing cracks in the timber from new, or developed through ageing and wear.

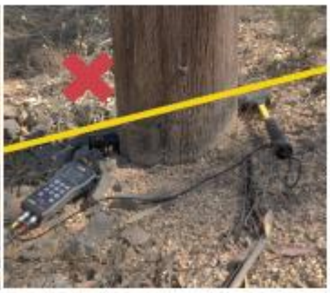
As a general rule, cracks that have an air gap greater than 2mm in width are to be avoided as contact points. Small cracks with little or no air gap (<2mm in width) are suitable as contact points.

Deformities such as knots or lumps are also to be avoided as contact points where practical, as they can also adversely impact results.

SLOPING GROUND

Where a pole is located on sloping ground, it is important for the geophone to be level with, or lower than the hammer strike location. A strike location tolerance of up to 2 hammer heads above the geophone is acceptable and will ensure the stress waves are correctly received by the geophone

Where the pole is in a gutter or on a reasonable slope, having the contact points located directly across the slope will ensure the hammer and geophone can remain at the same level as well as making application easier for the user where they are positioned on the downward side.

RESTRICTED ACCESS CONTACT POINTS

It is not uncommon for only one suitable contact point to be accessible due to vegetation, multiple cover guards, fences or walls. As a last resort where selection of contact points at 180 degrees is not physically possible, the restricted access contact points can be used with the hammer on the same face of the pole directly above the geophone (held at ground level).

This technique involves the user holding the geophone at ground level with the hammer swung vertically above geophone to strike the pole like a pendulum.

6.3 Body Positioning

GENERAL

The following body positioning has been developed specifically for testing with the TH320P to ensure quality testing and accurate results.

Undertaking body positioning as set out below assists in removing the potential for movement of the geophone during the test as well as minimising the effort required to hold the geophone against the pole with the required force.

BODY POSITIONING PRINCIPLES

The primary aims of body positioning are to ensure a valid test is completed while providing options for ergonomic positioning to suit various users.

As stated in the selection of contact points section, the hammer and geophone are required to be located on the face of the pole no more than 100mm above ground level.

The following positioning steps are provided as a reasonable guide to allow a valid test result to be obtained.

- Choose which hand you prefer to hold the geophone and hammer. Users typically find it easier to hold the geophone in their non-dominant hand and the hammer in their dominant hand.
- Kneel down close to the pole. Knees should be no more than 300 or 400mm from the pole to allow for comfortable use of Thor.
- The knee on the geophone side can be either on the ground or raised (i.e. foot on the ground), whichever is most comfortable for the user.
- The knee on the hammer side can be either on the ground or raised (i.e. foot on the ground), whichever is most comfortable for the user.
- The users head is located on the hammer side of the pole to allow clear vision of the strike area and thus ensure a flush strike.
- Place the Mobile device on the hammer strike side of the pole to allow vision of the screen during the test.

Suggested Body positioning for one knee down and other knee supporting geophone arm.

The geophone is not a microphone and must be held level against the pole with medium force to allow correct operation. The App provides visual and audible feedback to ensure these parameters are met during testing.

Once the geophone has been located on the selected contact point for a test, it must remain in place for the duration of the test. Where a pole is being tested multiple times, the geophone may be removed and relocated on the pole in between complete tests.

It is important that users are aware the contact points are permitted to be changed between completed tests but not during an individual test.

Suggested Body positioning for both knees down

6.4.2 PRINCIPLES OF GEOPHONE APPLICATION

Place your palm over the end of the geophone and press against the pole. To help with stability and ensure close proximity to the ground, it is recommended your fingers wrap around the geophone and rest your knuckles on the ground.

6.4 Geophone

6.4.1 GENERAL

To allow Thor to analyse the pole health, the geophone is held against the pole at the selected contact point to allow receipt of the impulse waves created by the hammer.

Movement of the knuckles can assist with altering the level of the geophone. Once the geophone is seen to be held level (as displayed on the screen), slowly apply pressure against the pole until the App indicates sufficient force has been applied.

Note; it is possible to apply too much force, in which case the App will indicate to lower the force with an arrow away from the pole.

6.5 Hammer

6.5.1 GENERAL

The Thor impulse hammer strike on a pole generates stress/impulse waves that travel the total length of the pole and are received by the geophone.

A minimum of four hammer strikes is required to complete each test. The force of the hammer strike is required to be between 4000 and 10000 Newtons. The Thor unit assesses the strength of the strikes and will not accept strikes outside of this range and requests additional hits where this occurs.

The condition of the pole also impacts the force of the strike required. A pole in poor condition may require the user to increase force for the hit to be within the parameters. Conversely the user may need to strike the pole more softly where the pole is hard or in good condition.

Note: While the user is unable to identify the exact force applied, optimal force is around the middle of the range at 7000 Newtons. Where a tester regularly receives a strike harder message, it is advisable to increase the force of the regular hit. Conversely where the user regularly receives the strike softer message, it is advisable to reduce the strength of the regular strike.

This will ensure a test is completed with the optimal amount of hits and in a shorter period.

6.5.2 PRINCIPLES OF HAMMER APPLICATION

- Grip the hammer firmly.
- Commence with the hammer head 300 to 400mm away from the pole. Using the arm rather than the wrist to swing the hammer assists with a completing a flush strike
- The head of the hammer is required to strike the pole: Flush/square
- In line with the geophone (approximately180 degrees)
- With reasonable (medium) force
-
- A strong rebound and crisp sound will confirm a flush strike
- Undertake a minimum of four strikes approximately 3 seconds apart
- The App will advise when the next strike can commence.
- The App will advise where additional hits are required. (Refer to the 'Testing Process' section for further information)

6.6 PHI™ Background

The following information is a brief overview of how Thor assesses pole health.

THOR calculates an indicative pole diameter from the stress wave data based on the theoretical average material properties of the timber. Thor compares the generated indicative diameter value with the actual diameter value and derives its PHI™ value (%).

For asset management decisions, the specific PHI™ test results should be referred to in the portal rather than relying on the colour coding that is displayed on the screen.

6.7 Out of Context Results

It is important for trained users to complete the Thor testing as per the application and technique requirements set out in this manual.

Where users depart from the standard Thor application and technique requirements, the test result data may diverge from the expected Thor results.

Some examples are:

- Incorrect pole diameter (inputted into Thor)
- Contact points on large cracks
- Changing contact points during test
- Contact points > 100mm above ground
- Contact points not at approximately 180 degrees
- Frozen poles (operating below zero degrees Celsius)
- Cobra aluminium bandages at ground level

Cobra bandage (metal wrap) on pole

Appendix 5 – LV Pole Depth – "Installation Depth Monitoring System"

The following installation depth monitoring system was introduced in response to an incident involving the non-authorized removal of a section of pole below the 3m gouge mark on an LV Pole. It was determined that this action compromised the ability for future line staff / inspectors to determine the true sinking depth of the pole putting them at risk if climbing was attempted.

For detailed information on the required sites where this system shall be deployed, please see NSP/004/041 – "*COP for the Construction of LV ABC Overhead Lines*" and NSP/004/041/001 – "*COP for the renovation of LV Overhead Lines*".

However, the basic principles for their future expected use and thus the subsequent need to carry out inspections shall be based on the following logic:-

The system shall be employed on all sites where new or replacement poles are being installed in "land locked" i.e. where it is not possible to gain access to the poles using MEWP's and or it is anticipated that the poles may not have been installed using mechanical digging equipment, thus the risk of incorrect installation or interference with the normal pole sinking depth indication systems may have been compromised.

Method of installing 20mm plastic conduit onto the base of a LV pole to allow future monitoring of the pole sinking depth.

A standard 2.3m length of conduit shall be cut to length so that approx. 100mm of conduit will be left showing above the proposed finished ground level following reinstatement.
The conduit shall be secured to the pole with a minimum of 5 x 65mm Galvanized staples, making sure that the bottom end is flush with the butt of the pole and the top is accessible and will not interfere with any other required pole cables or capping.
Both ends of the conduit shall be effectively plugged to stop soil and debris filling the tubing.

To measure the pole sinking depth using this system
Removing the top cap to allow access, a non-conductive draw tape/wire, marked up with a piece of coloured tape located 3m from the end shall be slid into the conduit until the bottom of the conduit is felt. Then the draw tape shall be extended up the pole towards the pole identification gouge mark area. The coloured tape on the draw tape should align with the 3m gouge mark on the pole. If the tape marker extends beyond this point, then further investigation will be required as the pole is unlikely to be installed at the correct sinking depth. Note actual sinking depth will be 3m minus the distance between the tape marker and the pole ground line.

Appendix 6 - Northern Powergrid - Historical Pole Type Classification Table

Length of Pole			Light			Medium			Medium Stout			Stout			Extra Stout		
Approx. Conv. In (M)	Fee t	Range of Pole Sink Depths (M)	Dia. at top (mm)		Min Dia 1.5m from Butt (mm)	Dia. At top (mm)		Min Dia 1.5m from Butt (mm)	Dia. at top (mm)		Min Dia 1.5m from Butt (mm)	Dia. at top (mm)		Min Dia 1.5m from Butt (mm)	Dia. at top (mm)		Min Dia 1.5m from Butt (mm)
			Min	Max		Min	Max		Min	Max		Min	Max		Min	Max	
8.5	28	1.5 - 1.8	127	152	177	146	177	215	158	203	241	190	241	266	228	-	292
9.0	30	1.5 - 1.8	127	152	184	152	184	222	158	209	247	190	241	273	228	-	298
10.0	32	1.5 - 1.8	127	158	184	152	184	238	165	209	254	190	247	279	228	-	304
10.5	34	1.5 - 1.8	127	158	184	152	184	234	165	209	260	190	247	285	241	-	317
11.0	36	1.5 - 1.8	127	165	196	152	184	241	165	215	266	190	247	292	241	-	323
11.5	38	1.8	127	165	196	152	184	247	177	228	273	190	247	298	241	-	330
12.0	40	1.8	127	165	8.0	152	184	247	177	228	273	190	247	304	241	-	342
13.0	42	2.1	-	-	-	158	184	260	177	228	285	190	247	317	241	-	342
14.0	45	2.1	133	171	203	165	203	273	177	228	285	196	254	330	241	-	355
16.0	50	2.4	133	177	241	165	209	285	177	234	317	196	260	349	241	-	374
17.0	55	2.4	-	-	-	177	222	317	184	234	342	203	266	374	241	-	400
18.0	60	2.4	-	-	-	177	222	336	190	247	361	203	266	393	241	-	419
20.0	65	3.0	-	-	-	177	228	353	196	247	381	203	266	412	241	-	419

Notes:

1. This table shall only to be used where poles are not already classified with pole scarfings to determine the modern equivalent pole grade and height