1

Conductor Analysis

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2

Conductor Samples Analysed

We have received conductors to be analysed as below samples and the questions being asked from the analysis is HOW LONG WILL THE CONDUCTOR LAST? WHAT IS THE REMAINING LIFE OF THE CONDUCTOR?

Hard Drawn Copper

ACSR Conductor

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3

3

HOW LONG WILL THE CONDUCTOR LAST?

This is a difficult question and there is no straight forward answer to this.

Conductor corrosion happens rapidly in the beginning and slows down with time and the formula that can be use for this:

Reduction of the breaking load [%]= $c \times t^n$

where t = time in service, c and n are coefficient depends on corrosion type and environment.

Based on some result from region in Panama, that has similar condition as NZ corrosion environment, n=2/3 can be accepted.
Problem is coefficient "c" and it can be calculated using interpolation if

- We know when conductor has been installed
- What was original construction
- Test result of the supplied conductor with tensile strength, wire diameter and other data are available

Also

- It is difficult to have reliable data of the climate condition and
- It is usually first time that sample has been taken and interpolation method cannot be efficiently applied

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4

4

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Prysmian NZ can provide information about **CURRENT CONDITION OF THE CONDUCTOR** based on comparison of the conductor sample test result with data specified in the standard for new conductor with same construction.

Relevant standards for overhead conductors are:
AS/NZS 1746:1991 Conductors – Bare overhead – Hard drawn copper
AS 3607-189 Conductors-Bare overhead Aluminium and Aluminium alloy – Steel reinforced
AS 1531-1991 Conductors-Bare overhead Aluminium and Aluminium alloy

Those standards specify following properties and required tests:

- Mechanical properties
- Diameter of the individual strand (Wire diameter) with tolerance +/- 1%
- Minimum Ultimate Tensile Strength (UTS) in megapascals
- Elongation as %
- Wrapping test
- Electrical Property
- Volumetric resistivity

From properties specified in the standard and conductor construction and wire size of the sample we can calculate breaking load of the wire and conductors as well as resistivity of the conductor when it has been installed.

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5

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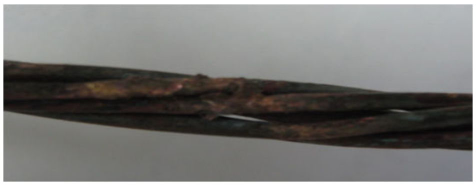
Typical Samples Analysed:

1. Visually, we can see the defective part of the conductor. This type of defect can be detected if careful inspection of the line is being done.



Wires broken

2. Conductor with visible corrosion but does not appeared to have any significant damage.

This conductor is difficult to judge until detail analysis is being done

6

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6

Prysmian NZ Laboratory – Example 1

A. Visual Inspection:
1. No wire damage or broken
2. Overall samples shows corrosion.
3. Assumption made on construction due to limited data – 10mm² HDCU

B. Conductor Properties – comparing to NEW 10mm² HDCU (standard)
1. Breaking Load → 90% of CBL based on 95% sum of individual
2. Resistance → 7% above allowable Max (AS1746)
3. Conductor OD → within tolerance

C. Wire Properties – "De-construct" the conductor
1. Outer layer wires above max OD → inclusive of corrosion layer
2. Individual wire breaking load → below minimum requirement
3. Wrap Testing → 3 out of 7 wires FAIL
4. Elongation → 2 out of 7 FAIL

	Ave. Wire Dia. Mm	Wire Breaking load (kN)	Wrap Test	Elongation (%)
central	1.355	97%	Fail	0.5
1	1.365	87%	Pass	1.5
2	1.385	85%	Pass	1.0
3	1.405	81%	Fail	0.5
4	1.400	84%	Pass	1.0
5	1.395	85%	Pass	1.5
6	1.385	84%	Fail	1.0

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7

7

Prysmian NZ Laboratory – Example 2

A. Visual Inspection:
1. No wire damage or broken
2. Overall samples shows HEAVY corrosion.
3. Assumption made on construction due to limited data – 13mm² HDCU

B. Conductor Properties – comparing to NEW 13mm² HDCU (standard)
1. Breaking Load → 99% of CBL based on 95% sum of individual
2. Resistance → 6% above allowable Max (AS1746)
3. Conductor OD → 8% above calculated MAX OD

C. Wire Properties – "De-construct" the conductor
1. Outer layer wires above max OD → inclusive of corrosion layer
2. Individual wire breaking load → below minimum requirement
3. Wrap Testing → all PASS
4. Elongation → 2 out of 7 FAIL

	Ave. Wire Dia. Mm	Wire Breaking load (kN)	Wrap Test	Elongation (%)
central	1.540	91%	Pass	1.0
1	1.830	89%	Pass	1.5
2	1.760	89%	Pass	1.0
3	1.780	89%	Pass	1.0
4	1.775	89%	Pass	1.0
5	1.760	91%	Pass	0.5
6	1.740	84%	Pass	0.5

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8

8

Prysmian NZ Laboratory – Example

Summary: Logically it is safe to conclude that with higher corrosion the conductor is more likely to FAIL but from the 2 samples shown:

1. Visual Confirmation on the conductor does not provide enough to judge the conductor performance
   - EXAMPLE 1 has "less" corrosion compare to EXAMPLE 2
   - EXAMPLE 2 has larger OD → bigger corrosion layer

1. From Analysis, it shows that Example 2 has better REMAINING performance

2. Lacking of Environmental and Historical Details of the conductor, prevents further extrapolation of performance for the conductor even if samples sizes is significantly large.

9

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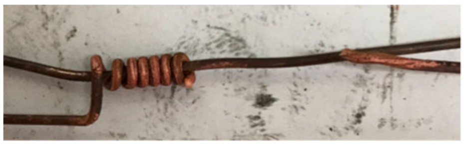
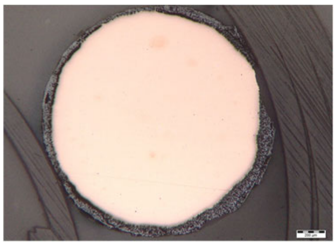
Where to from here ?

Potentially with further and proper analysis with appropriate assumption, a reference chart or formulation could be devised. Not all failure can be determine, i.e wrap failure, but could potentially provide a guide → remaining strength (?)

Information and Assumptions to be consider to compile relevant database:

1. Analysis of conductor based on years in service
2. Analysis of conductor based on a specific radius of environment.
   - Distance from the coast – sea breeze / content
   - Temperature and humidity reference
   - Proximity to farming, industrial or rural, etc
3. Study and discussion of aging test with agreed testing criteria to simulate / extrapolate to 30 or 60 years in service. i.e of criteria:
   - % concentration of salt spray
   - % humidity
   - Simulated temperature
4. Verification of the lab result comparing to actual analysis condition to see how well the model fits to enable some guide in the rate of corrosion based on remaining strength or remaining base metal.





Microscopic analysis for remaining base metal.

10

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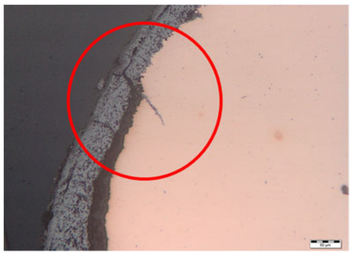
Where to from here ?

Associated **RISK** when trying to devise a extrapolation or chart

1. External factor to the environment where the conductor is string
   - Present of fertilisation (Nitrate) which causes accelerated corrosions and pitting/crevice corrosion
   - Lighting / arcing
   - External impact forces
2. Initial condition of the conductor
   - Both copper and aluminium will form oxide layer relatively quickly. This oxide layer acts as a protective layer which then reduces the rate of corrosion but if there is present of "accelerated" component before this layer is completely form then it will lead to a quicken deterioration of the conductor. i.e sulphuric
3. The bigger the conductor the higher the discrepancy due to the underlaying layers will be difficult to evaluate or correlate.
   - Internal layers has potentially higher corrosion due to the contaminate not being "washed" in the rain as the outer layer (surface)
   - ACSR typically has corrosion internally where steel is the main part of corrosion.



Pitting/crevice on copper wire due to corrosion

11

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Where to from here ?

61 strands ACSR Conductor Evaluation

Internal layer with a wire broken due to extreme corrosion

Outer layer does not show extreme corrosion condition

12

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12

Over Head Lab

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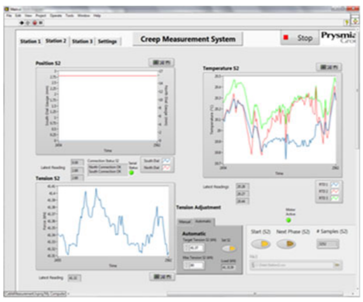
Over Head Conductor Testing Lab – Creep Testing

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

Our Laboratory exceeds those requirements by significant margin to give our customers the highest level of assurance their conductors will meet the performance requirements and reduce cost of installation:

Facility Capabilities:

1. Temperature controlled environment → capable to control the testing environment temperature to 20 ±1 °C [criteria 20 ±2.5 °C]
2. Conductor tensioning by AC drive → enabling constant increase in loading till full load 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 there after for the duration of the test.
6. Remote access for monitoring and control of the testing system.



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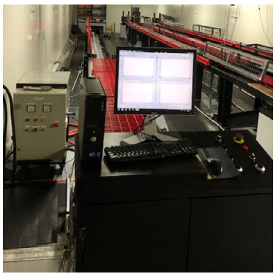
Over Head Conductor Testing Lab – Thermal Expansion

The test has to be done in strictly controlled conditions specified in AS/NZS 3822 and IEC standards.

Facility Capabilities:

1. Conductor tensioning by AC drive → enabling constant increase in loading till specified load applied.
2. Conductor Temperature heating via current injection.
3. Closed Loop feedback system [via LabView] for applied load to ensure load is held within ±0.2% of specified loading tension and conductor temperature within ±1.0 °C [criteria ±2.5 °C].
4. Automated simultaneous data logging for applied load, conductor temperature and elongation.



15

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15

16

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16

Thank You

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17