ICING MEASUREMENTS AT DEADWATER FELL TEST SITE

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***Abstract**:* A severe weather test site was set up on Deadwater Fell on the UK English/Scottish border. It is at a land height of 580m and has a single 190m test span. This paper describes the site including the meteorological instruments and video and logging instruments. Conductors erected at the site are fitted with load cells and vibration monitors. Conductors currently under test are J-Power's Gap, CTC's Lisbon and Oslo ACCC and Lumpi-Berndorf's (Z)TAL/HACIN types. These 'new' conductor types are being compared with standard AAAC Sycamore and ACSR Lynx for wind/ice accretion tests and vibration performance. The Gap and Lisbon conductors have undergone wind/ice load tests over three winters and so have, in total, suffered over 60 wind/ice incidents with the worst incident causing tension increases of up to 100% in the conductors. An Oslo (ACCC) conductor was erected in 2008. Over the 2008 to 2010 these conductors were tested for vibration over a range of tensions and compared with Sycamore and Lynx as control conductors. Conductors tested at equal % Ultimate Tensile Strength (UTS) and also at equal sag. Tests had also been carried out in 2007 on smooth and round stranded conductors of conventional aluminium alloy for Nexans Benelux. Data will be shown for the new conductor types in comparison to standard conductors. The aim of these tests is to determine which new conductor types are suitable to provide increased power capacity at 33 to 400kV lines in ice-prone areas in the UK.

1. INTRODUCTION

Due to the increase in wind farms world-wide, the networks in many countries are proving unsuitable for transferring loads from these extensive multiple sources as well as the smaller number of traditional power stations. Running existing conductors at higher temperatures can lead to ground clearance and metallurgical problems. The most common solution to the problem of running conductors at high temperatures without incurring sag problems is to combine a high temperature aluminium alloy with a low expansion core material as the main support system rather the whole conductor. The new types of high temperature (HT) conductor can significantly improve power capacities whilst maintaining ground clearance and avoiding higher stresses on the structures. (Z)TAL/HACIN (High temperature Aluminium Clad INvar core) conductors generally use an Invar steel core which has a lower expansion coefficient than the normal steel. ACCC (Aluminium Conductor Composite Core) has a composite core which has a very low expansion coefficient and uses a pure annealed aluminium envelope. ACCC exhibits 'load shift' which means that after a heavy ice load the load will shift permanently from the aluminium to the core.

2. RESULTS AND DISCUSSION

These two conductor types have been tested at the EA Technology Deadwater Fell Severe Weather test site [1] and compared directly with standard Lynx and Sycamore conductors. Two important basic parameters in line design are the wind/ice load and vibration limit. In summary:

The (Z)TAL/HACIN conductors (191 and 246) have excellent low vibration properties and similar ice accretion characteristics to Lynx and Sycamore. Further ice accretion tests are continuing and will be reported at the Workshop.

The ACCC conductors (Lisbon and Oslo) shift from a 50-50 load share to around 85-15 share after ice loads up to 36kN. Any load shift is permanent and when complete, these conductors appear to have a reduced susceptibility to wind/ice loads. The vibration characteristic initially showed high frequencies but the performance improved significantly once full load shift occurs.

In the current winter, a new ULS (Ultra Low Sag) Oslo has been installed in a manner designed to take it to the fully load shifted state immediately. The aim of this is to have the low sag, low vibration performance immediately from erection. Its performance is being investigated and will be reported at the Workshop.

Both these conductors are suitable for polluted/corrosive areas as the (Z)TAL/HACIN uses the ACS (Aluminium Clad Steel) core principle and the ACCC does not have a metallic core. Both also utilise very strong, low expansion core materials and can be tailored to specific customer requirements.

3. CONCLUSION

This paper has shown how these conductors compare under snow/ice loads and summer and winter vibration levels. The results indicate that both these conductor types can combine safe operation with superior ampacity and low sags over conventional conductor types. The work is continuing and further data will be shown at the May Workshop.

4. REFERENCES

[1] J. B. Wareing, "Deadwater Fell Test Site" presented at the 9th Int. Workshop on Atmos. Icing of Structures, Andermatt, Switzerland, Sept, 2009.

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I. Introduction

Due to the increase in wind farms world-wide, the networks in many countries are proving unsuitable for transferring loads from these extensive multiple sources as well as the smaller number of traditional power stations. One solution to this problem is to refurbish the existing network with conductors that have a higher power capacity. In such circumstances the new conductors must not break existing ground clearance regulations and also, preferably, not put any higher loads on existing structures. The latter aspect would be difficult to achieve if simply larger conventional conductor sizes were employed. Running existing conductors at higher temperatures can also lead to ground clearance and metallurgical problems. The new types of high temperature conductor can significantly improve power capacities whilst maintaining ground clearance and avoiding higher stresses on the structures. In this case it is common to talk about new conductors being equivalent to traditional types, where the replacement conductor is of a similar size to the existing type but can run hotter (and so increase power capacity) without running into ground clearance or metallurgical problems.

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II. Testing of New High Temperature Conductors

A. Conductor testing

Whilst new lines are being built, in most cases new high temperature (HT) conductors are required to replace existing conductors by re-conductoring an existing network. To this end, several HT conductors that are either Lynx (ACSR) equivalent or Sycamore (AAAC) equivalent have been tested at the EA Technology Deadwater Fell Severe Weather test site. These have been compared directly with standard Lynx and Sycamore conductors installed at the site. Two important basic parameters in line design are the wind/ice load and vibration limit and the testing has aimed to answer these questions about HT conductors. The site is operated 'dead' i.e. the conductors are not at voltage or have any current flowing through them.

B. The Deadwater Fell Test Site

The EA Technology Deadwater Fell severe weather test site is situated at a height of 580m on an isolated, exposed hill top near the Scottish/English border, equidistant between the East and West coasts of the UK. It consists of a 190m test span with terminal H-poles, each supported by 14 stay wires (Figure 1). It is equipped with meteorological measuring instruments and eight time lapse video cameras connected to digital video recorders. All conductors are fitted with load cells, turnbuckles and Sefag VR500-EXT vibration monitors. All data is logged at 10 minute intervals.

Fig 1 Deadwater Fell test site showing instrument hut

The site is unmanned but all logged data is automatically sent daily by mobile phone to EA Technology. Full details of the site are given in a previous IWAIS paper [1].This report considers mainly the wind/ice loads suffered by ACCC (Aluminium Conductor Composite Core) conductors (made by CTC) as well as briefly mentioning their vibration performance compared with Gap (so called because it has a gap between the aluminium envelope and the steel core) and (Z)TAL/HACIN (High temperature Aluminium Clad INvar core) conductors (made by Lumpi-Berndorf) and the conventional Lynx and Sycamore over the last four years.

III. RESULTS

A. Load shift

The most common solution to the problem of running conductors at high temperatures without incurring sag problems is to use a low expansion core material as the main support system rather the whole conductor. The concept of 'knee point' is used, where the conductor sag characteristic changes from being determined by the aluminium to being determined by the core. Gap is designed to have a knee point at erection temperature and so the sag is determined almost totally by the steel core. (Z)TAL/HACIN conductors have a higher knee point but generally use an Invar steel core which has a lower expansion coefficient than the steel used as the Gap core. ACCC has a composite core (Figure 2) which has a very low expansion coefficient (much lower than Gap or (Z)TAL/HACIN) but a knee point of 30 to 40°C. Gap and (Z)TAL/HACIN have their knee points fixed but ACCC and ACSS (Aluminium Conductor Steel Supported) exhibit 'load shift' which means that after a heavy ice load the load will shift permanently from the aluminium to the core. ACSS has not been tested at Deadwater Fell, but ACCC has undergone extensive testing.

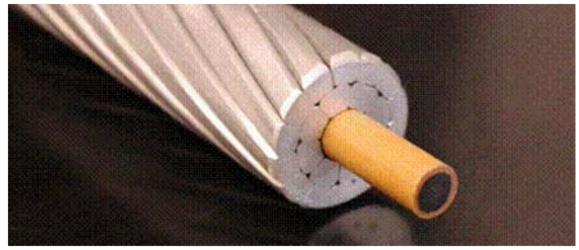

Fig 2 Lisbon ACCC conductor

B. Effect of load shift on vibration levels

Vibration tests were performed over several years on Lisbon ACCC (21.8mm diameter, 309mm² aluminium area, 103kN UTS). No pre-tensioning was done. Initially the Lisbon had exhibited vibration levels up to 200Hz, although at low amplitudes (Figure 3).

FREQ. [Hz]	Upper limits of amplitude class (p-p) [µm] 63	125	188	251	314	376	439	502
2	2422	104	0	0	0	0	0	0
5	4394	346	0	0	0	0	0	0
10	13676	3836	72	1	0	0	0	0
15	4288	947	20	1	0	0	0	0
20	2572	747	73	21	11	2	0	0
25	3292	1621	669	319	202	35	3	0
30	4559	4905	1515	261	125	1	0	0
34	1846	576	68	1	0	0	0	0
40	2120	586	36	0	0	0	0	0
45	2552	570	4	0	0	0	0	0
50	2467	1083	30	0	0	0	0	0
59	3284	735	21	0	0	0	0	0
83	2045	85	0	0	0	0	0	0
100	1694	28	0	0	0	0	0	0
143	20543	1961	0	0	0	0	0	0
200	10152	4125	67	0	0	0	0	0
Sum	81906	22255	2575	604	338	38	3	0

Fig 3 Initial vibration levels of Lisbon conductor

However, later tests on the same Lisbon ACCC which had by now suffered heavy ice loads and a new Lisbon showed that the 'old' Lisbon (which had undergone load shift) had a significantly reduced vibration level (Figure 4).

FREQ. [Hz]	Upper limits of amplitude class (p-p) [µm] 63	125	188	251	314	376	439	502
2	1973	3	0	0	0	0	0	0
5	1625	213	0	0	0	0	0	0
10	5323	1070	5	0	0	0	0	0
15	2847	958	6	1	0	0	0	0
20	2355	591	12	0	0	0	0	0
25	1275	325	5	0	0	0	0	0
30	374	3	0	0	0	0	0	0
34	106	0	0	0	0	0	0	0
40	22	0	0	0	0	0	0	0
45	4	0	0	0	0	0	0	0
50	3	0	0	0	0	0	0	0
59	4	0	0	0	0	0	0	0
83	0	0	0	0	0	0	0	0
100	0	0	0	0	0	0	0	0
143	14	0	0	0	0	0	0	0
200	18	0	0	0	0	0	0	0
Sum	15943	3163	28	1	0	0	0	0

Fig 4 'Old' Lisbon vibration levels

Both conductors in Figures 3 and 4 were at the same tension. It was apparent therefore if a pre-tension could be applied to load shift the conductor before or at erection, then lower vibration levels could be achieved from the start. The 'New' Lisbon has not suffered any wind/ice loads and so the conductor load is 57% carried by the aluminium and 43% by the core. The 'Old' Lisbon, however, has suffered two winters of wind/ice loads and so >80% of the load is now carried on the core.

C. *Ice loads and sags*

The load shift process had also led to a change in sag and also Lisbon suffered larger sags than the equivalent Gap conductor under ice loads. A new version of Lisbon was therefore produced with a slightly larger (but distinctly stronger) core. The new version, called 'Oslo' was 22.4mm diameter but had a UTS of 147kN. This was tested without any pre-tension under heavy ice loads throughout the entire 2009/10 winter. No dampers were used but the vibration levels were within acceptable limits (Fig 5) even under the ice loads and increased tensions (due to the low winter temperatures).

FREQ. [Hz]	Upper limits of amplitude class (p-p) [µm] 63	125	188	251	314	376	439	502
2	8101	1535	133	22	5	5	5	0
5	13191	2611	544	134	50	19	14	2
10	31417	38522	14744	3301	413	133	81	23
15	14196	8020	1283	358	67	14	0	0
20	18582	14706	3356	632	178	77	19	5
25	17248	12559	4253	732	128	50	38	5
30	11002	4360	636	90	4	0	0	0
34	7383	2558	556	112	1	0	0	0
40	16344	12541	3331	689	115	0	0	0
45	25312	22754	6293	1178	107	4	0	0
50	18578	12025	1942	439	246	16	0	0
59	18069	4927	346	34	2	0	0	0
83	6510	577	16	2	0	0	0	0
100	769	15	0	0	0	0	0	0
143	19847	3789	33	10	1	1	0	0
200	28577	7943	142	20	5	2	0	0
Sum	255126	149442	37608	7753	1322	321	157	35

Fig 5 Vibration levels of Oslo conductor during the 2009/10 winter without dampers.

The high frequency vibration characteristic is due to the carbon fibre composite core. This has been laboratory tested and shown not to fatigue under these vibration levels. The increased core strength of the Oslo (essentially Lisbon with a 47% stronger core) was evident in the reduced sags under ice loads compared with Lisbon, Gap and Sycamore conductors. This winter had produced the highest ice loads for many years but there was evidence to suggest that the Oslo and Lisbon conductors did not accrete wet snow loads as high as Gap in the same blizzards. Fig. 6 shows data from January, 2010. Lisbon 1 is the 'old' Lisbon which had been up several winters. It shows the same tension before and after the icing incidents. Oslo and Lisbon 2 are in their first winter and show the effect of load shifting (lower tension after the first icing incident but not for the next two). The Sycamore had been fitted with a 35kN load cell, hence limiting the recorded tension values to this level.

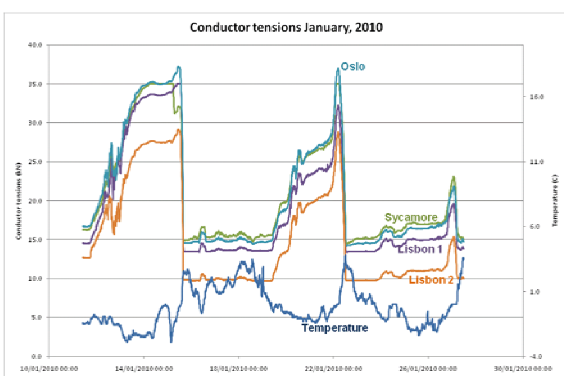

Fig. 6 Increased tensions on all conductors 19-30 December, 2009.

It is known that the composite core in ACCC has a very low sag at high temperatures. It has also been shown that ACCC conductors have significantly reduced vibration levels after load shifting is complete. The high strength cores also allow lower sags and hence lower tensions and stress on support structures. These changes occur during loads applied in network use. However, if, for example, Oslo could be pre-tensioned so that these beneficial features could occur from erection, then its network performance would make ACCC use very attractive in ice prone areas. It is estimated that pre-tensioning Oslo to 25%UTS would reduce the knee point to the erection temperature and the load sharing, which would be 49% on the core and 51% on the aluminium without any pre-tensioning would change to 83% on the core and just 17% on the aluminium.

D. *Current tests on ULS Oslo*

A low sag version of ACCC Oslo (Ultra Low Sag or ULS) has been developed by CTC and was erected at Deadwater Fell in January, 2011. It was pre-tensioned to 24%UTS for one hour and then reduced to 15%UTS (to match the sag of Sycamore). It is hoped that ice loads during the current winter will show low sags and possible vibration tests during the summer of 2011 will show low vibration levels. Results are not available at the time of writing this paper but will be given during the IWAIS conference.

Figs 7 and 8 compare the performance of Lynx and 191 (Z)TAL/HACIN. These

E. *(Z)TAL/HACIN conductors – Ice loads*

(Z)TAL/HACIN conductors have a high temperature aluminium alloy envelope and a low sag either high tensile steel or Invar steel core. This steel core is also in the form of aluminium clad steel (ACS) which reduces the possibility of corrosion of the steel core in polluted climates. ACS has been used for many years in OPGW earth wires and so the technology is well established. Although Invar steel does not have the extremely low sag properties of the ACCC composite core, it does have a significantly better sag performance than galvanised mild or high tensile steel.

Lynx and Sycamore equivalent 191 and 246 (Z)TAL/HACIN conductors were erected at Deadwater Fell in the summer of 2010 along with actual Lynx and Sycamore. They were then tested for vibration and are currently still erected to test their performance under wind/ice winter conditions. This latter performance will be reported at IWAIS.

Lynx is 19.53mm diameter, with an aluminium area of 226mm² and a UTS of 81kN compared with 191 (Z)TAL/HACIN at 19.95mm diameter, with an aluminium area of 236mm² and a UTS of 78kN. Sycamore is an AAAC of 22.61mm diameter, with an aluminium area of 303mm² and a UTS of 85kN compared with 246 (Z)TAL/HACIN at the same diameter, and aluminium area but with a UTS of 97kN. Figure 7 shows tension data for all the conductors as well as ambient temperature. The aim of the tests was to see whether the ice loads accreted by the (Z)TAL/HACIN conductors were similar to those of the standard Lynx and Sycamore.

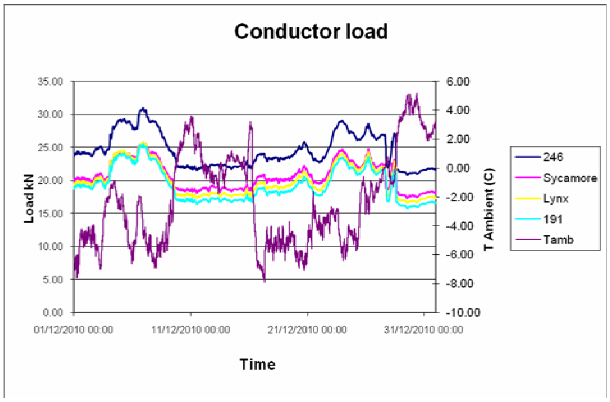

Figure 7 Conductor tensions at Deadwater Fell in December, 2010.

All the conductors followed a similar accretion pattern in the icing incidents of 11 and 25 December, 2010. Lynx and the 191 (Z)TAL/HACIN are very similar ACSR construction whereas Sycamore, being an AAAC, has a lower tension (at same sag) than the ACSR 246 (Z)TAL/HACIN. All conductors were at the same sag of 2.3m over a 190m span.

F. (Z)TAL/HACIN conductors - vibration

Vibration data is shown for the conductors in Figures 8 to 11. Figures 8 and 9 show 10 week data for Sycamore and 246 (Z)TAL/HACIN during the ice accretion period 12 November, 2010 to 19 January, 2011. Both conductors had low vibration levels with peaks around 15Hz and maximum amplitudes around 250µm. Sycamore had around 85,000 recorded cycles compared with 60,000 for the 246 (Z)TAL/HACIN.

	Upper limit of amplitude class (p-p) [µm]							
Frequency [Hz]	62	125	188	250	312	375	438	500
1	275	0	0	0	0	0	0	0
2	929	9	0	0	0	0	0	0
3	1510	25	0	0	0	0	0	0
4	1188	106	0	0	0	0	0	0
5	1397	260	0	0	0	0	0	0
6	1045	203	0	0	0	0	0	0
7	1779	355	0	0	0	0	0	0
8	2554	879	4	0	0	0	0	0
9	2396	1401	42	2	0	0	0	0
10	2314	3257	477	52	3	0	0	0
15	11552	19005	3596	525	51	0	0	0
20	8110	6072	357	33	9	0	0	0
24	3165	1453	70	0	0	0	0	0
29	3957	3564	491	0	0	0	0	0
35	818	187	3	0	0	0	0	0
39	229	17	0	0	0	0	0	0
44	117	6	0	0	0	0	0	0
50	81	3	0	0	0	0	0	0
53	12	0	0	0	0	0	0	0
59	9	0	0	0	0	0	0	0
63	2	0	0	0	0	0	0	0
67	1	0	0	0	0	0	0	0
71	0	0	0	0	0	0	0	0
77	0	0	0	0	0	0	0	0
83	0	0	0	0	0	0	0	0
91	0	0	0	0	0	0	0	0
100	0	0	0	0	0	0	0	0
111	0	0	0	0	0	0	0	0
125	0	0	0	0	0	0	0	0
143	0	0	0	0	0	0	0	0
167	0	0	0	0	0	0	0	0
200	0	0	0	0	0	0	0	0
Total cycles	43440	36802	5040	612	63	0	0	0

Fig 8 Sycamore 12 Nov 2010 to 19 Jan 2011

	Upper limit of amplitude class (p-p) [µm]							
Frequency [Hz]	62	125	188	250	312	375	438	500
1	916	18	1	1	0	0	0	0
2	1185	14	0	1	0	0	0	0
3	1081	24	2	0	0	0	0	2
4	789	153	10	1	0	0	1	0
5	1356	480	31	3	2	1	0	1
6	1694	500	48	3	3	1	0	0
7	1738	1181	108	6	2	1	1	0
8	1685	1716	199	17	2	0	0	0
9	1601	1782	395	32	2	2	1	1
10	1924	2169	542	34	6	0	0	1
15	7826	9384	1496	81	5	3	1	1
20	2929	4166	1077	93	3	2	3	0
24	1204	2266	798	71	1	1	0	0
29	938	1082	240	29	4	1	1	2
35	351	159	25	7	2	1	0	0
39	139	33	4	0	3	1	0	1
44	187	18	1	0	0	2	2	0
50	946	26	3	3	3	1	1	0
53	385	14	0	1	0	1	0	0
59	464	10	5	2	2	0	0	1
63	81	1	1	0	0	0	1	0
67	40	1	1	2	0	0	0	0
71	30	6	1	0	0	1	1	0
77	21	2	3	3	0	0	1	0
83	17	2	2	0	0	0	0	1
91	18	2	2	1	2	1	1	0
100	26	4	0	0	1	0	0	0
111	16	2	1	0	1	0	0	0
125	4	8	4	1	2	1	0	0
143	4	4	4	0	0	0	2	0
167	2	4	1	1	1	0	0	0
200	5	5	2	0	0	0	0	0
Total cycles	29602	25236	5007	393	47	21	17	11

Fig 9 246 TAL (Z)TAL/HACIN 12 Nov, 2010 to 19 Jan 2011

Figures 10 and 11 show data from Lynx and 191 (Z)TAL/HACIN. Lynx has a minor peak around 15Hz but a significant, high amplitude peak around 30Hz with amplitudes up to 1mm. The 191 (Z)TAL/HACIN, on the other hand, exhibits a minor peak at 15Hz but a much more significant peak at 50Hz with amplitudes up to 375µm. Overall, this 5 week test had cycles of 184,000 for Lynx but only 88,000 for the 191 (Z)TAL/HACIN.

	Upper limit of amplitude class (p-p) [µm]							
Frequency [Hz]	62	125	188	250	312	375	438	500
1	1244	10	0	0	0	0	0	0
2	1730	23	0	0	0	0	0	0
3	1892	99	1	0	0	0	0	0
4	1601	187	2	0	0	0	0	0
5	1979	451	7	0	0	0	0	0
6	1523	543	40	1	0	0	0	0
7	1863	1134	517	45	2	1	0	0
8	2493	4618	3222	300	61	0	0	0
9	3730	7792	5283	782	73	2	0	0
10	4456	14010	7485	969	121	4	0	0
15	13286	28601	6265	1151	150	8	0	0
20	6341	9024	1700	245	81	22	8	10
24	3340	5067	1821	1011	601	302	99	56
29	3514	5756	3581	2709	1403	626	473	392
35	2496	4418	2621	1490	1005	576	419	365
39	761	393	315	217	116	81	71	37
44	753	800	434	61	21	11	4	4
50	780	437	170	2	0	2	0	0
53	50	10	1	0	0	0	0	0
59	50	9	0	0	0	0	0	0
63	15	1	0	0	0	0	0	0
67	12	0	0	0	0	0	0	0
71	9	1	0	0	0	0	0	0
77	3	1	0	0	0	0	0	0
83	2	0	0	0	0	0	0	0
91	4	0	0	0	0	0	0	0
100	3	0	0	0	0	0	0	0
111	5	0	0	0	0	0	0	0
125	5	0	0	0	0	0	0	0
143	9	0	0	0	0	0	0	0
167	5	0	0	0	0	0	0	0
200	1	0	0	0	0	0	0	0
Total cycles	53975	83385	33465	8983	3634	1635	1074	864

Fig 10 Lynx 6 Oct, 2010 to 11 Nov 2010.

	Upper limit of amplitude class (p-p) [µm]							
Frequency [Hz]	62	125	188	250	312	375	438	500
1	1352	4	0	0	0	0	0	0
2	2373	2	0	0	0	0	0	0
3	2647	3	0	0	0	0	0	0
4	1838	18	0	0	0	0	0	0
5	975	14	0	0	0	0	0	0
6	745	15	0	0	0	0	0	0
7	2823	64	0	0	0	0	0	0
8	5330	219	0	0	0	0	0	0
9	6260	895	0	0	0	0	0	0
10	8358	3108	0	0	0	0	0	0
15	17821	5850	50	0	0	0	0	0
20	3150	758	16	0	0	0	0	0
24	761	456	17	0	0	0	0	0
29	517	712	100	11	0	0	0	0
35	543	802	294	30	0	0	0	0
39	301	708	370	61	2	0	0	0
44	566	961	438	116	20	5	0	0
50	3940	3620	1226	681	371	69	3	0
53	1336	673	138	80	26	2	0	0
59	1559	390	42	18	4	0	0	0
63	247	43	0	0	0	0	0	0
67	158	38	1	0	0	0	0	0
71	96	17	0	0	0	0	0	0
77	37	3	0	0	0	0	0	0
83	21	0	0	0	0	0	0	0
91	8	0	0	0	0	0	0	0
100	7	0	0	0	0	0	0	0
111	2	0	0	0	0	0	0	0
125	2	0	0	0	0	0	0	0
143	1	0	0	0	0	0	0	0
167	2	0	0	0	0	0	0	0
200	0	0	0	0	0	0	0	0
Total cycles	63776	19373	2692	997	423	76	3	0

Fig 11 191 TAL (Z)TAL/HACIN 6 Oct 2010 to 11 Nov, 2010.

None of the conductors in these tests were fitted with vibration dampers.

G. *Results Summary*

The two types of conductors discussed in detail here reflect two distinct types of conductor. Whilst the (Z)TAL/HACIN type are similar in construction to the standard ACSR and use similar fittings, they rely on Zirconium alloys on Invar aluminium clad steel (ACS) cores to obtain high ampacity and low sag. In contrast, The ACCC (Oslo, Lisbon) use a pure annealed aluminium with a novel, non-metallic core to achieve the same aim. Whilst both exhibit the knee phenomenon, the ACCC type also has a load shift characteristic where the load eventually resides almost entirely in the core material. In summary:

- The (Z)TAL/HACIN conductors have excellent low vibration properties and similar ice accretion characteristics to Lynx and Sycamore. Further ice accretion tests are continuing.
- The ACCC conductors shift from a 50-50 load share to around 85-15 share after ice loads up to 36kN. Any load shift is permanent. The vibration characteristic initially shows high frequencies but the performance improves significantly once full load shift occurs.
- In the current winter, a new ULS Oslo has been installed in a manner designed to take it to the fully load shifted state immediately. The effect of this on tension and ice accretion is being investigated and will be reported at the Workshop.
- Tests in previous years covered Gap and Nexans Aero-Z conductors but this data is not presented here.

H. *Current specialist installations*

The intended low sag characteristic of the ULS Oslo conductor is aimed at countries where wind and ice loads are common. There are currently installations at 132 and 400kV in the UK as well as in many other countries.

The corrosion resistant (Z)TAL/HACIN conductors are attractive in areas where pollution can be a major problem for steel cored conductors. Two particularly polluted areas are the deserts of the Middle East and the Atlantic coast of Ireland where installations are being made. With the standard ACSR type construction, (Z)TAL/HACIN conductors are being installed at network voltages as low as 33kV.

IV. SUMMARY

Deadwater Fell in the Scottish Borders area of the UK is a proven test site for new conductor types to be compared with conventional systems in terms of wind and ice loads and vibration levels. Over the last 20 years, this site has been used for conductors from 32 to 800mm² section and is now providing invaluable data but is currently looking at how new conductor types compare to 175mm² Lynx and 250mm² Sycamore conductors. The composite cored ACCC shows the load shifting characteristic typical of this and the ACSS conductor types. The work done over the last 3 years is enabling conductor development to take place to use this characteristic to advantage. The (Z)TAL/HACIN conductors obtain low sags by using an Invar steel core and avoid corrosion by using the ACS technique. This paper has shown how these conductors compare under snow/ice loads and summer and winter vibration levels. The results indicate that both these conductor types can combine safe operation with superior ampacity and low sags over conventional conductor types. The work is continuing and further data will be shown at the May Workshop.

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