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Relation between test span measured ice loads and conductor size

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Relation between test span measured ice loads and conductor size

- IEC60826 Recommendations
- Test sites
- Procedure for ice load evaluation
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- Conclusions

IEC60826 Recommendations

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- The prediction of ice loads is an important part of overhead line design. IEC 60826 (2005) includes a parameter, g_R, as the reference ice load for a 30mm diameter conductor at 10m above ground.
- When applying this to conductors of other sizes, g_R should be multiplied by the factor K_d shown in the next slide.
- This implies that the ice load increases linearly with conductor diameter, and that the rate of increase is greater for precipitation (wet-snow) icing than it is for in-cloud (rime) icing.
- In the early 1990s, some national standards changed to a "no conductor-size dependency" (i.e. $K_d = 1$), probably for ease of line design. A compromise of $K_d = 1$ up to D = 30 mm but increasing with D above D = 30 mm was subsequently introduced in Cigré and the IEC, and this was adopted in the draft of IEC 60826 (2010) .

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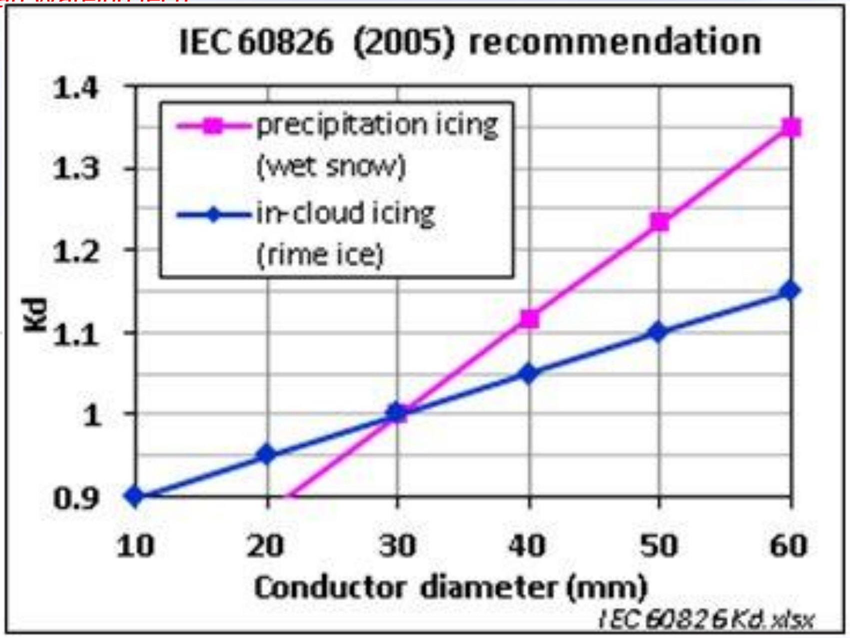
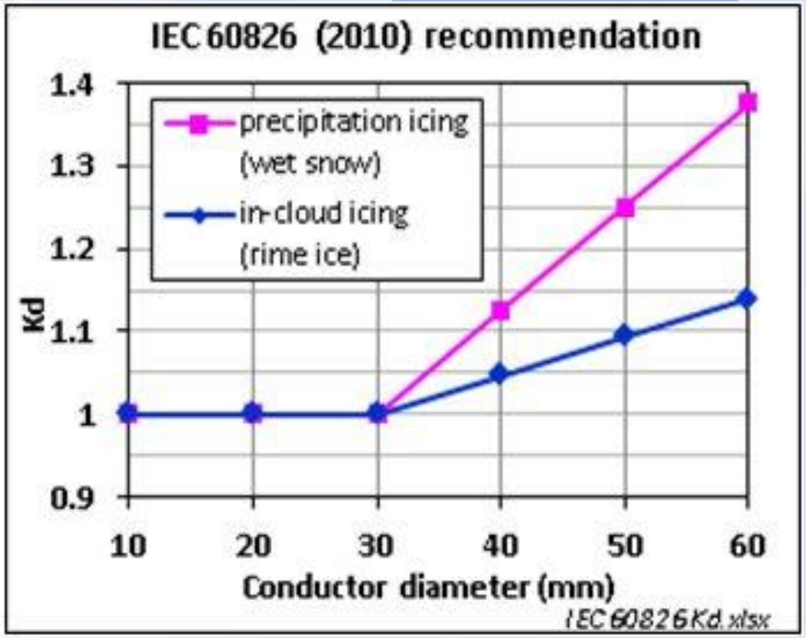
IEC60826 Recommendations





(a) (b)

Variation of ice load factor K_d with conductor diameter D relative to 30 mm conductor (a) from IEC 60826 (2005) and (b) from IEC 60826 (2010)

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IEC60826 Recommendations

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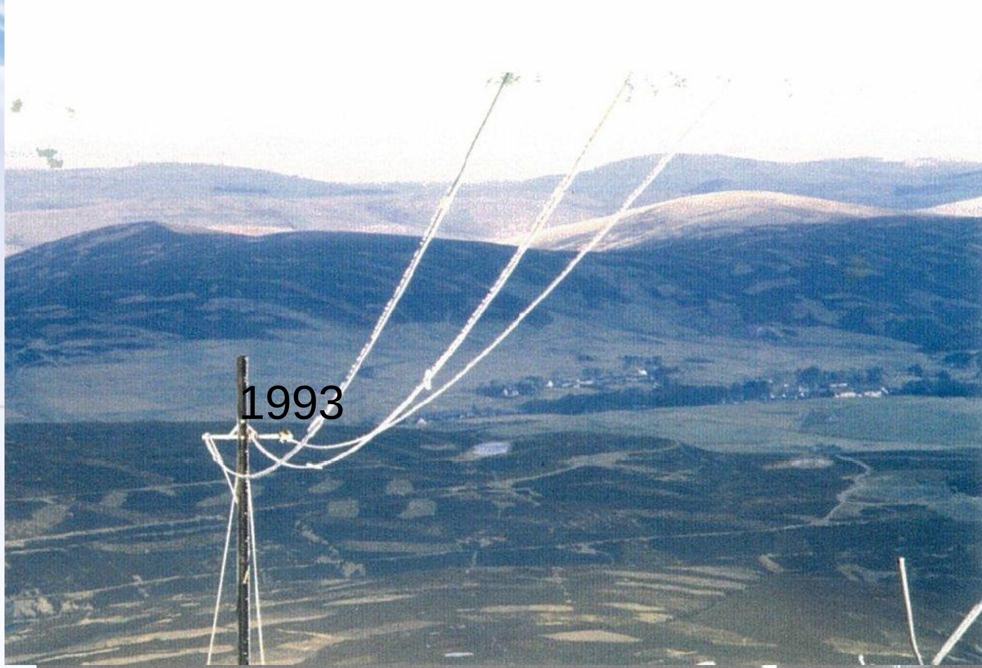
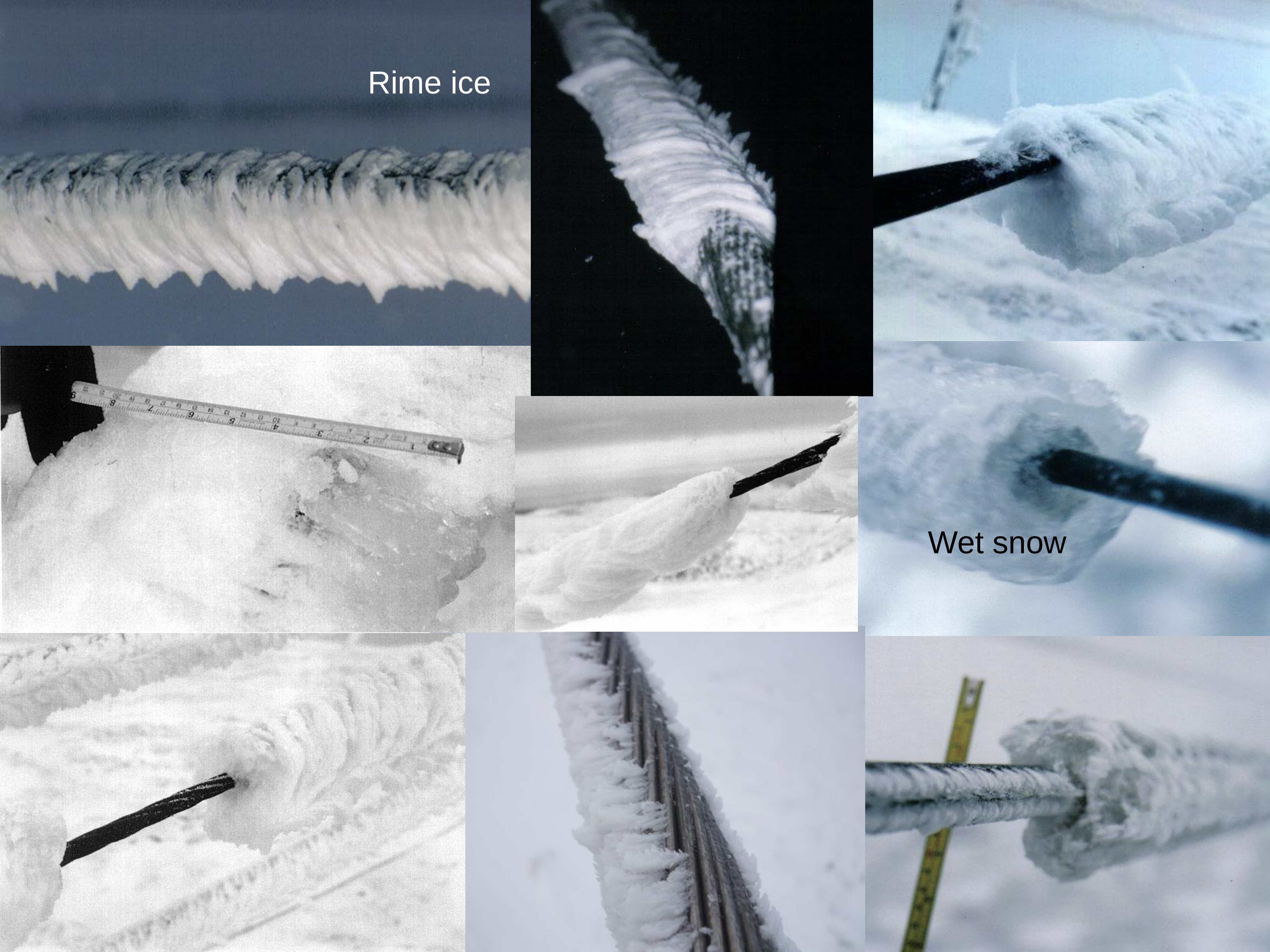
- Note that both IEC 60826 figures only go down to 10 mm and no recommendation is given in the standard for conductors smaller than 10 mm diameter even though these are commonly used on distribution lines.
- However, experimental data obtained over the last 23 years from EA Technology Severe Weather test span sites at Green Lowther (land height of 745m in South West Scotland) and Deadwater Fell (land height of 580m on Scotland/England border) on conductors ranging from 8 to 37 mm diameter under both rime ice and wet snow conditions have suggested that the load factor increases again at small conductor sizes

The test sites – Green Lowther



Deadwater Fell


Rime ice
Wet snow

Procedure for ice load evaluation

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- Ice loads were determined for two or more different-sized conductors under the same conditions at the same time, and hence determine the relationship between ice load and conductor diameter.
- 70 icing incidents – 37 rime ice, 33 wet snow
- 20 different conductors – all 20 involved in rime ice incidents, 18 involved in wet snow incidents.
- Rime ice was assumed for temperatures < -0.5°C.
- The loads were determined from conductor tension measurements made using in-line load cells after allowing for the appropriate wind pressure (taking the wind speed normal to the span from measured wind direction using ultrasonic and cup anemometers).

Procedure for ice load evaluation

- The data was evaluated at three ice densities: 913, 850 and 510 kg/m^3 (standard values from BSEN50341) to determine the radial ice thickness.
- For each icing incident, the calculated ice load for a conductor of diameter D mm, w(D), was normalised by dividing it by the corresponding ice load for a "30 mm" conductor w(30) obtained under the same conditions.
- This gave an experimental value of $K_d(D)$:
  - $K_d(D) = w(D)/w(30)$.
- In incidents where no 30 mm conductor was available for comparison, a two-stage normalisation was necessary.

Load cell data

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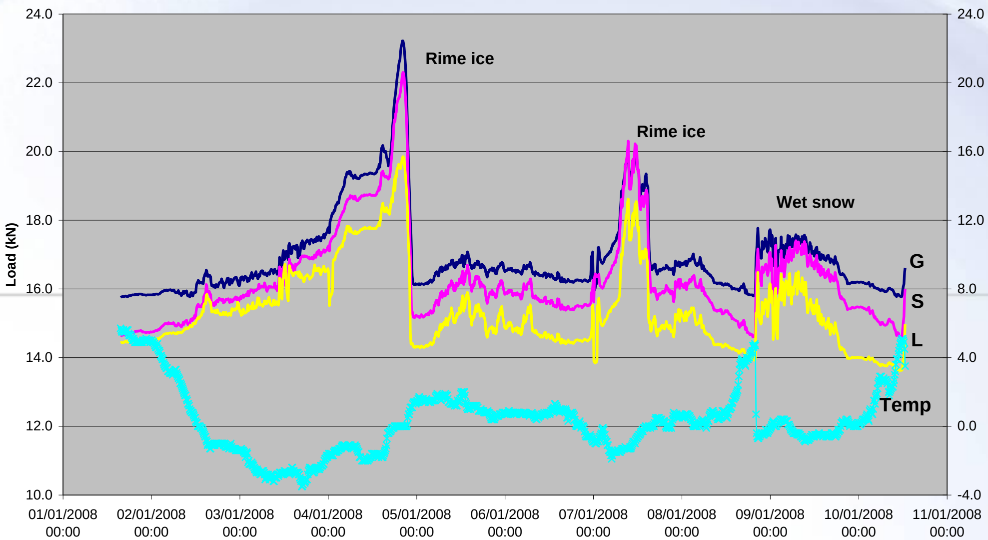
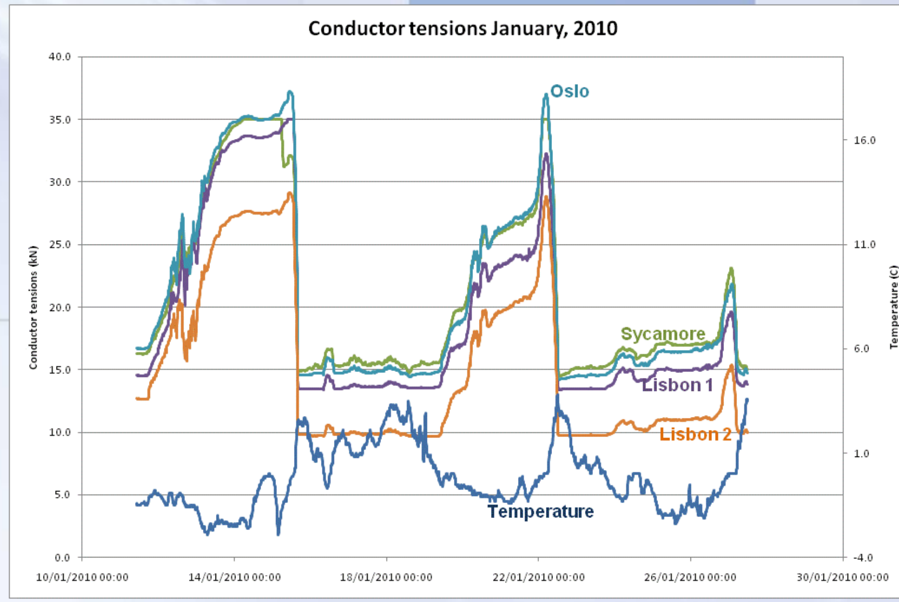
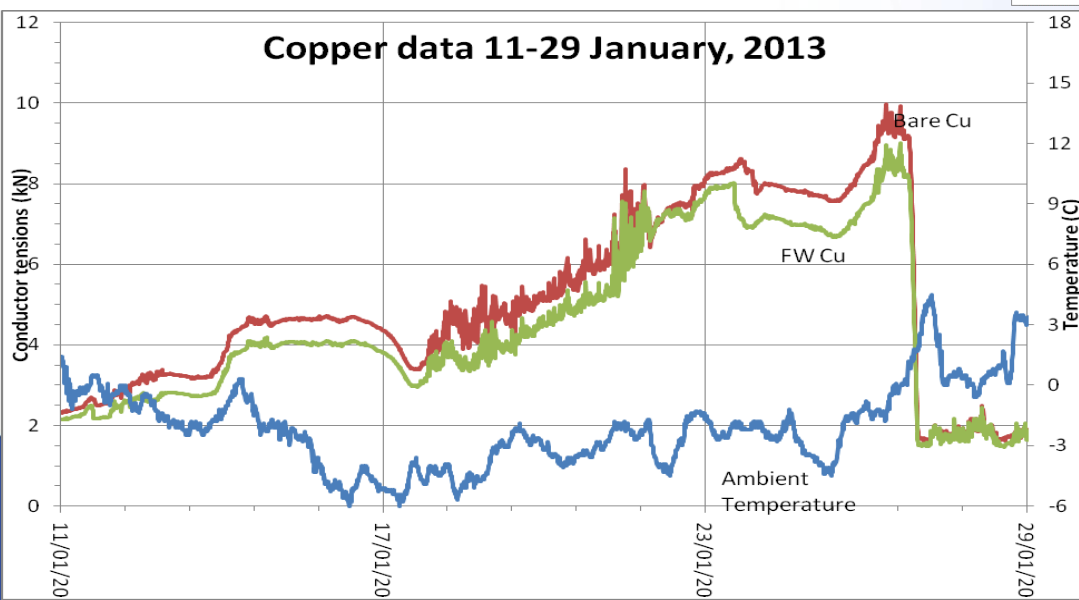
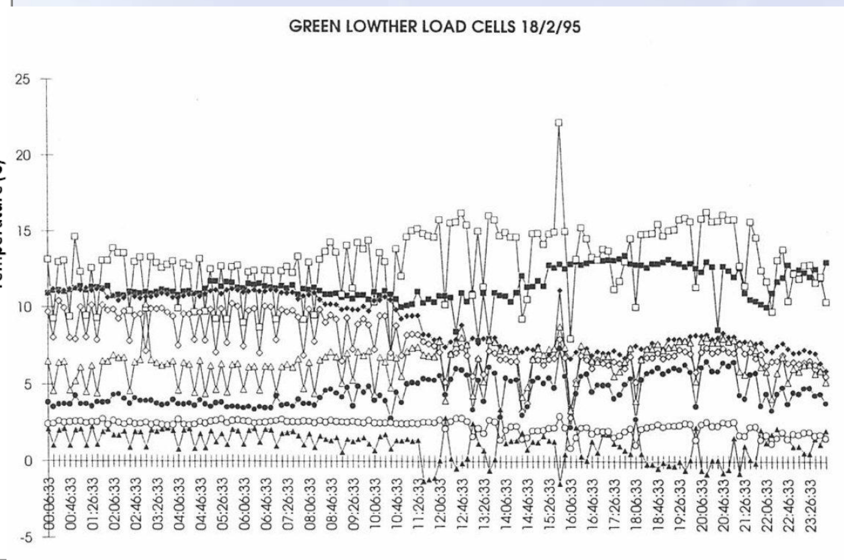
Loads 4-10 January, 2008









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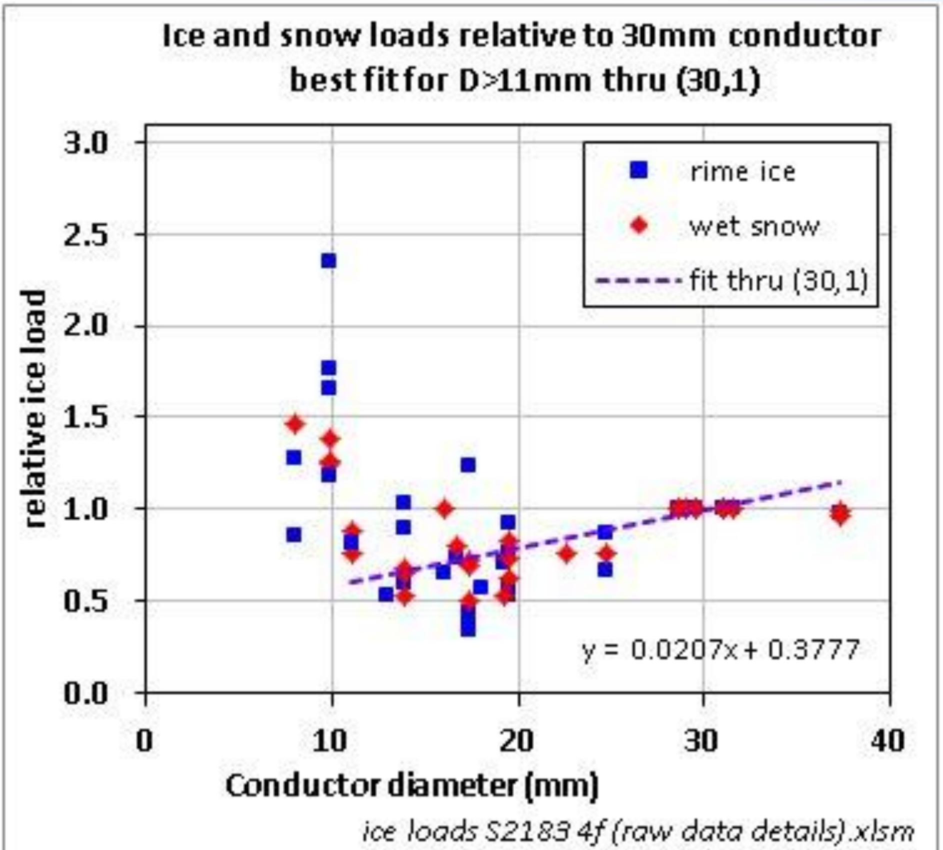
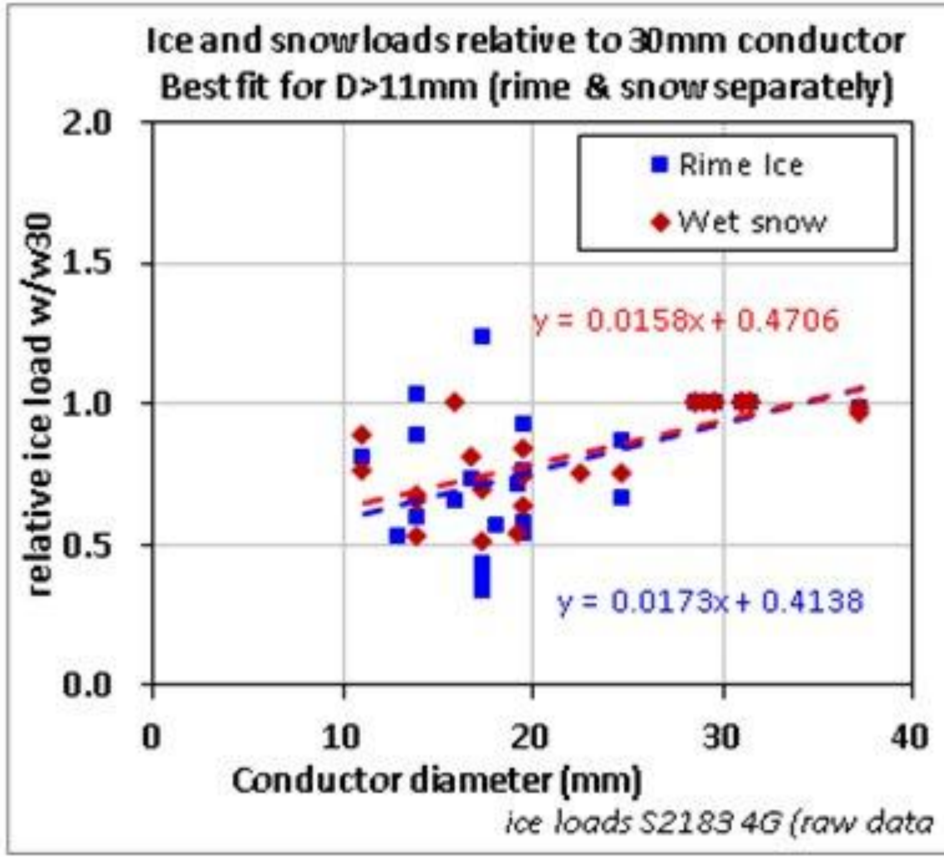
Results

Both the rime ice and wet snow data suggest that K_d falls slightly with decreasing D for D between 40 and 10 mm, but that it rises abruptly as D decreases through 10 mm.





Results

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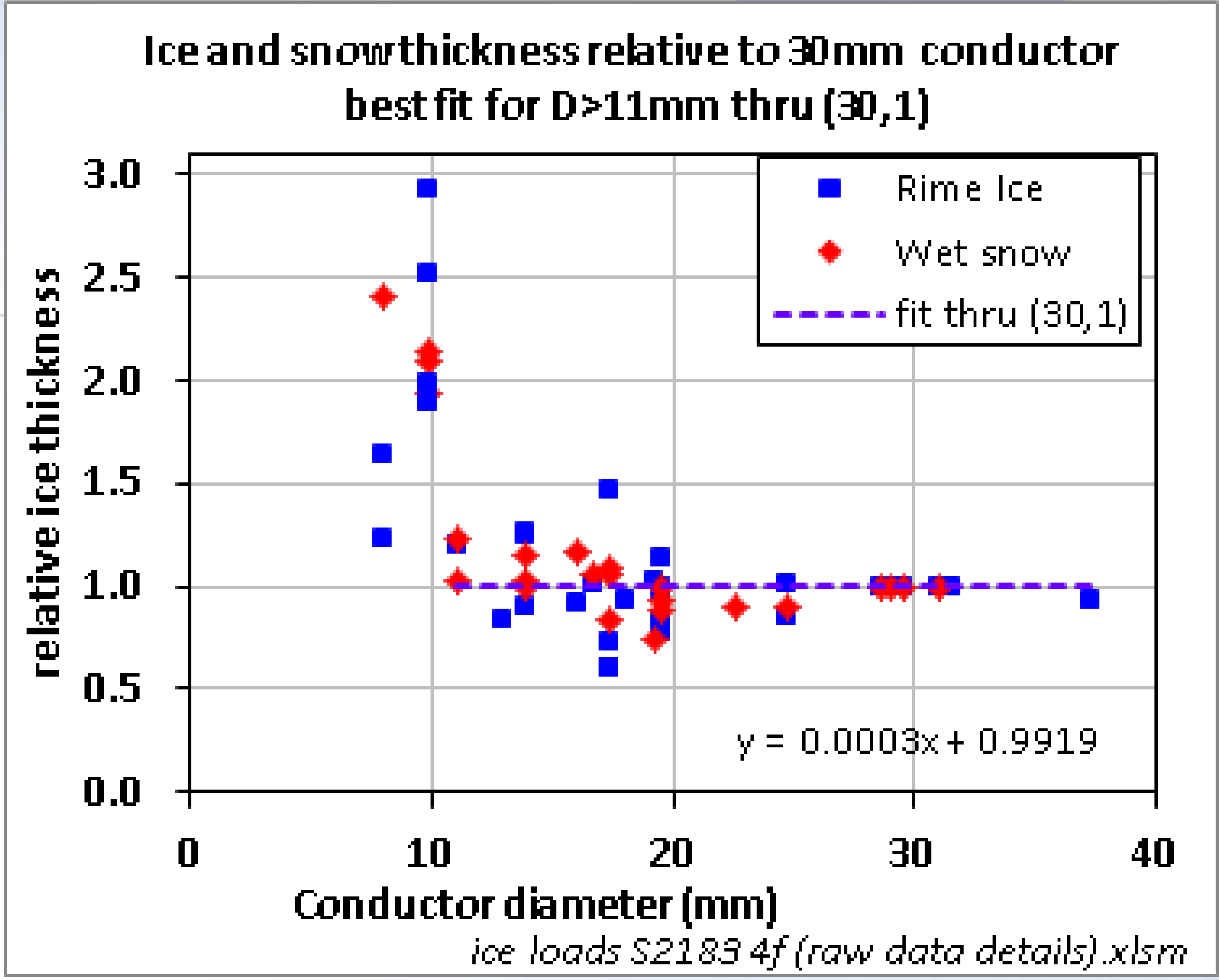
As with the ice load data, the rime ice thickness graph and the wet snow thickness graph are very similar, suggesting that the separate treatment of rime ice and wet snow may not really be necessary.



Results for small conductors (D<11mm)

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- As noted already, the relative ice loads w/w30, and the associated relative thicknesses t/t30, increase dramatically as the conductor diameter D falls below 11 mm.
- The scatter in the data also increases significantly to three times as high for D<11 mm.
- Possible causes of the difference being related to temperature or the date of the event can be ruled out since the same temperature and date ranges are covered by both groups of conductors with very different results.
- It can therefore be concluded that the high values of ice accretion seen for small (D<11 mm) conductors is almost certainly a real effect.

Results for small conductors (D<11mm)

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- The large amount of scatter in ice loads on conductors with D < 11 mm has been discussed and, in some cases, ignored, for many years both within Cigré (SCB2 WG06) and IEC TC11, and also by many utilities, with the assumption of low or even zero ice loads for small distribution conductors.
- There is an argument that smaller diameter conductors could, under certain conditions, accrete a greater thickness of ice than larger ones. Possible reasons for this are
  - that small conductors are more susceptible to ice-induced rotation (smaller conductors rotate more easily due to their lower torsional stiffness) and so accrete more wet snow, and
  - that small conductors have a ‘sharper’ profile and so are more likely to be hit by supercooled water droplets and hence accrete more rime ice, than are larger, bluffer conductors which deflect the wind flow.
- This would manifest itself as a higher mean value, and probably also a greater scatter since the effect would vary with conditions.

Comparison with IEC 60826

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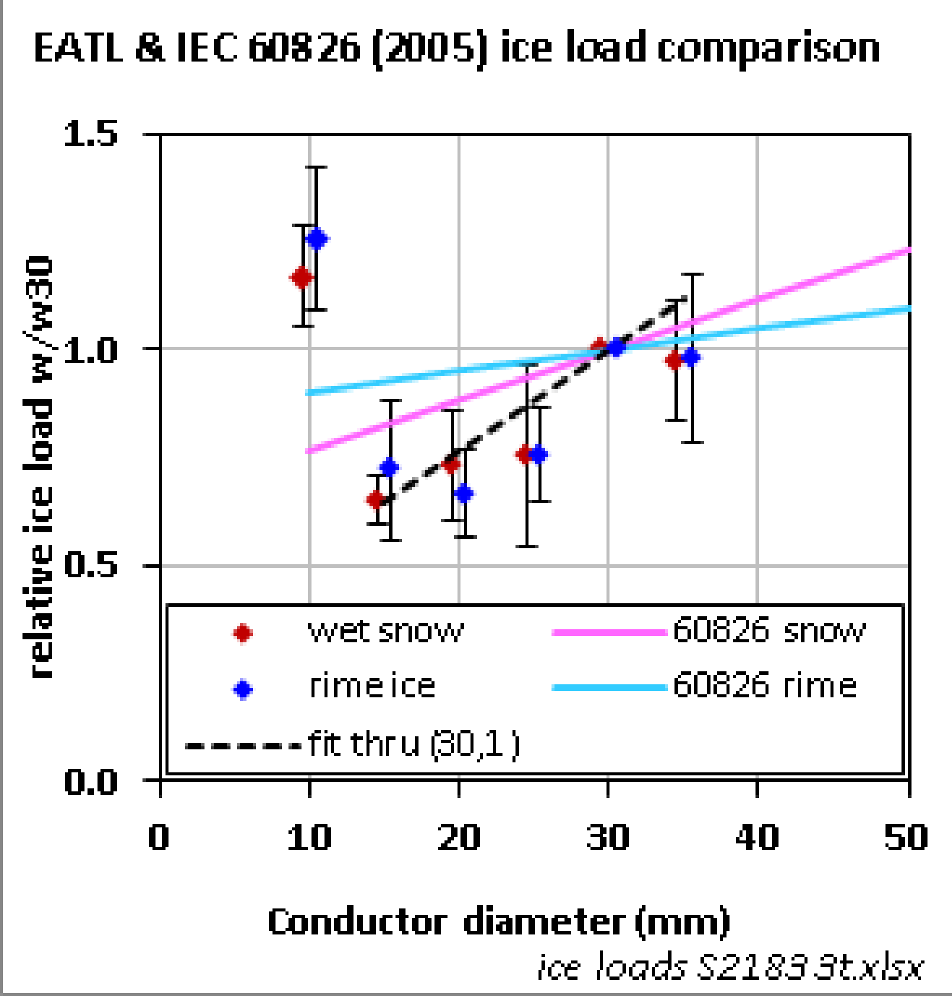
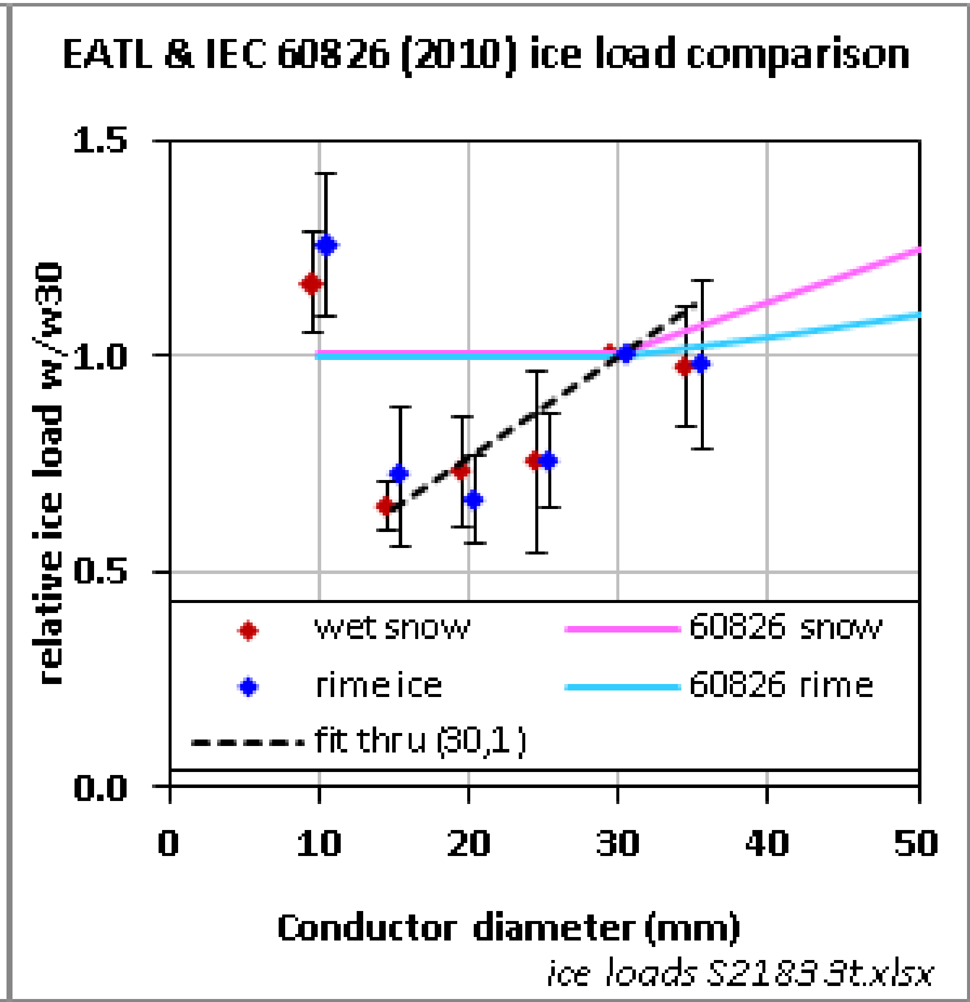
Relative ice & snow loads w/w30 (=K_d) compared with recommendations in 2005 and 2010 versions of IEC 60826.





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Conclusions

- The assertion in IEC 60826 (2010) that ice loads are independent of conductor diameter D for conductors of ≤30 mm diameter is not borne out by the experimental data.
- On the contrary, the data appear to suggest that radial ice thickness, rather than ice load, is independent of conductor diameter, at least in the range D = 11 to 37 mm.
- However, the data for the smallest conductors (D<11 mm) suggest that these small conductors do not fit this pattern and generally suffer significantly higher ice accretion rates than larger conductors.

Conclusions

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- The assertion in IEC 60826 (2005) that ice loads rise with increasing D for D ≤30 mm is found to be qualitatively correct, at least down to D=11 mm.
- However, the measured rate of increase is substantially greater than that suggested by IEC 60826 (2005).

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