Validation of ice loads predicted from meteorological models

Anthony Veal & Alasdair Skea (UK Met Office)
Brian Wareing (Brian Wareing.Tech Ltd)

Abstract - **Recent catastrophic ice storms in Europe and North America have lead to a renewed interest in issues related to ice accretion on overhead lines, including forecasting of icing events, icing prevention and de-icing technologies. In 2002 a review of ice models was made by Fikke and Wareing for the UK Met Office. In the 2003-04 winter the UK Met Office funded tests at EA Technology's severe weather test site at Deadwater Fell on the English/Scottish border to validate these models. The tests were conducted by comparing ice loads on a Hazel conductor on a fully monitored test span with a meteorologically based ice model using a laser device (Gerber) for determining the liquid water content of the air. The intention now is to extend the range of conductor sizes in tests during the 2004-05 winter and also bring in a rotating rig for close-up profiles of ice accretion envelopes. The aim is to validate an ice model in terms of accretion rates on different sized conductors. UK OHL design is currently based on wind/ice weather maps and BSEN 50341-3-9 probabilistic and deterministic methods. One eventual aim of this work is to revise these weather maps which have proved incompatible in many areas with utility experience and lifetimes achieved by current OHL designs. This project will establish the basis for these maps to be reviewed for their validity as well as looking for a capability for 'nowcasting' icing events and predicting iceloads. This paper reviews the work in 2002-04 and data from the 2004-05 winter.**

I. INTRODUCTION

A review of icing models was presented in previous paper[1] as well as validation requirements and field data. Application of these models to predict ice loads on conductors from meteorological data was covered and a recommendation made to carry out field trials to determine whether meteorological data could be used in this way. The EA Technology test site at Deadwater Fell was suitable for this purpose and so initial tests were started in December, 2003. The work was part of an EA Technology project funded by the UK Met Office. The UK meteorological office sourced two instruments (Gerbers) capable of measuring the Liquid Water Content (LWC) of the air. Two Gerber PVM-100 instruments were provided by the UK Meteorological office and were installed at the EA Technology severe weather test site at Deadwater Fell test site on the English/Scottish border in the UK. The aim was to see whether output from these instruments could be related to the conditions under which overhead line conductors suffer ice loads.

A.. Deadwater Fell

The Deadwater Fell site provides load cells and video coverage that can be used to measure ice loads. Provision can be made for close up video coverage to identify ice shape. However, even without this, conductors of different sizes and at different span lengths can be installed to provide direct measurement of the total force on the conductors at their connection point to the supports. This force is made up of:

a) Conductor weight

b) Ice load

c) Wind-on-ice load.

Item a) is known and items b) and c) are measured together. The system can be used to evaluate the ice load by calculation of the wind load. The latter can be calibrated in above 0 °C incidents with no ice present. However, the main concern with overhead lines is the total wind and ice load, so it may not be necessary to separate these components in a practical situation.

II. DEADWATER FELL DETAILS

A. The site

The site is situated at 600m land height on the flat top of an isolated fell above Kielder Water in the northern UK. It is approximately 50 miles East and West from the North and Irish seas and is exposed to severe winds from all directions. Full details have been given in a previous paper[2]. The ambient air temperature, wind speed and direction are monitored at the Deadwater Fell weather station along with the load cell values. There are also time lapse video recorders and a web camera system viewing the performance of the conductors in the varying weather conditions. All the data is collected and stored at the site and also down loaded automatically via a mobile telephone every 24 hours to EA Technology at Capenhurst where the data is analysed.

The test spans are orientated North-South and suffer from severe winds as well as ice incidents and blizzards.

The test span has an access platform under the south ‘H’ pole (Figure 2.1). Monitoring started on 11th December 2003. At the time of this report the Gerber PVM-100 instruments were still erected at the site and working. Aspects of their performance over the 2003/4 winter period will be discussed within this report. The site is fitted with load cells and turnbuckles to adjust the conductor tensions.

Fig. 2.1 The access platform at the southern H-pole

III. Meteorological Data Required

Data needed for ice load assessment

The basic meteorological data identified in the initial report that was required to model an icing process depends on the accretion type and includes:

1. Wind speed
2. Wind direction (relative to structure)
3. Air temperature
4. Precipitation rate
5. LWC
6. Droplet size
7. Relative humidity
8. Visibility

LWC and droplet size are difficult to measure and therefore there is very little data on those quantities. Visibility is often used as a substitute since it is correlated with both LWC and median volume droplet sizes (MVD).

B. Meteorological Data Available

Section 3.1 identified 8 parameters. In restricting the ice model validation to rime (or in-cloud) icing, not all these parameters are required. Since it is in-cloud and not precipitation icing that is being considered, the precipitation rate (item 4) is not required. The presence of water droplets is a necessary requirement and so item 5 is required. Item 6 would be required to evaluate the collection efficiently accurately, but it is not essential.

At the Deadwater Fell site at present items 1-3 are available and the video system could provide item 8. Item 5 data will be provided by the Gerber instruments (Figure 3.1). These instruments had not been used at a severe weather site before and so there was some uncertainty as to their calibration and their ability to deliver consistent data (i.e. to maintain calibration). In fact, as the field trials showed, the calibration of the Gerbers remained within acceptable limits.

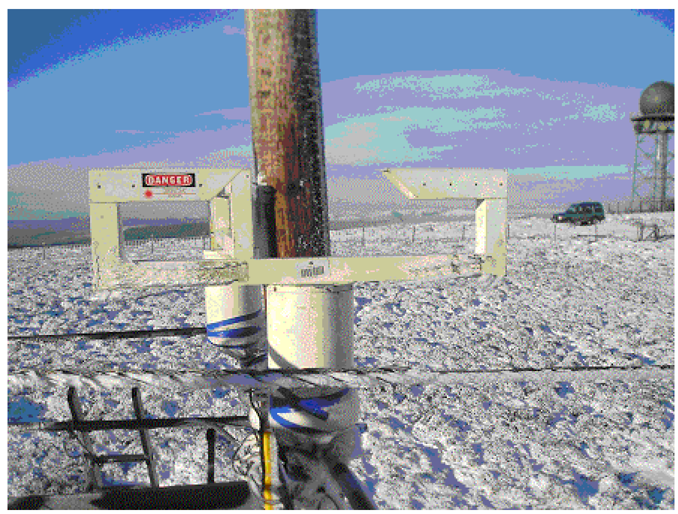

Fig. 3.1 Gerber instruments on southern dead end platform.

IV. PERFORMANCE

The Gerber particulate volume monitors have a 0 - 10VDC output which give a measurement range 0.002 – 10g/m3. Figures 4.1 to 4.4 show some typical weeks data from the test site.

One PVM-100 was mounted and aligned north/south on the south dean platform and the other aligned east/west as shown in Figure 3.1.

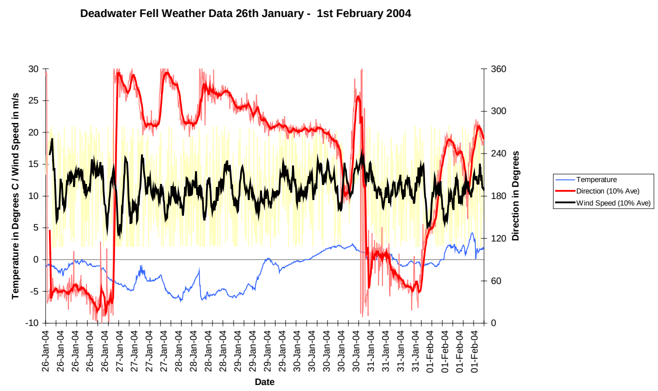

Fig. 4.1 Weather data 26 Jan – 1 Feb 04

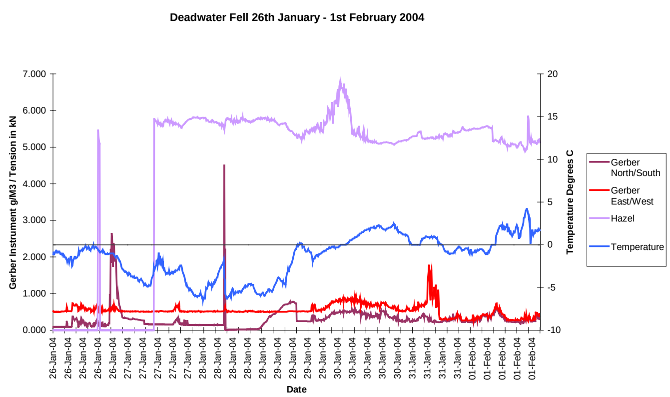

Fig. 4.2 Load cell and Gerber data for conditions in Fig. 4.1

The site span is orientated north-south so winds around 0° or 180° should cause very little ice load accretion on the conductors according to the meteorological models even if icing conditions are met. Winds around 90° and 270° will be normal to the span and icing on the conductor should occur if the meteorological conditions are right. However, sub-zero temperatures and appropriate winds should not cause icing if there is no liquid water content i.e. the Gerbers do not indicate the presence of water particles. In Figures 4.1 and 4.2, there are sub-zero temperatures up to 29 January with occasional winds normal to the span. However, the Gerbers do not indicate the presence of moisture and there is also no indication of ice load on the Hazel conductor. Late on 29 January, the temperatures are rising slightly but still sub-zero and both Gerbers are starting to indicate the presence of moisture. The wind direction is normal to the span and ice accretes on the Hazel as indicated by the increasing load in a steady wind speed. Later on 30 January the temperature rises above zero and there is no icing even though the Gerbers indicate moisture. So this week indicates correct performance.

Figure 4.3 shows a week in March when the winds were almost always in a direction giving a major component across the span. these were associated with sub-zero temperatures for most of the period.

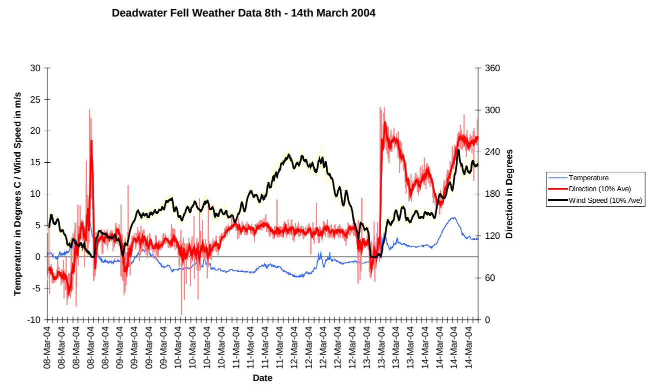

Fig. 4.3 Weather data for 8-14 March

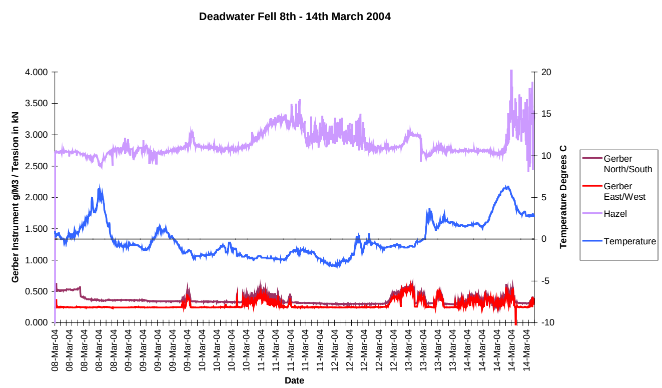

Fig. 4.4 Gerber and load cell data for period covered in Fig. 4.5

On 9 March a minor indication of moisture from the Gerbers combined with a wind normal to the span and sub-zero temperatures indicated icing conditions which was confirmed by a minor load increase on the Hazel. Late on 10 March the Gerbers indicated more severe icing conditions with a wind at 30° to the span. The Hazel suffered a significant increase in ice load which stopped when the Gerbers indicated no further liquid water content in the air. The ice load stayed for a while as the temperatures were still below zero. Another incident occurred on 12/13 March when icing conditions showed up with a further ice load on the Hazel. Gerber indications of moisture but at above-zero temperatures on 13/14 March did not indicate icing conditions and no ice-load was measured. In the final day of the period load variations measured were due to an increase in wind speed and violent conductor movement.

A full 17 weeks data was supplied to the UK Meteorological office on a separate CD. This includes logged tension data from the bare Hazel conductor strung over the 200m span with an intermediate pole at 100m. A camera was also set up to monitor the ice load characteristics near the H-pole. This would identify rime and wet snow icing events.

V. CONCLUSIONS

The data provided from the Deadwater work included logged data from the Gerbers, weather data and load data from the Hazel (10mm diameter aluminium alloy) conductor.

When the combination of temperature, wind direction and Gerber output indicated icing conditions these were always confirmed by the Hazel load cell data. When one of these factors did not indicate icing then no ice load was measured. The tests have thus confirmed the validity in the Gerber instruments to predict the occurrence of icing conditions when combined with other meteorological data.

As the ice models predicted different ice loads depending on conductor size, it would have been a useful exercise to have strung up several different conductors up to 20mm diameter and possibly of different types. Such an exercise would be able to provide data of great interest to the UK Distribution Network Operators (DNOs). The current wind/ice weather maps of the UK as published in EATS 111 (1989) and ENATS 43-40 (1988) have not altogether been fully trusted by the DNOs and a fresh look at how ice loads are related to weather conditions could be used to validate or re-calibrate this original data.

VI. REFERENCES

1. Wareing JB, Fikke SM, 'Meteorological Icing Models' EATL Report T4391, August, 2003
2. Wareing J B and Chetwood P A, 'Ice accretion tests at Deadwater Fell' IWAIS 2000, Chester , UK, June, 2000.