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Conductor Condition Assessment

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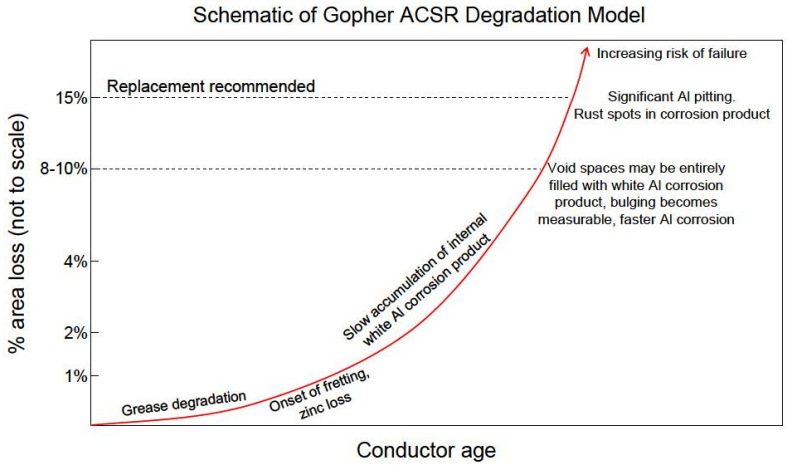
Background

- 3,500 km of HV overhead conductor
- A significant proportion of this conductor was installed in the 1950's and 60's, although the exact date of installation was not always known
- We didn't have a lot of information about the remaining life of our conductor

Initial Conductor Assessment

- Our initial assessment was carried out by a materials specialist
- This assessment was to gauge the overall health of our older conductor
- The initial assessment included both copper and ACSR conductor
- We had had some cases of ACSR conductor in coastal areas failing after about 25 years of service
- The failure of the ACSR conductor was found to be a grease problem, the specialist referred to it as a "grease holiday"
- The copper conductor deterioration was a combination of corrosion (scaling) and metal fatigue



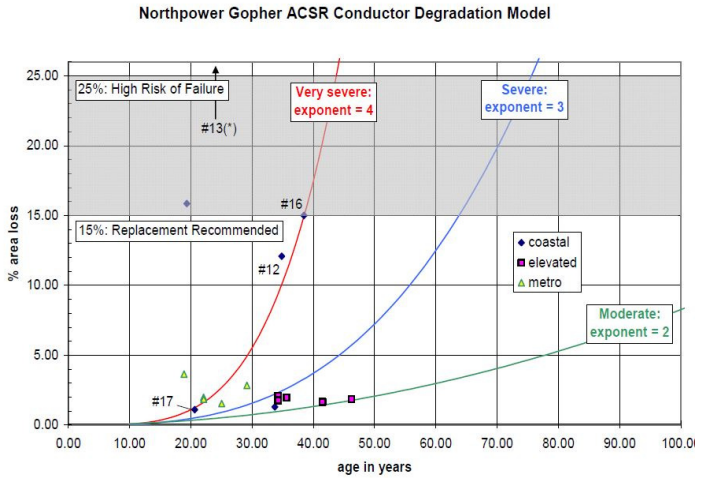


Figure 30. Northpower condition assessment data and Gopher ACSR conductor degradation model.

In-House Conductor Assessment

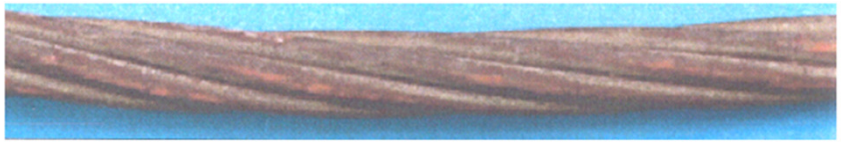
- While the material specialist was very capable assessing conductor it was felt that an in-house tool and method of assessment of conductor would allow us to better target conductor replacement
- The assessment is made on the standard at which the conductor was manufactured and looks at the degree of degradation
  - Copper BS125:1954 & 1970
  - Aluminium BS215:1956 & 1970

Conductor Assessment Method

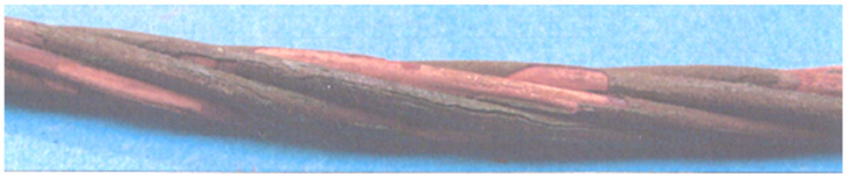
- The assessment has three parts
  - Visual inspection and grade as to the degree of corrosion – all strands in the conductor
  - Wrap test to gauge if the conductor has "work hardened" – a strands from the outer layer is taken for this test
  - Tensile strength measurement – this involves taking 3 strands of the outer layer and the inner conductor and measure the breaking strength of each strand
- The same tests are applied to copper and aluminium conductors

The Visual Inspection

- This looks at the degree of corrosion on all strands and a picture chart was developed to assist assessment of corrosion



(a) Light Visual Damage – Light Weathering

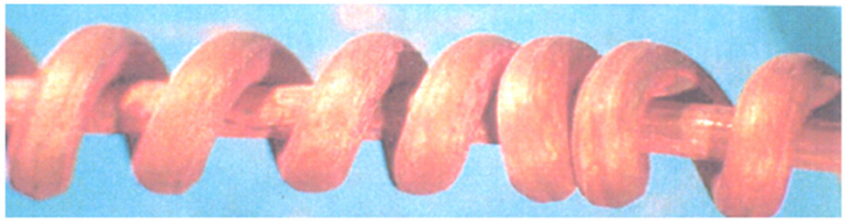


(d) Heavy Visual Damage – Moderate/Heavy Flaking of Outer Corrosion Layers

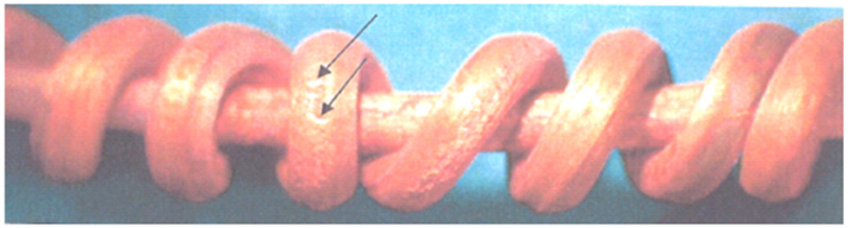
(e) Hexagonal/Distorted Shape of Inner Wire Surfaces Due to Severe Corrosion

The Wrap Test

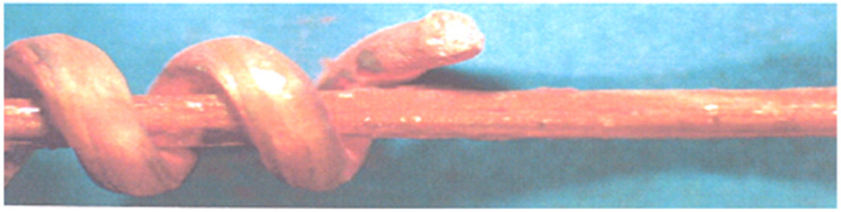
- This involves wrapping conductor strand around it's own diameter for a set number of turns
- If the strand breaks it is a "fail"



(a) No Visual Damage - Pass



(b) Very Superficial Fine Cracking Indicated by Arrows - Pass



(c) Wire Break - Fail

Tensile Strength

- This averages the breaking strength of the three of the outer strands and then takes a weighted average with the breaking strength of the inner conductor to give the estimated breaking strength for the conductor sample
- This is then compared with the original specification of the conductor to give a degree of strength degradation

Conductor Size 7/0.064" hard drawn bare copper	British Standard 125:1954 Tensile Breaking Strain			British Standard 125:1970 Tensile Breaking Strain		
	Outer Wires kN	Inner Wire kN	Conductor KN	Outer Wires kN	Inner Wire kN	Conductor KN
100% Breaking Strain	0.947	0.947		0.892	0.892	
Permitted Minimum Breaking Strength of Wires	0.876	0.876		0.825	0.825	
Permitted Minimum Breaking Strength of Conductor			5.607			5.744

Test Results

- There will be variations in tensile strength between strands
- Conductor in good condition may have a higher breaking strength than the standard and the standard is a minimum strength requirement
- The breaking strength test result is a measure of degradation in strength from what was used in the line design

Conductor Installed 1976: Sample Tested to BS125:1970	Breaking Strength of Wires from Sample - kN		Calculated Conductor Breaking Strength kN	Percentage of BS 125 Specification	Percentage Reduction in Breaking Strength
	Layer 2	Layer 1			
Wire 1	0.650	0.762	95 % of [0.762 + (6 x 0.672)] = 4.554 kN	79.3%	20.7%
Wire 2	0.692				
Wire 3	0.673				
Mean Value	0.672	0.762			
Specification	0.825	0.825	5.744	100%	

Conductor Installed Unknown: Sample Tested to BS125:1954	Breaking Strength of Wires from Sample - kN		Calculated Conductor Breaking Strength kN	Percentage of BS 125 Specification	Percentage Reduction in Breaking Strength
	Layer 2	Layer 1			
Wire 1	0.797	0.798	95 % of [0.798 + (6 x 0.797)] = 5.301 kN	94.5%	5.5%
Wire 2	0.801				
Wire 3	0.794				
Mean Value	0.797	0.762			
Specification	0.876	0.876	5.607	100%	

Decision on Conductor Replacement

- The conductor may be replacement on the failure of any one of the tests
- The priority for conductor replacement is likely to be risk based, which conductor strength is a factor
- The acceptable degree of conductor degradation may also consider the present line design standard rather than a fixed level of degradation

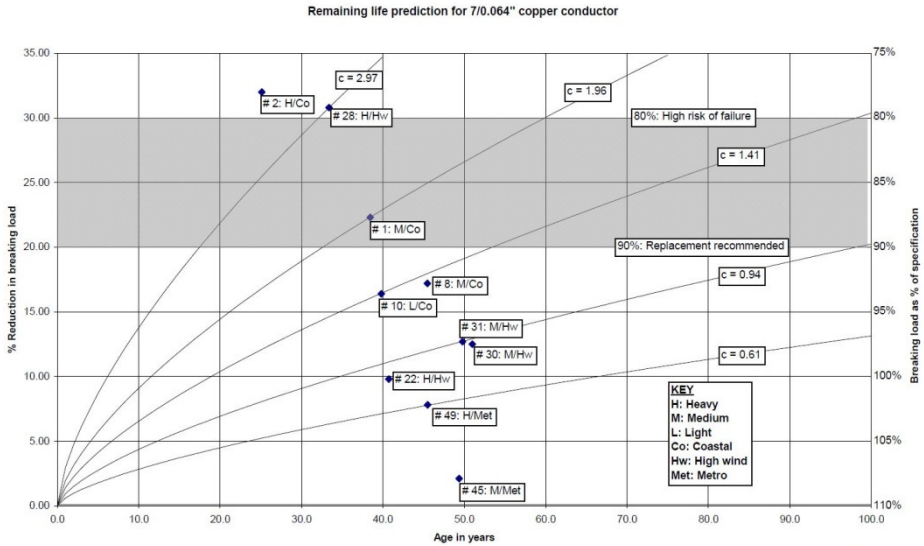
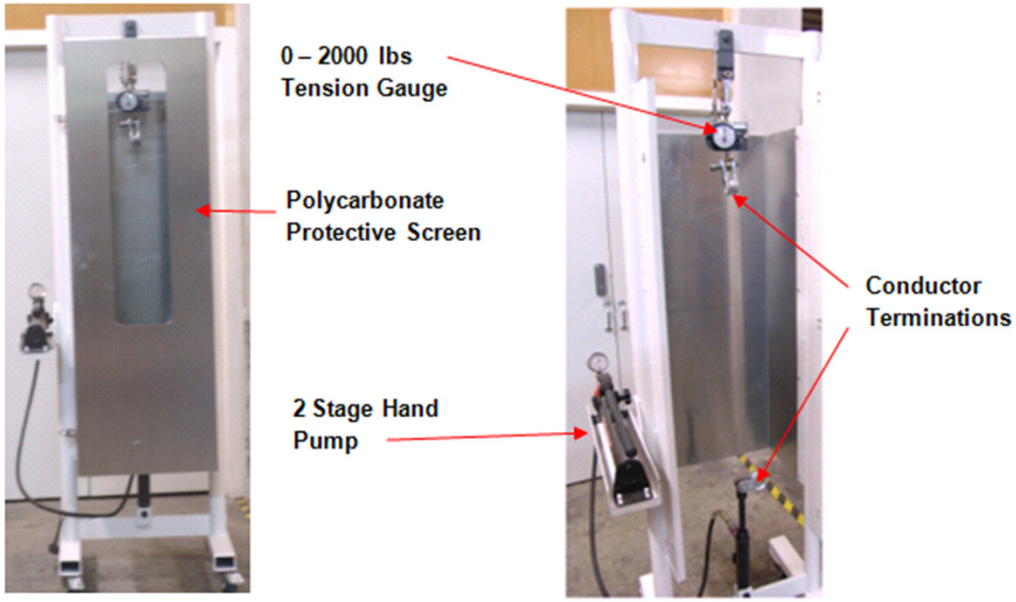


Figure 17. Northpower condition assessment data and model of Copper HDBC conductor degradation used for remaining life prediction.

The Tensile Strength Test Rig

- The wrap test doesn't require any special equipment
- A test rig was developed for measuring the tensile strength of the conductor strands



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Test Data

	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P	Q
1					Wrap Test Results		BS 125:1954 Specifications kN			Tensile Breaking Strength Test Results in kilo Newtons (kN)						Comparison of Results to BS Spec	
2	Zone/Sample No.	GIS/WASP Asset ID	Age (years)	Visual Inspection Observations	W1 P/F	W2 P/F	Cu L1	Cu L2	Conductor	L2 - W1	L2 - W2	L2 - W3	Mean	L1	Conductor	% of Spec	% Reduction
3	Coastal/8	Pole 1108071-Mangawhai	45.5	Flaky oxide corrosion/No other visible damage	F	P	0.876	0.876	5.607	0.755	0.76	0.79	0.768333	0.867	5.20315	92.79739611	7.202603888
4		Adams Rd (POLES 51167-511	57	B - Medium Visual Damage - some flaking of outer corrosion layers	P	P	0.876	0.876	5.607	0.623	0.623	0.712	0.652667	0.801	4.48115	112.02875	-12.02875
5		Adams Rd (POLES 51153-511	58	B - Medium Visual Damage - some flaking of outer corrosion layers	P	P	0.876	0.876	5.607	0.712	0.712	0.712	0.712	0.712	4.7348	84.44444444	15.55555556
6		Addison Road	57	- Heavy Visual Damage - Moderate/Heavy Flaking of outer corrosion laye	F	F	0.876	0.876	5.607	0.601	0.623	0.623	0.615667	0.667	4.14295	73.88888889	26.11111111
7		George Point Rd	55	B - Medium Visual Damage - Some flaking of outer corrosion layers	P	F	0.876	0.876	5.607	0.623	0.623	0.623	0.623	0.712	4.2275	75.3968254	24.6031746
8		Fisher Terrace (Kamo)	49	A - Light Visual Damage - Light Weathering	P	F	0.876	0.876	5.607	0.667	0.667	0.623	0.652333	0.801	4.47925	79.88674871	20.11325129
9		Montgomery Ave (Dargaville)	42	- Heavy Visual Damage - Moderate/Heavy Flaking of outer corrosion laye	F	F	0.876	0.876	5.607	0.667	0.623	0.623	0.637667	0.712	4.3111	76.8878188	23.1121812
10		Wilson Road (Parakao)	C	- Heavy Visual Damage - Moderate/Heavy Flaking of outer corrosion laye	F	F	0.876	0.876	5.607	0.534	0.578	0.623	0.578333	0.712	3.9729	70.85607277	29.14392723
11		Gomez Road	D	- Heavy Visual Damage - Moderate/Heavy flaking of outer corrosion layer	F	F	0.876	0.876	5.607	0.534	0.489	0.534	0.519	0.667	3.59195	64.06188693	35.93811307
12		Ararua Road	48	B - Medium Visual Damage - Some flaking of outer corrosion layers	P	P	0.876	0.876	5.607	0.689	0.645	0.623	0.652333	0.712	4.3947	78.3788122	21.6211878
13		Millbrook Rd, Waipu		B - Medium Visual Damage - Some flaking of outer corrosion layers	P	F	0.876	0.876	5.607	0.534	0.756	0.756	0.682	0.756	4.6056	82.14018192	17.85981808
14		Stead Rd, Waiotira	48	- Hexangonal/Distorted shape of inner wire surfaces due to severe corrosi	F	F	0.876	0.876	5.607	0.445	0.4	0.4	0.415	0.445	2.78825	49.72801855	50.27198145
15		Waimatenui Rd		A - Light Visual Damage - Light Weathering	P	P	0.876	0.876	5.607	0.712	0.623	0.623	0.652667	0.712	4.3966	78.41269841	21.58730159
16		Cartwright Rd	48	- Heavy Visual Damage - Moderate/Heavy flaking of outer corrosion layer	F	F	0.876	0.876	5.607	0.445	0.445	0.445	0.445	0.489	3.00105	53.52327448	46.47672552
17		Mangakahia Road		B - Medium Visual Damage - Some flaking of outer corrosion layers	P	P	0.876	0.876	5.607	0.578	0.534	0.623	0.578333	0.712	3.9729	70.85607277	29.14392723
18		Mangakahia Road	44	- Heavy Visual Damage - Moderate/Heavy Flaking of outer corrosion laye	P	F	0.876	0.876	5.607	0.534	0.534	0.578	0.548667	0.667	3.76105	67.07775994	32.92224006
19		Mangakahia Road (POLES 18	54	A - Light Visual Damage - Light Weathering	P	P	0.876	0.876	5.607	0.667	0.667	0.667	0.667	0.712	4.4783	79.8698056	20.1301944
20		Opouteke Rd (POLES 18611-	49	A - Light Visual Damage - Light Weathering	P	P	0.876	0.876	5.607	0.712	0.712	0.623	0.682333	0.712	4.5657	81.42857143	18.57142857
21		Mangakahia Road (POLES 18	43	- Heavy Visual Damage - Moderate/Heavy Flaking of outer corrosion laye	P	F	0.876	0.876	5.607	0.623	0.623	0.578	0.608	0.712	4.142	73.87194578	26.12805422
22		Whakapira Rd (POLE 23798)	47	- Heavy Visual Damage - Moderate/Heavy flaking of outer corrosion layer	P	F	0.876	0.876	5.607	0.489	0.489	0.489	0.489	0.623	3.37915	60.266631	39.733369
23		Whangarei Heads Rd (POLE 51855 - Solomons		F - Poor Condition - Moderate/Heavy Flaking of internal corrosion layers	F	F	0.876	0.876	5.607	0.267	0.178	0.445	0.296667	0.534	2.1983	39.20634921	60.79365079
24		Stead Road (POLES 34386 - 3	48	- Heavy Visual Damage - Moderate/Heavy flaking of outer corrosion layer	F	F	0.876	0.876	5.607	0.489	0.4	0.445	0.444667	0.489	2.99915	53.48938826	46.51061174
25		Sorrento Street, Onerahi (POL	46	A - Light Visual Damage - Light Weathering	P	P	0.876	0.876	5.607	0.756	0.889	0.8	0.815	0.778	5.3846	96.03352952	3.966470483
26		Paiaka Road	50	B - Medium Visual Damage - some flaking of outer corrosion layers	P	P	0.876	0.876	5.607	0.6227	0.5782	0.5872	0.596033	0.6672	4.03123	71.89637953	28.10362047
27		Takahiwai Road (POLES 19740 - 19739)		C - Heavy Visual Damage - Moderate/Heavy Flaking of outer corrosion laye	P	P	0.876	0.876	5.607	0.712	0.712	0.712	0.712	0.801	4.81935	85.95238095	14.04761905
28		Takahiwai Road (POLES 19803 - 19804)		B - Medium Visual Damage - some flaking of outer corrosion layers	P	P	0.876	0.876	5.607	0.801	0.712	0.712	0.741667	0.801	4.98845	88.96825397	11.03174603
29		Takahiwai Road (POLES 19717 - 19718)		A - Light Visual Damage - Light Weathering	P	P	0.876	0.876	5.607	0.712	0.667	0.712	0.697	0.801	4.73385	84.42750134	15.57249866
30		Glenmohr Road (POLE 39268)	51	- Heavy Visual Damage - Moderate/Heavy flaking of outer corrosion layer	P	P	0.876	0.876	5.607	0.623	0.667	0.623	0.637667	0.712	4.3111	76.8878188	23.1121812

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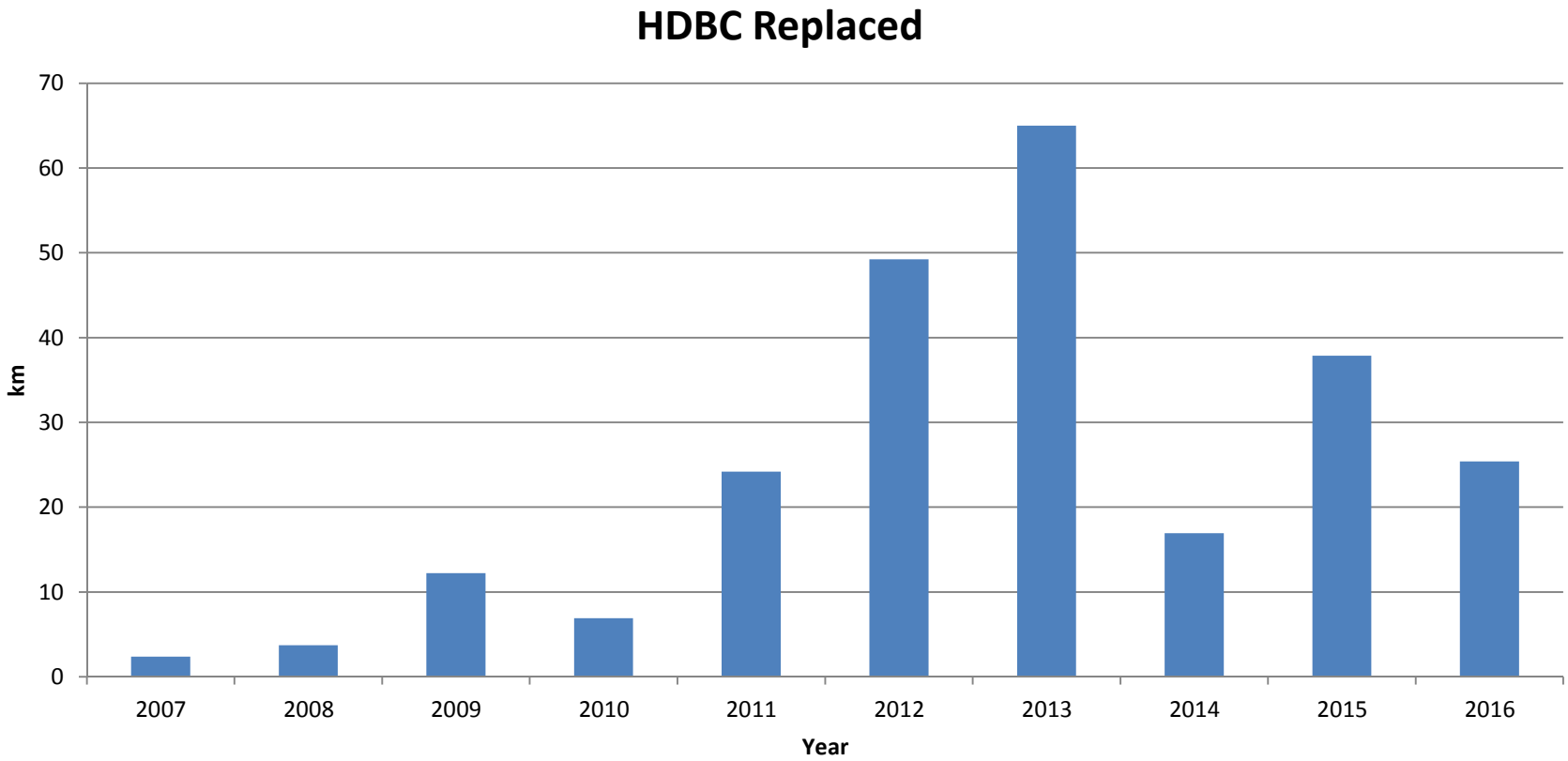
Conductor Replacement



Acknowledgement & Questions?

- Alan Gower - Electrical Engineer who developed the in- house test procedures and test rig