ASSET MANAGEMENT PRINCIPLES AND THE CONDITION ASSESMENT OF AGED CONDUCTORS

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PRYSMIAN Draka

INTRODUCTION – WHY ASSET MANAGEMENT

Why is it important to have reliable performance data for overhead conductors?

There are several reasons we manage critical assets:

1. Improving efficiency, performance and utilisation
2. Maximising Return on Investment
3. Facilitating data collection
4. Identifying & minimising Waste

Another link related to overhead power line design is to maintain adequate distance between energized conductors and ground clearance

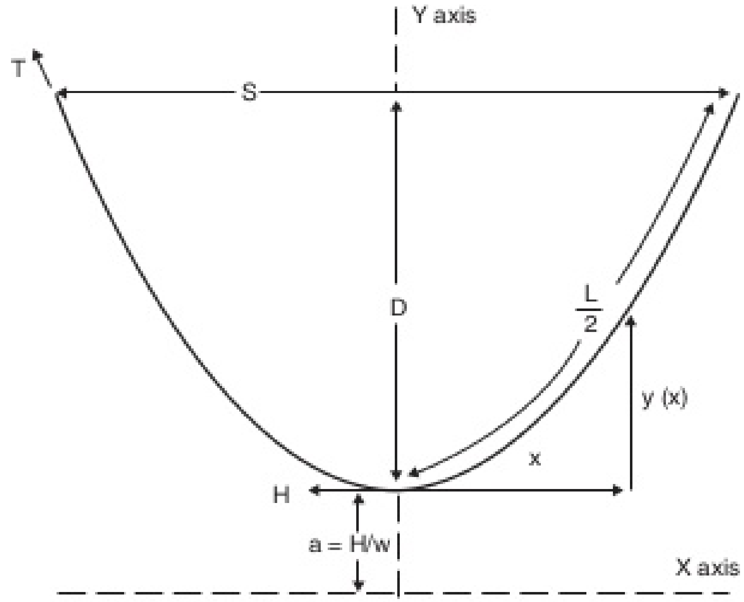
Clearance from the ground will always change as result of thermal expansion and creep

Once the characteristics of a conductor are known Operators can maximise conductor load at known ambient temperatures without risk of breaching safety margins – thus improving operating efficiencies

INTRODUCTION – EXAMPLE LINE DESIGN

<u>IN THE CASE OF REGULATED CLEARANCE (for instance)</u>:
Safety clearance can be achieved either through

1. Increasing the height of towers (cost)
2. Increasing the number of towers (reduced span – cost)
3. Running the line at more conservative load ratings (efficiency / performance - cost), or
4. Choosing different conductor designs to achieve desired results (asset lifespan – cost)



Increases in conductor length must be taken into account during the line design stage and installation process; increases in conductor length resulting from creep produces increased sags

TESTING STANDARDS

Relevant standards for overhead conductors:

1. AS/NZS 1746:1991 Conductors – Bare Overhead Hard Drawn Copper
2. AS 3607 Conductors – Bare Overhead Aluminium and Aluminium Alloy Steel Reinforced
3. AS 1531:1991 Conductors – Bare Overhead Aluminum and Alloy

4. AS 3822 – Test Methods for Bare Overhead Conductors

The first 3 tests concern construction and Quality Assurance
AS/3822 govern the tests necessary to predict future performance (Creep / Thermal Expansion, etc.)

The standards specify the following properties and test parameters:

- Mechanical properties
- Diameter of individual strands with tolerance +/- 1% (Wire diameter)
- Minimum Ultimate Tensile Strength (UTS) in mega-pascals
- Elongation as a percentage
- Wrapping test
- Electrical Properties
- Volumetric resistivity
- Long-term Creep
- Coefficient of Thermal Expansion

WHY CONDUCTOR CREEP DATA IS IMPORTANT

Conductor Creep can be divided into a series of events during the process of installation and the asset life of the conductor

- Initial Settlement of the conductor is a function of:
  - Construction of the conductor and wire stranding lay direction (1, 6, 12, etc.)
  - Due to the different layers of wires, when tension is applied the conductor will have the tendency to “settle” among and between the different layers of wires / strands

- Long term creep (in-elastic material stretch):
  - Function of conductor material composition / molecular properties (i.e. all aluminium, aluminium steel reinforced) and applied stress

- Stress is a function of:
  - Environmental conditions (wind, ice/snow loading, temperature)
  - Final stringing tension
  - Operating parameters (load)

PRYSMIAN’S TEST FACILITY

Creep testing is complex and requires careful preparation; the test has to be done in strictly controlled conditions specified in AS/NZS and IEC / EN standards.

The Prysmian NZ Laboratory has been designed to provide a high level of assurance that conductors will meet exacting performance requirements.

Testing Capabilities:

1. Temperature controlled environment – capable of controlling the testing environment temperature to 20±1 ° C (standard is 20 ±2.5 ° C)
2. Conductor tensioning by AC drive – enabling constant increase in loading till full load is applied
3. Closed Loop feedback system (via LabView) for applied load to ensure load is held within ±0.2% CBL of specified loading tension [criteria ±1% CBL]
4. Automated simultaneous data logging for applied load, conductor temperature and creep
5. Increased data logging – programmable to log data every minute for the 1st hour and 15 minutes thereafter for the duration of the test (a minimum test period of 1,000 hours).
6. Remote access for monitoring and control of the testing system.
7. Thermal Expansion / Break Load test rig

CREEP & TERMAL EXPANSION CAPABILITY

CREEP TESTING	THERMAL EXPANSION
Develop understanding of metallurgical conductor creep under stress, with ability to tailor the applied stress on design / request Provides long term creep data for line design with regards to statutes, i.e. clearance	Determine the coefficient of thermal expansion by conductor to assist line designers with clearance compensation

Only facility of its kind in New Zealand conducting tests per standards

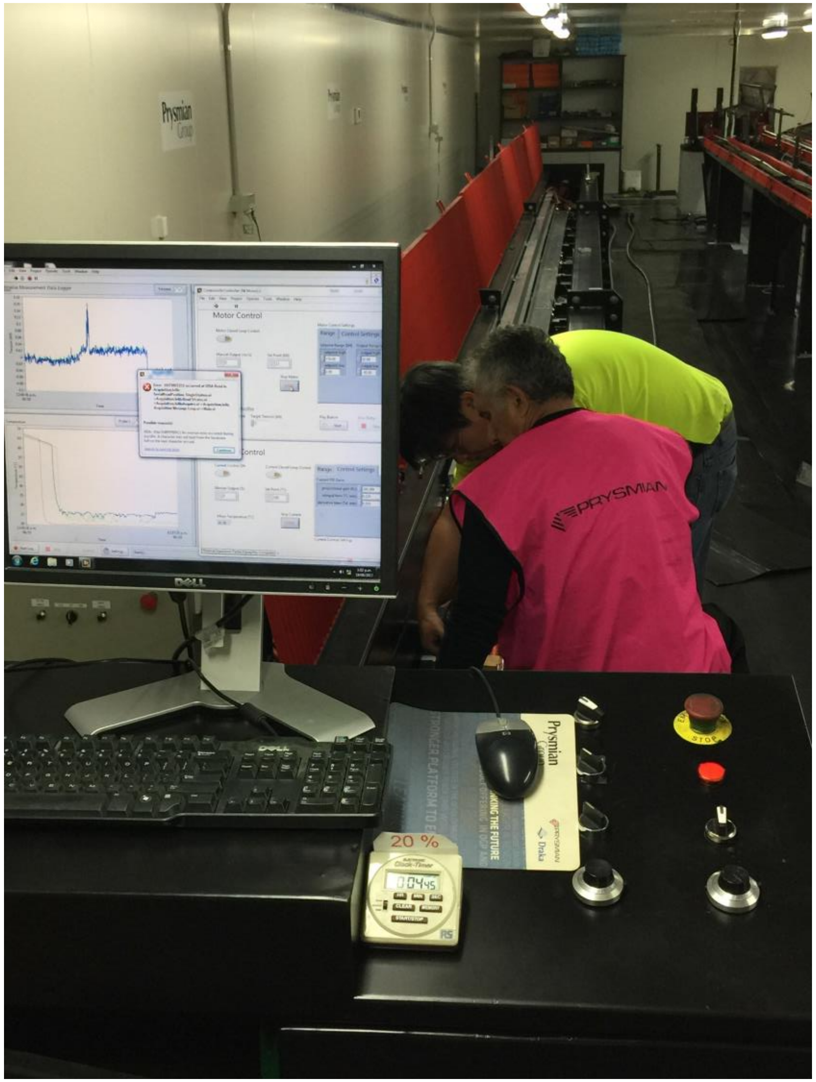
Standard conductor testing includes:

- Resistivity
- Tensile Strength / Wrap
- Diameter Measurement
- Wire Elongation

Special conductor testing can include:

- Creep
- Conductor Breaking Load
- Microscopic Confirmation (high corrosion instances)

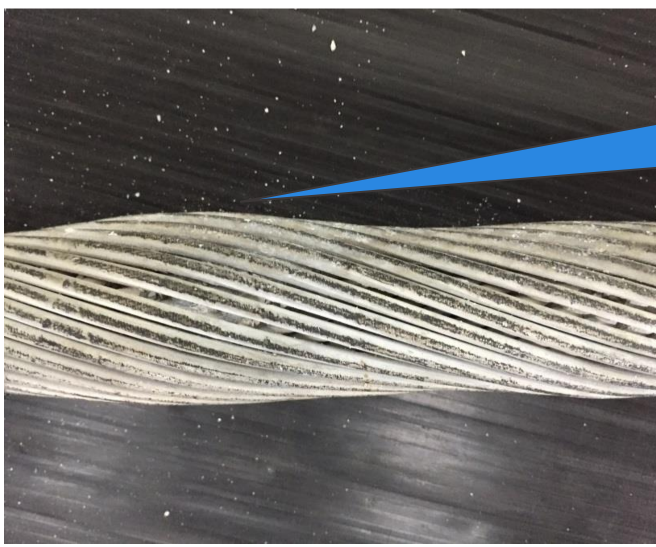
CREEP & TERMAL EXPANSION



DESIGN QUALITY CONTROLS in ASSET MANAGEMENT

	AS/NZS	IEC / EN Standards
Determination of Grease Volume	Specifies that grease “may” be applied “wholly or partly”	Specifies the attributes which determine the volume / mass of grease to apply
Drop Point & Technical Attributes	“not less than 120^{o}C”	Specifies testing for drop point, stability (oil separation), ageing, penetrability, adhesion, corrosion

RESULT Prysmian built capability to ensure conductors are greased to a benchmark that exceeds existing standards – improving asset life and by protecting capital investment



SUMMARY

1. To estimate the service life of existing conductors is a complex task because there are multiple and historically unknowable variables. Reliable historical data would help, combined with sample testing to confirm calculated values.

2. We can provide test results including microscopic analysis that indicate CURRENT CONDITION OF THE CONDUCTOR (tensile strength, elongation, brittleness and resistivity) to assess / estimate the remaining performance life.

3. Conductor loading (stringing tension, wind load) and Current loading are all variables which must be considered.

4. We can determine that a conductor lost X-% of its breaking load but…

5. Operators are in better position to make final risk assessments given the operating parameters.

INDUSTRY DATABASE MAY BE VALUABLE

QUESTIONS (JUST THE EASY ONES)

EXAMPLE OF TEST AND REPORTING PROVIDED

EXAMPLE OF HDCu BOHC MECAHNICAL AND ELECTRICAL TEST

2 VISUAL INSPECTION

Conductor show sign of the severe corrosion and at one position three wire was broken (Photo 1). Probably cause for the broken wires is arcing o - touching tree or similar.

Photo 1

EXAMPLE OF HDCu BOHC MECAHNICAL AND ELECTRICAL TEST

2 VISUAL INSPECTION

Conductor shows sign of the corrosion but in reasonable condition (photo 2) except at one position where two wires are damaged by arcing (Photo 3). Arcing is probably caused by touching tree or similar events.

Photo 2

Photo 3

EXAMPLE OF TEST AND REPORTING PROVIDED

EXAMPLE OF HDCu BOHC MECAHNICAL AND ELECTRICAL TEST

Wrap test is specified by AS1746 standard and it is an indication whether the wire is brittle or not. In case of the brittleness wire will break or has “cracks”.

ACSR CONDUCTOR AFTER X-TIME IN SERVICE

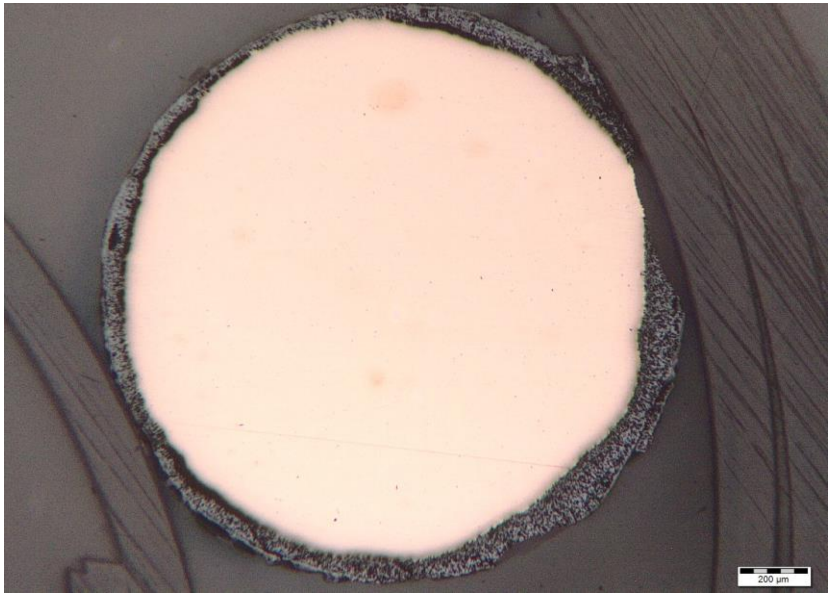
In **A**luminium **C**onductor **S**teel **R**einforced conductors, steel is part of the conductor construction. There are two type of steel “coating” to prevent steel from rusting – zinc coating (GZ) and Aluminium cladding (AC).

Besides steel coating, greasing is used to prevent the steel from rusting and lack of grease is very often the main reason for ACSR conductor failure.

The main reason for ACSR conductor failure is electrolytic corrosion between the steel and Aluminium wires due to lack of greasing of the steel core.

EXAMPLE OF TEST AND REPORTING PROVIDED

Analysis of conductor using electronic microscope



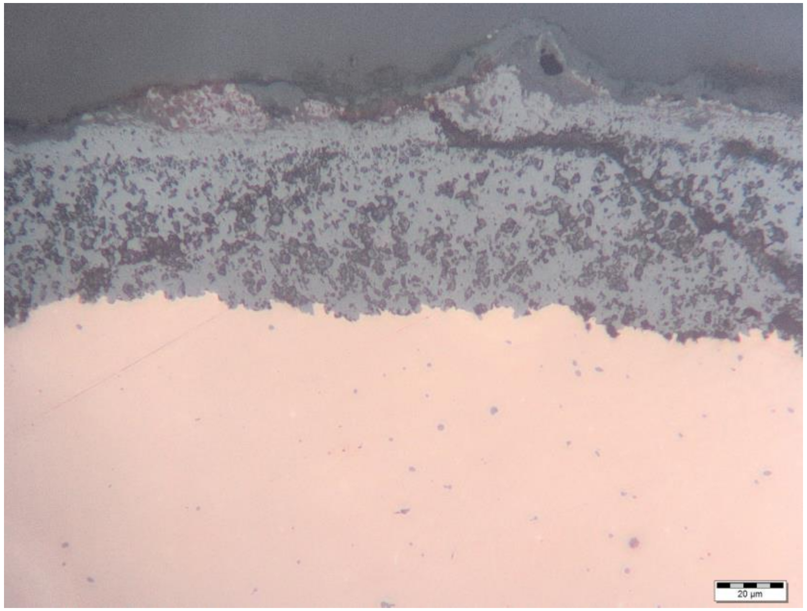


Photo 4

Effective conductor diameter is 1.53 mm

Photo 5

Average thickness of the corrosion is 130 microns

EXAMPLE OF TEST AND REPORTING PROVIDED

ANALYSES OF THE CONDUCTOR USING ELECTRONIC MICROSCOPE

Microscopic images indicate that the crust on the wires have three layers in it

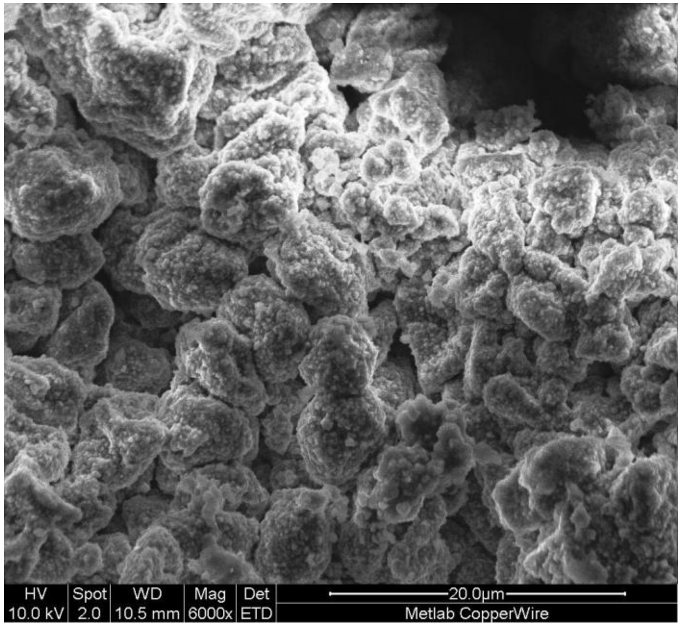


Photo 7

Green deposit on the surface - of copper chloride hydroxide

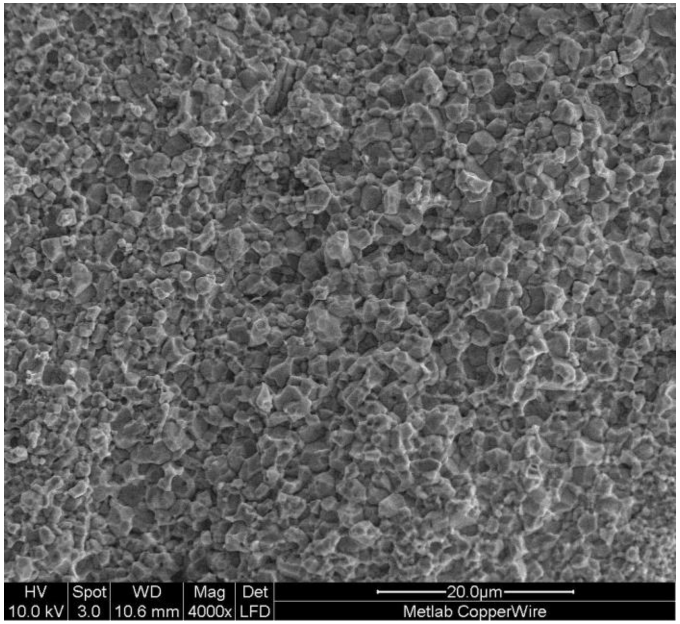


Photo 8

Mid Crust - Cuprite Cu_2O

EXAMPLE OF TEST AND REPORTING PROVIDED

ANALYSES OF THE CONDUCTOR USING ELECTRONIC MICROSCOPE

Surface of the strand

Photo 10

Damage due to fretting