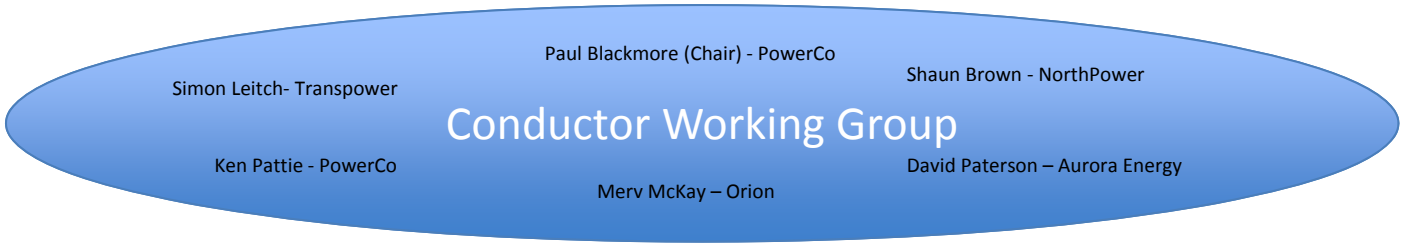
Electricity Engineers' Association

ASSET MANAGEMENT

Conductor Health

EEA.CO.NZ

Working group members

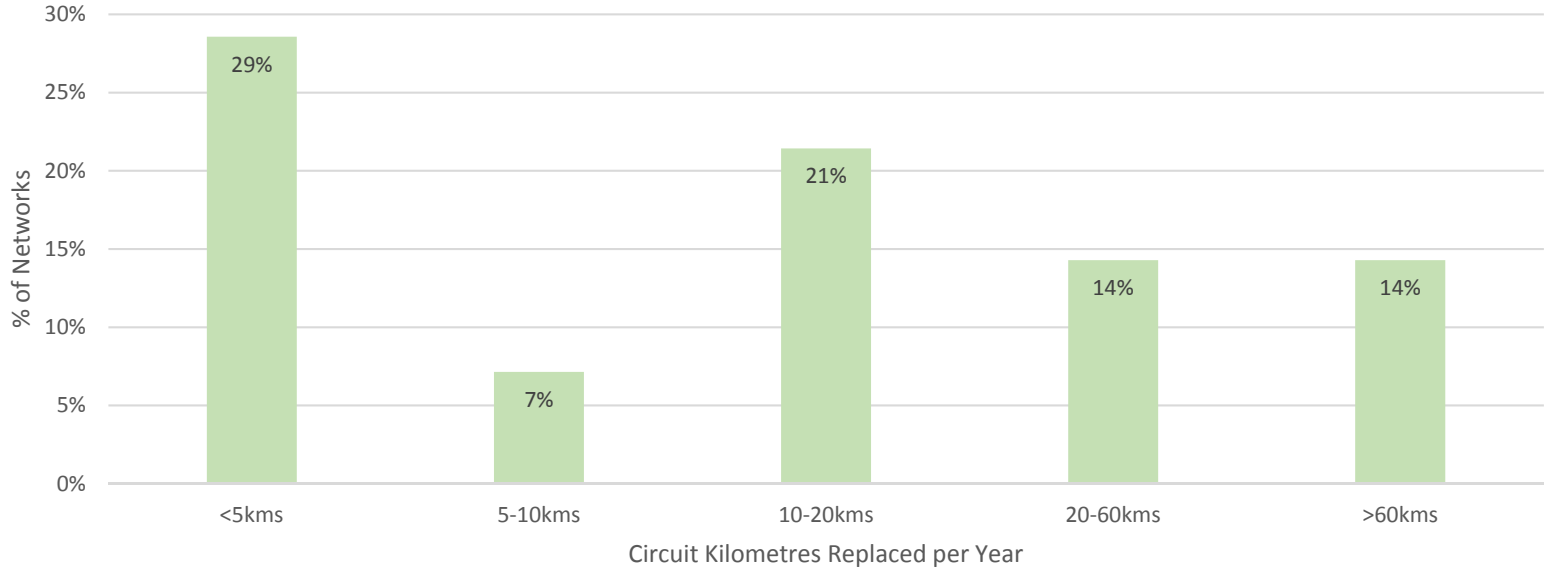


Background

The EEA Asset Management Group (AMG):

- Had concerns that **Conductor Condition** is poorly understood
- Conducted a survey in 2015 on conductor types, failure modes, replacement plans, and conductor inspection / testing techniques employed
- Would like to provide general guidance to industry
- Working group established in 2017

Annual Replacement of Conductor (km/year)



Working group – outputs

- Conductor condition techniques assessment
- ACSR Conductor Assessment Laboratory Scope
- Test standards
- Conductor sample requirements

Conductor condition techniques assessment

Category	Technique	Technical description	Typical productivity (spans per day)	Applicable access methods	Typical minimum skill requirements for key personnel	Speed	Ease of Use	Maturity	Accuracy	Field Results	Consistency	Cost	NZ use (commercial)
Visual	Ground-based	Visual inspection of conductor from the ground. Typically completed as part of defect patrols.	1-100	• Walking • Driving	Experienced line mechanic/inspector.	1	3	3	0	3	0	2	3
Visual	Structure climbing	Visual inspection of conductor from conductor height near each structure. Typically completed as part of condition assessment inspections.	1-5	• Structure climbing - inspection only • Elevated work platform - inspection only	Experienced line mechanic/inspector.	1	2	3	0	3	1	1	2
Visual	Remote camera	Wireless camera (e.g. go-pro) mounted on a hotstik. Typically used to inspect pole top condition on distribution assets rather than conductor condition.	1-20	• Telepole from ground	Experienced line mechanic/inspector.	1	2	2	0	3	1	2	2
Visual	Helicopter - close aerial inspection	Visual inspection of conductor from a helicopter flying along side a line at 10-15 km/h with numerous inspectors looking for and recording conductor condition issues and defects. In some cases, these inspections can be supplemented by electronic video records.	100-200	• Helicopter - inspection only	Multiple experienced line mechanics/inspectors.	2	2	2	2	3	2	2	3
Visual	Fixed wing - aerial inspection	Visual inspection of conductor from a fixed wing aircrat flying along side a line at XX km/h. High definition video is collected and post processed. [SCOTT TO PROVIDE INFORMATION]	[SCOTT TO PROVIDE INFORMATION]	• Fixed wing aircraft		2	2	1	1	0	1	2	2
Visual	Smart Aerial Inspection Platform	A rack of independently controlled high definition digital cameras which track conductor while taking images. Automated image processing routines provide a long-list of images to be reviewed by trained staff. Provides information on corrosion bulging.	50-200	• Helicopter - inspection only	Numerous specially trained Engineers and technicians.	2	1	0	1	0	1	0	0
Visual	Insulator lifting inspections	Hands-on visual inspection of conductor, including manipulation of outer strands, primarily for the identification of vibration damage and corrosion. Requires disconnection of conductor from insulator hardware to enable removal of helical support rods.	2 (clamps)	• Structure climbing • Elevated work platform	Line mechanic (de-energised).	0	2	2	1	3	2	0	2
NDT	Cormon (aka OHLCD)	A remote controlled cart/sensor which uses eddy currents to quantify the remaining protective coating thicknesses on steel cores of ACSR/GZ and AC conductors.	1-20 (individual sub-conductor spans)	• Structure climbing - live-line or de-energised • Elevated work platform - live-line or de-energised • Helicopter - live-line (at or above 110 kV) or de-energised	Specially trained Engineer - only available resource for NZ is through ATTAR and is based in Australia.	1	1	2	2	0	3	1	3
NDT	LineCore (drone)	A drone deployed device which uses eddy currents to quantify the remaining protective coating thicknesses on steel cores of ACSR/GZ and AC conductors. https://www.youtube.com/watch?v=z3Hh_AlYJ3o&feature=youtu.be&list=PLU8jUGZ6sQ38gz46I2Ew9N-Hwn2gjLSJP Given the precommercial nature of this device, we have assumed the same technical characteristics as Cormon.	Unknown	• Unmanned Aerial Vehicle	Unknown	1	1	0	2	3	3	1	0
NDT	Corona (e.g. CoroCAM, DayCor)	Handheld camera which can identify conductor surface irregularities through high electric fields. This technique can reliably identify: • Broken strands • Conductor clamp defects • Insulator defects • Severe surface scratches	1-100	• Walking • Driving • Helicopter - inspection only	Experienced Corona camera operator with lines Engineering or lines mechanic/inspector background	2	1	2	3	3	2	2	3
NDT	LineVue	A remote controlled cart/sensor unit that uses hall effect sensors to measure the remaining steel cross section of steel conductors (e.g. SC/GZ, SC/AC, ACSR). The device also claims to provide an indication of the severity and extent of surface pitting corrosion.	1-7	• Structure climbing - live-line or de-energised • Elevated work platform - live-line or de-energised • Helicopter - live-line (at or above 110 kV) or de-energised • Too heavy for hotstick deployment	Specially trained operator - only available resource for NZ is through SaferPower and is based in Australia.	1	1	2	1	0	Unknown	1	0
NDT	Acoustic (Foresight / Northpower)	Handheld ultrasonic audio device which detects partial discharges. This technique can reliably identify broken strands, hardware/clamp defects, and insulator defects. Investigations are underway to confirm its reliability with conductor corrosion and grease holiday defects.	1-500	• Walking • Driving	Highly trained operator (requires 6-months training in Korea), one available in NZ. Note, there are other suppliers of similar technologies which may provide very different results.	2	1	1	2	3	2	2	2
NDT	CDIS (Quest Integrity)	A remote controlled cart/sensor unit that assesses aluminium cross section area on conductors with aluminium strands (e.g. ACSR, AAAC, etc).	N/A	• Structure climbing - live-line or de-energised • Elevated work platform - live-line or de-energised • Helicopter - live-line (at or above 110 kV) or de-energised	Specially trained operator.	1	1	0	Unknown	0	Unknown	0	0
NDT	EMAT (Electromagnetic-acoustic transducer)	The EMAT imparts an acoustical signal to the conductor and records reflections. The result can be correlated with the number of broken conductor strands, particularly under clamps. The technology is capable of detecting damaged strands at distances up to 6m from the measurement location.	N/A	• Structure climbing • Elevated work platform	Line mechanic and specialist EMAT operator (none in NZ).	1	1	0	Unknown	0	Unknown	Unknown	0
NDT	Portable digital x-ray	Digital x-ray imaging of conductors, accessories or hardware to identify defects (broken strands, corrosion, offcentre 2-stage ACSR joints). Particularly under clamps, joints, and helical fittings.	1-4 (circuit structures on single bundle conductors)	• Structure climbing - live-line or de-energised • Elevated work platform - live-line or de-energised	Certified x-ray technician, relatively easy to find.	1	0	1	2	3	Unknown	2	1
NDT	Thermography	Handheld digital infrared spectrum camera which aims to detect hot conductor or joints indicating presence of defects. Results are more reliable under ideal weather conditions and with high circuit loads. In some cases the latter can be created by operators temporarily reconfiguring networks.	1-200	• Walking • Driving • Structure climbing - inspection only • Helicopter - inspection only • Unmanned Aerial Vehicle	Experienced and certified Thermography professional with lines Engineering or lines mechanic/inspector background.	2	1	3	2	3	1	2	3
NDT	Ohmstik resistance testing (live line)	Handheld micro-ohm meter which measures a voltage drop across the probe and current through the conductor to calculate a resistance. The Ohmstik can be used on bare conductor, joints and bolted connections under live line conditions.	1-50	• Structure climbing - live-line or de-energised • Elevated work platform - live-line or de-energised • Helicopter - live-line (at or above 110 kV) or de-energised	Experienced Engineer/technician and line mechanics to operate and interpret the results in real-time. Experienced Engineer required to interpret the test results.	1	1	3	2	3	2	0	3
Destructive	Conductor sampling then Laboratory or Engineering assessment	Removal of a short length of conductor of interest, typically 5m to 20 m. Detailed analysis of a conductor sample that has been removed from a line. Possible to accurately quantify the level of degradation in the conductor as well as to predict the remaining life. Limited by the applicability of small sample sizes. Due to the significant costs, it is very difficult to get a meaningful sample size to enable an Engineer to accurately assess the general condition of the conductor.	1-2 (individual samples)	• De-energised work methods typically used, some live-line sampling is done overseas	Specialist laboratory required for the dismantle and assessment of the conductor sample - a few such labs exist within NZ. Experience Engineer/Asset Manager required to assess the results and determine what actions are necessary.	0	2	3	3	0	3	1	2

ACSR Conductor Assessment Laboratory Scope

	Item	Description	Test
Mandatory Scope Items	1	Visual assessment of conductor sample, include photos and notes of: - Defects, e.g. broken strands, arcing damage, fretting, fatigue failures, - Visible corrosion products - Significant abrasion, wear, or fretting damage - General condition - Pay extra attention to the under-clamp or armour rod region of samples from clamp sites	N/A
	2	Verification of the critical dimensions and stranding: - Nominal Aluminium strand diameter (mm to 2 d.p.) - Nominal Steel strand diameter (mm to 2 d.p.) - Total number of Aluminium strands (e.g. for Zebra ACSR, 54) - Total number of Steel strands (e.g. for Zebra ACSR, 7) - Aluminium layers (e.g. for Zebra ACSR, three layers 12/18/24) - Steel layers (e.g. for Zebra ACSR, two layers 1/6)	N/A
	3	Residual electrical capacity, determined by either of the following methods: - Strand resistivity (minimum of 25% sample of Aluminium strands), or - Strand mass loss (all strands, after careful chemical cleaning), or - microscopic visual assessment of remaining Aluminium section (all strands).	AS 3607 TBC TBC
	4	Residual structural capacity, tensile test of strands - minimum of 25% sample of each Aluminium **AND** Steel strands	AS 3607
	5	Residual material ductility, wrap test of Aluminium strands - minimum of 25% sample of Aluminium strands	AS 3607
	6	Report, in accordance with the "report layout"	N/A
Optional Scope Items	7	Prediction of remaining life of conductor to Client provided replacement criteria	N/A
	8	Remaining material ductility, torsional ductility test of all Steel strands	AS2505.5:2002
	9	Corrosion products analysis (as required)	N/A
	10	Grease drop point analysis (as required)	ASTM D566-02 (2009)
	11	Microscopic assessment to characterise damage and evaluate metal loss including quantification of: - Remaining Aluminium area and loss - Remaining Steel area and loss - Residual coating thickness - Loss of galvanising or aluminium cladding	N/A N/A AS/NZS 4534 AS/NZS 4534

Test Standards

Test Type	ACSR	SC/GZ or SC/AC (Often applicable to ACSR steel cores)	AAAC and AAC	Copper
Record of Geometric Properties	- AS 3607 – 1989 Conductors – Bare overhead, aluminium and aluminium alloy – Steel reinforced	- AS 1222.1- 1992 Steel conductors and Stays – Bare overhead (Part 1: Galvanised SC/GZ)	- AS 1531 – 1991 Conductors – Bare overhead – Aluminium and aluminium alloy	- AS 1746- 1991 Conductors- Bare overhead- Hard-drawn copper
	- AS 3822 – 2002 Test methods for bare overhead conductors	- AS 1222.2- 1992 Steel conductors and Stays – Bare overhead (Part 2: Aluminium clad (SC/AC)	- AS 3607 – 1989 Conductors – Bare overhead, aluminium and aluminium alloy – Steel reinforced	- AS 3822 – 2002 Test methods for bare overhead conductors
			- AS 3822 – 2002 Test methods for bare overhead conductors	
Resistivity test	- BS 215-2:1970 Specification for aluminium conductors and aluminium conductors, steel-reinforced for overhead power transmission. Aluminium conductors, steel-reinforced		- AS 1531 – 1991 Conductors – Bare overhead – Aluminium and aluminium alloy	- AS 1746- 1991 Conductors- Bare overhead- Hard-drawn copper
	- AS 3607 – 1989 Conductors – Bare overhead, aluminium and aluminium alloy – Steel reinforced		- AS 3607 – 1989 Conductors – Bare overhead, aluminium and aluminium alloy – Steel reinforced	
Ultimate tensile test	- AS 1391 – 2005 Metallic materials- Tensile testing at ambient temperature		- AS 1391 – 2005 Metallic materials- Tensile testing at ambient temperature	- AS 1746- 1991 Conductors- Bare overhead- Hard-drawn copper
	- BS 215-2:1970 Specification for aluminium conductors and aluminium conductors, steel-reinforced for overhead power transmission. Aluminium conductors, steel-reinforced		- AS 1531 – 1991 Conductors – Bare overhead – Aluminium and aluminium alloy	- AS 1391 – 2005 Metallic materials- Tensile testing at ambient temperature
	- AS 3607 – 1989 Conductors – Bare overhead, aluminium and aluminium alloy – Steel reinforced		- AS 3607 – 1989 Conductors – Bare overhead, aluminium and aluminium alloy – Steel reinforced	
Wrap test	- BS 215-2:1970 Specification for aluminium conductors and aluminium conductors, steel-reinforced for overhead power transmission. Aluminium conductors, steel-reinforced		- AS 1531 – 1991 Conductors – Bare overhead – Aluminium and aluminium alloy	- AS 1746- 1991 Conductors- Bare overhead- Hard-drawn copper
	- AS 3607 – 1989 Conductors – Bare overhead, aluminium and aluminium alloy – Steel reinforced		- AS 3607 – 1989 Conductors – Bare overhead, aluminium and aluminium alloy – Steel reinforced	
Torsional Ductility test (optional)	- AS 2505.5 -2002 Metallic materials Method 5: Wire – Simple torsion test		- AS 3607 – 1989 Conductors – Bare overhead, aluminium and aluminium alloy – Steel reinforced	
	- ASTM A938-07 (Reapproved 2013) Standard Test Method for Torsion Testing of Wire			
Coating thickness (as required)	- AS/NZS 4534- 2006 Zinc and zinc/aluminium-alloy coatings on steel wire	- AS/NZS 4534- 2006 Zinc and zinc/aluminium-alloy coatings on steel wire	- AS 3607 – 1989 Conductors – Bare overhead, aluminium and aluminium alloy – Steel reinforced	
		- AS 1222.1- 1992 Steel conductors and Stays – Bare overhead (Part 1: Galvanised SC/GZ)		
		- AS 1222.2- 1992 Steel conductors and Stays – Bare overhead (Part 2: Aluminium clad (SC/AC)		
Dropping point of grease (as required)	- ASTM D 566 – 02 2009 Standard Test Method for Dropping point of Lubricating Grease			

Conductor Guide content

Panel discussion

- What areas should be included in the guide?
  - Asset data availability
  - Bare and covered conductors
  - Failure mechanisms/modes
  - Service life experiences
  - Condition assessment tools/techniques
  - Laboratory assessment methods
  - Conductor testing in the field

- What experience do you have that is worth including?