Testing of High Voltage Cables

Manual

Horizon Power 1st Edition
February 2013

Prepared by
Field Practices
Safety & Health
### DOCUMENT CONTROL

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* Must be the Process Owner and is the person assigned authority and responsibility for managing the whole process, end-to-end, which may extend across more than one division and/or functions, in order to deliver agreed business results.

** This person will have the power to grant the process owner the authority and responsibility to manage the process from end to end.

*** Frequency period is dependent upon circumstances—maximum is 5 years from last issue, review, or revision whichever is the latest. If left blank, the default will be 1 year unless otherwise specified.

### STAKEHOLDERS

| The following positions must be consulted if an update or review is required: |
| Work Delivery Coordinators |
| Network Asset Management Coordinators |
| Engineering & Projects |

### NOTIFICATION LIST

| The following positions must be notified of any authorised change: |
| Regional Managers |
| Manager Asset & Works |
| People Development - HR |
Important Notice to Users

This Testing of High Voltage (HV) Cables manual has been developed for use by Horizon Power employees’ and Service Providers engaged to perform construction and maintenance work on Horizon Powers’ underground networks.

This manual has been developed to provide guidelines for a minimum acceptable standard of testing that is required by Horizon Power. To this end, this manual provides the framework by which auditing of the Testing of HV Cables may be undertaken.

It is issued by as a controlled document by Horizon Power to Horizon Power employees’ and Service Providers on the condition that it will only be used whilst undertaking Testing of HV Cables work on Horizon Power networks.

Testing of HV Cables work will only be performed by individuals who are appropriately trained and qualified in accordance with accepted standards within Horizon Power. This Manual is not intended, and should not in any way be relied upon, as a substitute for such training.

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1 PURPOSE

The purpose of this manual is to provide general instruction on how to conduct tests on HV Cables for System Voltages up to 33 kV.

This document refers to other Horizon Power documents to provide reference standards for underground cable installation work.
This Page Not Used.
2 SCOPE

This manual has been developed for use by authorised Horizon Power employees’ and Service Providers engaged in Testing of HV Cables on the Horizon Power electrical networks.

Horizon Power employees’ and Service Providers shall comply with these requirements, except as otherwise approved.
3 GENERAL REQUIREMENTS

All personnel engaged in performing Testing of HV Cables must observe general safety precautions in accordance with the requirements of Horizon Powers’ (HP) Field Instruction Procedures & Standards Manual (FIPSM), HP Testing & Commissioning Manual (DM# 3127547v5) and other applicable policies, guidelines and statutory requirements.

This document should also be read and followed in conjunction with HP Electrical Safety Standards (DM# 3061083v3).

3.1 Training and Authorisation

Testing of HV Cables work shall only be performed by individuals who are appropriately trained, qualified and authorised in accordance with accepted standards within Horizon Power.

Service Providers are responsible for ensuring all its employees’ and Sub-Contractor employees’ have been authorised by Horizon Power. They must submit to Horizon Powers site representative confirmation of authorisation for each employee, prior to the commencement of the works.

Note: This Manual is not intended, and should not in any way be relied upon, as a substitute for training.

3.2 Job Planning and Risk Assessments (Work Planning)

Prior to the commencement of the work, an on-site job risk assessment must be undertaken by all Horizon Power and Service Provider team members in accordance with Horizon Powers Job Risk Assessment Process and Field Instruction – FI 2.23 – Job Hazard & Risk Assessment, to ensure all aspects of our “work” is carried out in a safe manner.

The on-site job risk assessment shall include but not limited to:

- Identify and discuss the job hazards;
- Assess the risks that may result because of the hazard;
- Agree on the tasks assigned to control or remove the hazards & risks; and
- Implement the control measures

3.3 Personal Protective Equipment (PPE)

Horizon Power and Service Provider employees’ performing Testing of HV Cables on the Horizon Power electrical networks shall wear the Personal Protective Equipment (PPE) as required in accordance with Horizon Power’s Minimum Personal Protective Clothing and Footwear Standard and relevant Field Instructions.
This includes but not limited to:

- Long sleeve overalls or long sleeve shirts and trousers with High Visibility properties for day and night – AS/NZS 1906.4:1997;
  - Have properties not inferior to 100% cotton drill;
  - Minimum material weight of 185gsm;
- Safety footwear to comply with AS 2210 and Horizon Power Field Instruction 2.6 - Worksite Clothing/PPE Requirements
- Safety glasses must be worn in accordance with Horizon Power’s Field Instruction 2.5 - Wearing of Eye Protection
- Safety Helmets must be worn in accordance with Horizon Power’s Field Instruction 2.2 - Wearing of Safety Helmets

3.4 Contractor Responsibilities

The Contractor is to provide qualified and competent personnel to undertake Testing of HV Cables.

All Contractor personnel utilised to carry out work activities on or near Horizon Powers electrical networks must have Horizon Power authorisation prior to the commencement of the Services.

3.5 Traffic Management

Horizon Power and Service Providers shall ensure that where Services are sited adjacent to existing roads, adequate precautions are taken at all times to protect personnel, associated plant, and the general public.

Horizon Power and Service Providers shall comply with the Main Roads Department Traffic Management for Road Works Code of Practice and Horizon Powers’ Field Instruction – FI 2.15 - Temporary Safety Barriers and/or Warning Signs (DM# 3136675)

All vehicles shall be fitted with suitable warning lights.

3.6 Instructions, Procedures and Standards

Horizon Power and Service Providers shall comply with Horizon Power instructions, procedures and standards when engaged in performing Testing of HV Cables on the Horizon Power electrical networks.

This includes but not limited to the following Horizon Power documents:

- Selected Horizon Power Field Instructions and Work Procedures
- Electrical Safety Standards (ESS)
- “Fit for Work” Policy
- Minimum Personal Protective Clothing and Footwear Standard
- Job Risk Assessment Procedure
- Hazard Incident Reporting Notification and Investigation Procedure
- Testing & Commissioning Standard
Copies will be provided to Service Providers at pre-star meetings, prior to the commencement of the works.

3.7 Environmental Aspects and Implications

No environmental aspects and implications associated in this document.
This Page Not Used.
4 REFERENCES

FIPSM

HP Testing and Commissioning Manual

Switching Operation Manual

Manufacturer’s Operating Manual for VLF Test Set

AS 1429.1 – 2000 CENELEC HD 620 VDE DIN 0276 / 620 IEEE P400.2, National and International Cable and Cable Test Standards

Network Testing and Commissioning Standards DM # 3127547
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5    TOOLS AND TEST EQUIPMENT

There are currently several types of HV Cable test equipment used by Horizon Power. These are

1. kV Insulation Resistance Tester
   - Megger – MT 510
   - Megger - BM 15
   - Metrel
   - Uni Lap Geox
   - AMEC model 5050
   - Fluke 1550B 5kV
   - Fluke FLU1503 1kV

2. VLF (0.1 Hz) Test Sets
   - HVA60 – 4 in 1 Universal HV Test System

3. Earth leads, Shorting leads

Note: Some test equipment is required to be calibrated each year to maintain reliability of test values and results. Please check the manufacturers operating manual for calibration requirements.
This Page Not Used.
6 RESPONSIBILITY

6.1 Permit Issuing Officer

The ‘Issuing Officer’ must be competent and capable of carrying out his/her responsibilities safely.

The ‘Issuing Officer’ is responsible for the following:

- Ensuring all permits are registered with HPCC
- Ensuring that the condition of the equipment covered by the permit meets ESI requirements for the work to be undertaken.
- Ensuring that there are no other current permits that may interfere with the intended work.
- Installing barriers, as necessary, to clearly define the work area.
- Describing and, where practicable, showing the ‘Recipient in Charge’ and the initial ‘Recipients’ the following:
  1. Limits of the work area
  2. Isolating arrangements
  3. Location of the applied programme earths
  4. Adjacent live points.
- Producing a legible permit with a precise description of the conditions under which it is being issued and received.
- Cancellation of the permit, first ensuring that all ‘Recipients’ have been accounted for and that the permit is relinquished by the ‘Recipient in Charge’.

6.2 Tester in Charge

The ‘Tester in Charge’ is the authorised tester to whom a Sanction to Test permit has been issued.

The ‘Tester in Charge’ is responsible for the following:

- Ensuring that all HV testing is carried out in accordance with the requirements of this ‘Voltage Testing of HV Cables’ manual.
- Ensuring that isolation (including secondary isolation) and earthing have been carried out and are adequate for the safe performance of the intended work.
- Ensuring that all members of his/her work party sign on and understand the conditions imposed by the permit.
- Ensuring that all members of his/her work party are trained and fully capable of working safely.

- Ensuring that all subsequent staff arrivals and departures are included in the permit signing on and off arrangements and are aware of the conditions.

- Ensuring that all members of the work party are informed of any change in conditions under which the party is working.

- Ensuring the safety of adjacent work parties, by informing the senior member when equipment is due to be energised.

- Obtaining permission from the permit ‘Issuing Officer’, if equipment is to be operated, earths are to be removed or additional earths are to be fitted. (This may be given in writing on the permit when it is first issued).

- Relinquishing the apparatus in the same condition in which it was received, whenever possible, or advising the ‘Issuing Officer’ and entering details of any changes on the ‘relinquishment’ section of the permit.

- Ensuring that all members of the work party sign off on completion of the work. With the permission of the Operating Authority, and under exceptional circumstances, the ‘Tester in Charge’ may sign off on behalf of an absent ‘Recipient’, making sure that adequate precautions are then taken to prevent the absentee from approaching the apparatus.

- Notifying the ‘Issuing Officer’ that the work has ceased and all personnel have left the site.

6.3 Recipients

The ‘Recipient’ is responsible for the following:

- Ensuring that they understand completely the permitted area of access.

- Knowing the isolation points.

- Knowing where earthing has been carried out and being satisfied that it is adequate.

- Knowing which are the adjacent live points.

- Ensuring that they sign on the permit (where necessary) in a legible manner, before the stipulated work commences.

- Checking the current working conditions with the ‘Recipient in Charge’, after temporary absence from the work site.

- Ensuring that they sign off the permit (where necessary) after completion of work.
6.4 Cable Tester

The ‘Cable Tester’ is the authorised tester who has been appropriately trained and authorised to conduct Testing of HV Cables in accordance with accepted standards within Horizon Power.

It is the responsibility of the ‘Cable Tester’ to have a clear understanding and comply with the requirements of this ‘Voltage Testing of HV Cables’ manual.
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7 SAFETY PRECAUTIONS AND INSTRUCTIONS

7.1 Safety Requirements

Job Risk Analysis must be done by the work team before commencing any switching and tests in the vicinity of the underground cables and all parties concerned are in agreement upon that assessment.

The tester in charge shall ensure that drawings are made available to familiarise himself with the work area and equipment locations prior to commencing work.

The ENMAC switching schedule has been completed or followed and the EAP has been cancelled.

The Issuing Officer issues a STT, indicating the circuit to be tested and the isolation points. Under no circumstance shall any high voltage testing be carried out prior to the STT permit being issued.

Ensure that appropriate PPE’s shall be worn at all times while undertaking this task.

To avoid the possibility of accidentally detaching or disconnecting the earth connection to the test equipment while performing high voltage testing, constant vigilance and care should be taken while undertaking this task.

Ensure to connect a local earth on the test equipment, if practicable. The case earth must remain connected to the system earth in order to maintain an acceptable single earth potential.

Never use the test set in an explosive atmosphere.

Record and control any shorting medium used by entering the Shorting Points, the Date/Time installed, Installed By, Date/Time Removed and Removed By, in section 3 of the HV XLPE Cables Test Report form. (refer Appendix ‘B’)
7.2 Cable Testing between Two Ring Main Units

Flowchart - Cable Testing between Two Ring Main Units (RMU to RMU)

- **JRA by Work Team**
- **SWITCHING PROGRAM Completed/Followed & EAP CANCELLED**
- **SWITCHING ISOLATION POINTS OFF D/L AND EARTHS SWITCH ON D/L**
- **ISSUING OFFICER ISSUE STT**
- **CHECK CABLE STATE USING NVI AT CAP TEST POINTS AND CONFIRM CHECK ON ELBOW CAP POINTS USING MODIEWARK**
- **CABLE ENERGISED**
- **YES**
  - **TESTER IN CHARGE CONFIRMS EARTH SWITCH ARE ON D/L THEN PLUG TEST LEADS**
  - **CABLE IS TESTED THEN DISCHARGE EARTH SWITCH ARE ON AND THEN REMOVE TEST LEADS**
- **NO**
  - **OPERATOR CANCELS STT**

**RING MAIN UNIT**

**FEEDER CABLE**
Instruction:

1. Before accessing the test points, the Cable Tester to confirm the isolation position and earth switches are on and danger labelled at all ends of the cable and the information written on the STT permit is correct.

2. Checking the state of the cable and switch Labelled if it is energised or de-energised by looking at the continuous monitoring device Neon Voltage Indicator attach to the RMU test points.

3. Confirm that the cable is de-energised by removing the cap of the elbow. Set the modiewark at 240 V range and place the modiewark where capacitive test point sits. The test leads can be connected to the apparatus under test. The earth switches are then lifted/off and danger labelled by the Cable Tester.

**CAUTION**

If the cable to be tested is proven energised **cancel the test** and refer the status to the Switching Operator/Issuing Officer for review.

4. Ensure that the assistant “Safety Observer” is aware of the “emergency off” procedure.

5. Isolate the cable from all equipment before testing, if practicable.

6. Where it is not possible to isolate the cable from other equipment, ensure that Surge Arresters and VT”s are disconnected from the cable.

7. Be aware of possible overstressing of the insulation when the cable remains connected to switchgear and the line side of the Breaker is left energised.

8. It is always preferable to test the cable separately. In that way the cable can be test to the manufacturers rating rather than the system voltage to which it is connected.

9. If the cable cannot be disconnected, the applied test voltage must be selected to suit to apparatus still connected. The lowest rating of the equipment determines the maximum test voltage that can be applied. (e.g. if a 22 kV cable is connected to 11 kV switchgear, then the test voltage for 11 kV cables applies).

10. Nearby isolated and de-energised equipment such as capacitors, transformers and spare cables must be short circuited and earthed to prevent charge build-up.

11. Clearly identify the cable from end to end before connecting the test equipment into the cable. Safely secure each end of the cable prior to testing, if not practicable, then safety observers shall be used.
12. Use suitable barriers, barricades and warning signs on both sides of the cable to prevent access to the cable by persons not involved with the testing. If there is any danger of exposing the public or staff to energised conductors or equipment a safety observer must be used.

13. For SF6 gas insulated switchgears, ensure that SF6 gas indicator is on the "green" line or within the operating gas pressure as indicated in the nameplate data. If the gas pressure is below the "green" line or recommended operating pressure, the cable should not be tested while connected to the switchgear with the line side energised.

14. The cable is tested (SI, IR and VLF) then discharged. Close the Earth switch; the test set leads are then removed.

15. The tester in charge relinquishes the STT and the Issuing Officer cancelled the STT.

**WARNING**

Testing multiple cables through RMU’s part live is not recommended.
7.3 Cable Testing between Ring Main Unit and Pole Top Termination Cable or Between Pole Top Terminations

*Flowchart - Cable Testing between Ring Main Unit and Pole Top Termination Cable (RMU to PTS)*

**Flowchart Description:**

1. **JRA by Work Team**
2. **REVIEW**
   - **YES**
   - **NO**
3. **CABLE ENERGISED**
   - **AC**
   - **CHECK CABLE STATE USING NVI AT CAP TEST POINTS AND CONFIRM CHECK ON ELBOW CAP POINTS USING MODIEWARK**
4. **TESTER IN CHARGE CONFIRMS EARTH SWITCH ARE ON D/L THEN PLUG TEST LEADS**
5. **CABLE IS TESTED THEN DISCHARGE, EARTH SWITCH ARE ON AND THEN REMOVE TEST LEADS**
6. **ISSUING OFFICER CANCELS EAP**
7. **ISSUING OFFICER ISSUE STT**
8. **SWITCHING ISOLATION POINTS OFF AND EARTH SWITCH ON D/L PORTABLE EARTHS ARE PLACED AT POLE TOP TERMINATION**
9. **SWITCHING PROGRAMME Completed Followed & EAP CANCELLED**
10. **ISSUING OFFICER CANCELS EAP**

**Diagram Notes:**

- **Ring Main Unit**
- **POLE TOP SWITCH**
- **FEEDER CABLE**
- **OVERHEAD LINE**
- **TX**
Instruction:

1. Check that the switching isolation points are off and danger labelled, the earth switch is on danger labelled and portable earths are placed at the pole termination. (Ensure HV taps are removed from cable termination.)

2. Ensure cables from pole top termination are removed or separated from Surge Arresters.

3. The Issuing Officer cancels the EAP and issue a STT, indicating the circuit to be tested and the isolation points. Under no circumstance shall any high voltage testing be carried out prior to the STT permit being issued.

4. Checking the state of the cable if it is energised or de-energised by looking at the continuous monitoring device [Neon Voltage Indicator] attached to the RMU test points.

5. Confirm that the cable is de-energised by removing the cap of the elbow, Set the modiewark at 240 V range and place the modiewark where capacitive test point sits. The test leads can be connected to the apparatus under test. The earth switches are then lifted/off and danger labelled by the Tester in charge.

6. The Cable Tester to confirm earth switch is on and danger labelled at all ends before accessing the test points. The test leads can be connected to the apparatus under test. The earth switches are then lifted/off and danger labelled by the Tester in charge.

7. Record and control any shorting medium used as per section 7.1.
8. Ensure that the assistant “Safety Observer” is aware of the “emergency off” procedure.

9. Isolate the cable from all equipment before testing, if practicable.

10. Where it is not possible to isolate the cable from other equipment, ensure that Surge Arresters and VT’s are disconnected from the cable.

11. Be aware of possible overstressing of the insulation when the cable remains connected to switchgear and the line side of the Breaker is left energised.

12. It is always preferable to test the cable separately. In that way the cable can be tested to the manufacturers rating rather than the system voltage to which it is connected.

13. If the cable cannot be disconnected, the applied test voltage must be selected to suit to apparatus still connected. The lowest rating of the equipment determines the maximum test voltage that can be applied. (e.g. if a 22 kV cable is connected to 11 kV switchgear, then the test voltage for 11 kV cables applies).

14. Nearby isolated and de-energised equipment such as capacitors, transformers and spare cables must be short circuited and earthed to prevent charge build-up.

15. Clearly identify the cable from end to end before connecting the test equipment into the cable. Safely secure each end of the cable prior to testing, if not practicable, then safety observers shall be used.

16. Use suitable barriers, barricades and warning signs on both sides of the cable to prevent access to the cable by persons not involved with the testing. If there is any danger of exposing the public or staff to energised conductors or equipment a safety observer must be used.

17. For SF6 gas insulated switchgears, ensure that SF6 gas indicator is on the “green” line or within the operating gas pressure as indicated in the nameplate data. If the gas pressure is below the “green” line or recommended operating pressure, the cable should not be tested while connected to the switchgear with the line side energised.

18. The cable is tested (SI, IR and VLF) then discharged. Earth switch is closed; the test set leads are then removed.

19. The tester in charge relinquishes the STT and the Issuing Officer cancelled the STT and issue EAP to reconnect cable at the surge arrestors and HV Taps.
7.4 Cable Testing between Ring Main Fuse and Distribution Transformer

Flowchart – Cable Testing between Ring Main Fuse and Distribution Transformer

1. JRA by Work Team
2. REVIEW
3. SWITHCING PROGRAMME Completed/ Followed & EAP CANCELLED
4. LV 415 VOLT TRANSFORMER AND SWITCHING ISOLATION POINTS ARE OFF DANGER LABELLED
5. EARTH SWITCH IS ON AND DANGER LABELLED
6. CHECK CABLE STATE USING NVI AT CAP TEST POINTS AND CONFIRM CHECK ON ELBOW CAP POINTS USING MODIEWARK
7. TESTER IN CHARGE CONFIRMS EARTH SWITCH ARE ON D/L THEN PLUG TEST LEADS
8. CABLE IS TESTED THEN DISCHARGE, EARTH SWITCH ARE ON AND THEN REMOVE TEST LEADS
9. ISSUING OFFICER CANCELS STT

RINGS MAIN UNIT

Distribution Transformer

LV CABLE
LV BOARD

LV 415 VOLT TRANSFORMER

SWITCHING ISOLATION POINTS

EARTH SWITCH

DANGER LABELLED
Instruction:

1. Confirm the LV 415V transformer disconnects are off and danger labelled.

2. Confirm the switching isolation point is off and danger labelled, the earth switch is on and danger labelled.

3. The Issuing Officer issue a STT, stating the circuit to be tested and the isolation points. Under no circumstance shall any high voltage testing be carried out prior to the STT permit being issued.

4. Checking the state of the cable if it is energised or de-energised by looking at the continuous monitoring device [Neon Voltage Indicator] attach to the RMU test points.

5. Confirm that the cable is de-energised by removing the cap of the dead break elbow, Set the modewark at 240 V range and place the modewark where capacitive test point sits. The test leads can be connected to the apparatus under test. The earth switches are then lifted/off and danger labelled by the Tester in charge.

6. The Cable Tester to confirm the earth switches are switched on and danger labelled from both ends, prove the isolation of the transformer then removed the dead break elbow connector prior connecting the test leads.

7. Record and control any shorting medium used as per section 7.1.

**CAUTION**

If the cable to be tested is proven energised cancel the test and refer the status to the Switching Operator/Issuing for review.

Figure 2 – Voltage detector in capacitive test position
8. Ensure that the assistant “Safety Observer” is aware of the “emergency off” procedure.

9. Isolate the cable from all equipment before testing, if practicable.

10. Where it is not possible to isolate the cable from other equipment, ensure that Surge Arresters and VT’s are disconnected from the cable.

11. Be aware of possible overstressing of the insulation when the cable remains connected to switchgear and the line side of the Breaker is left energised.

12. It is always preferable to test the cable separately. In that way the cable can be test to the manufacturers rating rather than the system voltage to which it is connected.

13. If the cable cannot be disconnected, the applied test voltage must be selected to suit to apparatus still connected. The lowest rating of the equipment determines the maximum test voltage that can be applied. (E.g. if a 22 kV cable is connected to 11 kV switchgear, then the test voltage for 11 kV cables applies).

14. Nearby isolated and de-energised equipment such as capacitors, transformers and spare cables must be short circuited and earthed to prevent charge build-up.

15. Clearly identify the cable from end to end before connecting the test equipment into the cable. Safely secure each end of the cable prior to testing, if not practicable, then safety observers shall be used.

16. Use suitable barriers, barricades and warning signs on both sides of the cable to prevent access to the cable by persons not involved with the testing. If there is any danger of exposing the public or staff to energised conductors or equipment a safety observer must be used.

17. For SF6 gas insulated switchgears, ensure that SF6 gas indicator is on the “green” line or within the operating gas pressure as indicated in the nameplate data. If the gas pressure is below the “green” line or recommended operating pressure, the cable should not be tested while connected to the switchgear with the line side energised.

18. The cable is tested (SI, IR and VLF) then discharged. Earth switch is closed; the test set leads are then removed.

19. The tester in charge relinquishes the STT and the Issuing Officer cancelled the STT.
8 CABLE TEST PROCEDURES

Test requirement for high voltage XLPE feeder cables are:

1. Outer Sheath Integrity (SI) Test
2. Insulation Resistance (IR) Test
3. Very Low Frequency (VLF) Test

Test requirement for high voltage XLPE transformer cables, which has ≤250 metres long and without in-line joint, are:

1. Outer Sheath Integrity (SI) Test,
2. Insulation Resistance (IR) Test

Test requirement for new XLPE high voltage transformer cables, >250 metres and with in-line joint, are:

1. Outer Sheath Integrity (SI) Test
2. Insulation Resistance (IR) Test
3. Very Low Frequency (VLF) Test

8.1 Outer Sheath Integrity (SI) Test

Carry out Sheath Insulation test on the cable as per Test Criteria in section 9 and the procedure below.

1. Isolate the cable screen from earth potential at each end of the cable.
2. Ensure that cable screens and drain wire at each ends are clean and well clear of earth potential.
3. Ensure that you have sufficiently discharge the cable with discharge stick and safety earth leads on the cable prior to testing.
4. Connect the Insulation Resistance Tester or dc Test Set and the safety earth to the cable to be tested
5. Ensure all persons have vacated the test area and are outside the safety barriers.
6. Inform Safety Observers that testing is about to commence.
7. Remove the safety earth prior to applying test voltage to the cable screen.
8. Carry out Insulation Resistance Test. If the cable is less than 1 km long a charging time of one minute is sufficient. If the cable length exceeds 1 km the charging time is 5 minutes.
9. Record the measured values on the test report. (refer sample in Appendix B)

10. Switch off insulation resistance tester or dc test set and allow the cable to discharge via the instrument internal discharge facility, and confirm cable have been discharged and safe to work on.

11. Apply safety earth to the cable screen, then remove test set leads

**Note:** This test is only applicable to XLPE cables.

### 8.2 Insulation Resistance (IR) Test

Carry out Insulation Resistance test between each conductor to screen and earth, for each phase as per test connection below:

1. RØ to WØ & BØ & Earth
2. WØ to RØ & BØ & Earth
3. BØ to RØ & WØ & Earth.

1. Ensure that you have sufficiently discharge the cable with discharge stick and safety earth leads on the cable prior to testing.

2. Inform safety observer/s (where present) that testing is about to commence.

3. Ensure all personnel engaged in performing this task must have vacated the test area and are outside the safety barriers.

4. Ensure to remove the safety earth or earth switch on cable to be tested prior to testing, if present.

5. Ensure all persons have vacated the test area and are outside the safety barriers.

6. Inform Safety Observers that testing is about to commence.

7. Switch off insulation resistance tester or dc test set and allow the cable to discharge via the instrument internal discharge facility, and confirm cable have been discharged and safe to work on.

8. Record the measured values on the test report. (refer Appendix ‘B’ – DM 3287471v5)
8.3 Very Low Frequency (VLF) Test

VLF tests can be performed in frequency ranges from 0.01 Hz to 1 Hz. A typical test frequency level of 0.1 Hz is recommended for use on all high voltage cable testing, as applicable.

**Note:** High voltage tests may only be conducted using an approved VLF test set. All VLF tests shall be conducted using a frequency level of 0.1 Hz, as applicable.

1. Connect the VLF test set to the cable to be tested as per Figure 4 below.

   ![Figure 3 - Test setup for a 3 phase cable](image)

   **Local earth**

   The set-up shown is preferred and is designed to reduce the magnitude of travelling waves in case of flashover or puncture. It is however acknowledged that this is sometimes not possible. (e.g. cable terminated onto switchgear).

2. Ensure that all HV connections are either well clear of earth or are well-insulated using live line covers.

3. Ensure that cable screens and drain wire at both ends of the cable are earthed.

4. Inform safety observer/s (where present) that testing is about to commence.
Refrain from carrying out successive VLF measurements to prevent possible overstressing of cable insulation, as applicable.

Do not subject High Voltage XLPE cables to dc hi-pot test.

Ensure all personnel engaged in performing this task must have vacated the test area and are outside the safety barriers.

Ensure that you have removed the safety earth or earth switch on the cable to be tested prior to testing, if present.

The testing voltage may be changed in consultation with the customer fully understanding that reducing the test voltage limits the ability of the test to detect faults.

Any reduction from the acceptance test level shall not be permitted in conjunction with any reduction of the time from 60 minutes.

5. Energise HV output of respective VLF test set used as per test equipment operating manual and apply the required test voltage as per tables 1-3 in Appendix ‘A’.

Note: Maintenance test voltage is 80% of the acceptance test voltage level. This value is ONLY to be used for cables that have already been in service.

6. The agreement must be noted on the report and the test time adjusted (also on the report) to what is agreed with the customer.

The time may vary from 30 to 60 minutes depending on limited hours of shutdown / outage, bad weather condition, or other aspect/s that may possibly affect the duration of testing. Reducing the test time is ONLY to be used in extreme circumstances when the return of supply is of a critical nature to the customer.

In most cases, the test duration of 60 minutes is to be adhered to, to ensure adequate water tree growth. Reduction of the test time can ONLY be applied with Acceptance test voltages.
CAUTION

If there is any evidence of termite damage, or water treeing is suspected, or the cable is more than 30 years old, the voltage shall be adjusted to 60% of the acceptance test voltage level.

This must be noted on the Cable Test report form.

Alternately the cable can be ‘Soaked’ by applying the nominal rms voltage for a period of 24 hours.

This must also be noted on the Cable Test report form.

Note: It is important that the kV meter is observed throughout the test.

Some VLF test units may not trip out in case of cable failure. The only indication that the cable insulation breakdown occurs is that the VLF kV meter will read a reduced voltage.

7. When testing is interrupted, reset timer to zero and restart the VLF test.

8. Slowly reduce the applied voltage to 0 and switch off HV supply after the completion of the test.

9. Apply safety earth or earth switch to the cable before disconnecting the test lead and shorting medium from the cable under test.

Note:

If the cable fails the VLF test and the cable cannot be returned to service, the ‘Tester in Charge” shall:

- notify the customer
- where applicable, make note of the circumstances on the permit
- fill out the test report with applicable notes
- apply out of service tag

Fault location may be required.

10. Record the measured values on the HV XLPE Cables Test Report form. (refer Appendix ‘B’ – DM 3287471v5)
9 TEST CRITERIA

9.1 Outer Sheath Insulation Resistance (Applicable only for XLPE cables)

The integrity of the outer sheath is considered acceptable if the insulation resistance values are greater than 1000 MΩ for new XLPE cable or greater than 100MΩ for existing service cable.

Pass values at 5kV after 10 minutes

<table>
<thead>
<tr>
<th>New Cables</th>
<th>Cables older than 10 years</th>
</tr>
</thead>
<tbody>
<tr>
<td>&gt; 1000 MΩ</td>
<td>&gt; 100 MΩ</td>
</tr>
</tbody>
</table>

*Table 1 - Outer sheath Insulation Integrity*

If the above insulation resistance values cannot be achieved at 5kV, A dc High Voltage Withstand Test voltage of 4 kV per mm of specified thickness of outer sheath is to be applied with a maximum of up to 10 kV between the metallic sheath and outer electrode for a period of 1 minute.

The integrity of the outer sheath is considered acceptable if during the High Voltage Withstand Test, NO breakdown or disruptive discharge has occurred.

The test voltage should remain stable during the test and the test duration is 1 minute up to a maximum of 10 minutes.

9.2 Insulation Resistance Test

<table>
<thead>
<tr>
<th>Cable type</th>
<th>Typical IR results @ 5kV</th>
<th>Minimum IR results @ 5kV</th>
</tr>
</thead>
<tbody>
<tr>
<td>XLPE</td>
<td>&gt; 10 000 MΩ</td>
<td>&gt; 1000 MΩ</td>
</tr>
<tr>
<td>Mixed cables XLPE/PILC screened</td>
<td>&gt; 2 000 MΩ</td>
<td>&gt; 500 MΩ</td>
</tr>
<tr>
<td>Mixed cables XLPE/PILC belted</td>
<td>&gt; 500 MΩ</td>
<td>&gt; 200 MΩ</td>
</tr>
</tbody>
</table>

The difference in insulation resistance values between phases shall not exceed by 30% unless resistance values are greater than 10 000 MΩ. Depending on the length, age, type of termination or weather conditions, considerable lower insulation resistance values are possible. In some cases, lower insulation resistance values are acceptable provided that the cable under test can withstand the recommended test voltage. The typical IR results shown above are for cables not exceeding 1 000 metres long.

*Table 2 - Conductor Insulation Integrity Resistance Test*
9.3 Very Low Frequency (VLF) Test

The cable or test object must be able to withstand the applied test voltage (as per tables 1-3 in Appendix 'A') based on the agreed / recommended / approved test duration.
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## APPENDIX A – VLF TEST VOLTAGES

### VLF Test Voltages

#### Table 1 - VLF Test Voltages for Cosine- Rectangular Waveform

<table>
<thead>
<tr>
<th>Cable Voltage Designation (rms voltage in kV)</th>
<th>Acceptance test phase to ground (rms /peak voltage)</th>
<th>Maintenance test phase to ground (rms /peak voltage)</th>
</tr>
</thead>
<tbody>
<tr>
<td>3.8 / 6.6</td>
<td>11.5</td>
<td>9.2</td>
</tr>
<tr>
<td>6.35 / 11</td>
<td>19.0</td>
<td>15.2</td>
</tr>
<tr>
<td>12.7 / 22</td>
<td>38.0</td>
<td>30.4</td>
</tr>
<tr>
<td>19 / 33</td>
<td>57.0*</td>
<td>45.6</td>
</tr>
</tbody>
</table>

*Maximum output voltage for R20 System is 52 kV

**Note:** The cosine – rectangular waveform the **rms** is assumed to be equal to the **peak** value.

#### Table 2 - VLF Test Voltage for Sinusoidal Waveform – Peak Voltage

<table>
<thead>
<tr>
<th>Cable Voltage Designation (rms voltage in kV)</th>
<th>Acceptance test phase to ground (Peak voltage)</th>
<th>Maintenance test phase to ground (Peak voltage)</th>
</tr>
</thead>
<tbody>
<tr>
<td>3.8 / 6.6</td>
<td>11.5</td>
<td>9.2</td>
</tr>
<tr>
<td>6.35 / 11</td>
<td>19.0</td>
<td>15.2</td>
</tr>
<tr>
<td>12.7 / 22</td>
<td>38.0</td>
<td>30.4</td>
</tr>
<tr>
<td>19 / 33</td>
<td>57.0</td>
<td>45.6</td>
</tr>
</tbody>
</table>

#### Table 3 - VLF Test Voltage for sinusoidal waveform – RMS Voltage

<table>
<thead>
<tr>
<th>Cable Voltage Designation (rms voltage in kV)</th>
<th>Acceptance test phase to ground (rms voltage)</th>
<th>Maintenance test phase to ground (rms voltage)</th>
</tr>
</thead>
<tbody>
<tr>
<td>3.8 / 6.6</td>
<td>8.1</td>
<td>6.5</td>
</tr>
<tr>
<td>6.35 / 11</td>
<td>13.4</td>
<td>10.7</td>
</tr>
<tr>
<td>12.7 / 22</td>
<td>26.9</td>
<td>21.5</td>
</tr>
<tr>
<td>19 / 33</td>
<td>40.3</td>
<td>32.3</td>
</tr>
</tbody>
</table>

**Note:** Reduction of test times can only be carried out on acceptance test voltages.
## APPENDIX C - DEFINITIONS

<table>
<thead>
<tr>
<th>Term</th>
<th>Definition</th>
</tr>
</thead>
<tbody>
<tr>
<td>XLPE</td>
<td>Cross Linked Polyethylene</td>
</tr>
<tr>
<td>VLF</td>
<td>Very Low Frequency</td>
</tr>
<tr>
<td>Earth</td>
<td>Effective electrical connection to the general mass of Earth which may be achieved by way of connection to an existing earthing system on the site (where available), by connection to a means an buried metallic water pipe or by connection to a driven copper stake not less than 12mm dia x 500mm long.</td>
</tr>
<tr>
<td>Tester in Charge</td>
<td>A person authorised to receive and relinquish a Sanction to Test permit within the limits of their authorisation</td>
</tr>
<tr>
<td>Safety Observer</td>
<td>A competent person, not necessary employed with the HVL, assigned by the tester in charge whose sole function is to observe and warn against unsafe approach to live conductors.</td>
</tr>
<tr>
<td>Cable Tester</td>
<td>A competent person who has been appropriately trained and authorised to conduct Testing of HV Cables in accordance with accepted standards within Horizon Power.</td>
</tr>
<tr>
<td>Acceptance Test</td>
<td>A field test made after cable system installation, including terminations and joints but before the cable system is placed in normal service. The test is intended to detect installation damage and to show any gross defects or errors in installation of the system component.</td>
</tr>
<tr>
<td>Maintenance test</td>
<td>A field test made during the operating life of the cable system. It is intended to detect deterioration of the system and check the serviceability so that suitable maintenance procedures can be initiated.</td>
</tr>
<tr>
<td>SI</td>
<td>Sheath Integrity</td>
</tr>
<tr>
<td>IR</td>
<td>Insulation Resistance</td>
</tr>
<tr>
<td>JRA</td>
<td>Job Risk Analysis</td>
</tr>
<tr>
<td>STT</td>
<td>Sanction To Test</td>
</tr>
<tr>
<td>EAP</td>
<td>Electrical Access Permit</td>
</tr>
<tr>
<td>RMU</td>
<td>Ring Main Unit</td>
</tr>
<tr>
<td>D/L</td>
<td>Danger Labelled</td>
</tr>
<tr>
<td>Issuing Officer</td>
<td>A competent person who is authorised to issue work permit</td>
</tr>
<tr>
<td>Recipient in Charge</td>
<td>Carries out work order under an EAP, VA or STT</td>
</tr>
</tbody>
</table>