Atmospheric Icing Measurements in Fairbanks, Alaska

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Abstract—In the mid 1990s, Golden Valley Electric Association was planning a new 230 kV transmission line between Healy and Fairbanks, Alaska. For two winters, physical measurements of snow and ice loads were made on existing transmission and distribution lines in the Fairbanks area. These measurements showed that the glaze ice equivalents of the snow loads in the area regularly exceeded the ice loads specified in the U.S. National Electrical Safety Code. This paper describes the measurement techniques, the locations where the measurements were made, the ice thickness and the ice density

I. Introduction

In the mid 1990's, Golden Valley Electric Association (GVEA) was planning a new 230 kV transmission line between Healy and Fairbanks, Alaska. While the U.S. National Electrical Safety Code [1] specified a radial thickness of 12.7 mm of glaze ice, observed atmospheric ice loads on the transmission and distribution lines in Alaska are mainly due to snow accretions [2], see Figs. 1 & 2. GVEA wanted to get a sense of the size and density of ice accretions that naturally occur on their system. In some winters, the snow accretions are large enough to cause problems on the distribution system, and maintenance crews are employed to remove the snow. Beginning in the winter of 1994-95, the maintenance crews were asked to make measurements of the size and weight of the accretions before clearing the lines. Those measurements are reported here.

Fig. 1. Snow Accretion on a Telephone Line, Gus's Grind, Fairbanks, Alaska, 23 December 1990.

Fig. 2. Snow Accretion at Windsor and Birch, Fairbanks, Alaska, 23 December 1990

II. Fairbanks' Climate

Fairbanks, at 64°50' north latitude, is just south of the Arctic Circle at an elevation of 135 m. It is in Alaska's continental climate zone, which is characterized by large diurnal and annual temperature variations, low precipitation, low cloudiness, low humidity and generally light winds [3]. The record high temperature is 36 C and the record low is -52 C [4]. The average annual temperature is -3 C while the average annual minimum temperature is -45 C. Temperatures stay below freezing for long periods in the winter months.

III. Measurement Method

The line crews were equipped with wooden boxes and scales. The boxes were approximately 30 cm wide by 30 cm deep by 60 cm long (1 ft wide by 1 ft deep by 2 ft long). After measuring the diameter of the accretion, the box was held up to the bottom of the accretion and the snow and ice were scraped off the wire into the box. The box was weighed, and the mass of the snow filled box and the length of accretion scraped into the box were recorded, along with the empty mass of the box. The location, type of wire and the bare diameter of the wire were also recorded.

IV. Measurements

Figs. 3 & 4 show the snowfall, maximum and minimum daily temperatures and periods with mist, fog and ice fog from the beginning of winter weather to the time when measurements were made (shown by vertical lines). Tables 1 & 2 show the measurements taken in the winters of 1994-95 and 1996-97.

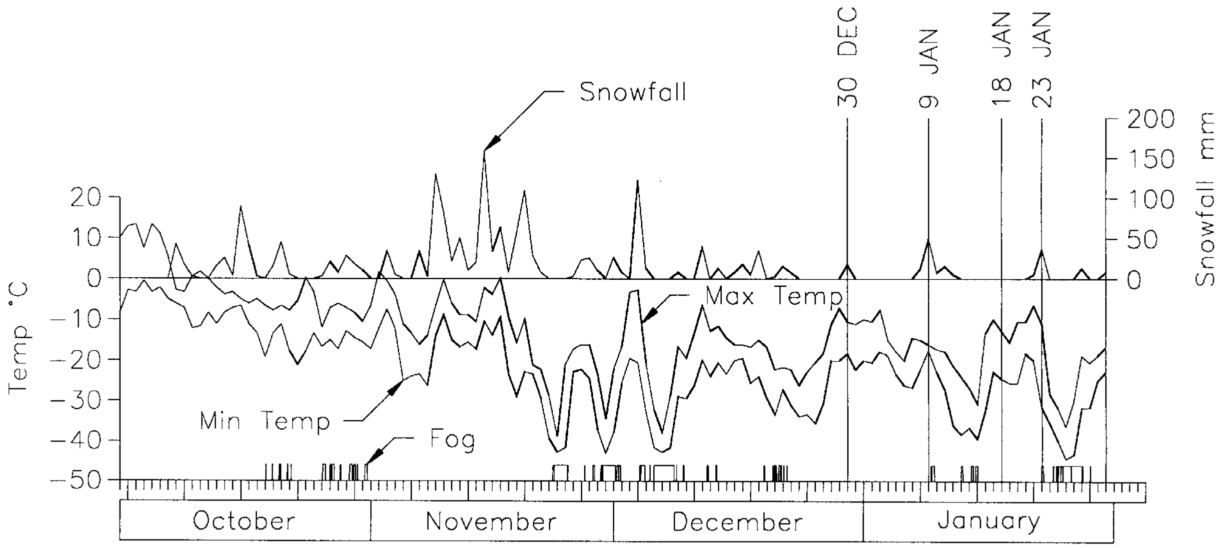

Fig. 3 Weather Conditions in Fairbanks in the Winter of 1994-95

TABLE 1
ATMOSPHERIC ICING MEASUREMENTS IN THE WINTER OF 1994-95

Location	Wire Type	Wire Diameter mm	Snow Diameter mm	Radial Snow mm	Sample Length m	Sample Mass gm	Sample Density Kg/m^3	Equivalent Radial Glaze Ice mm
30 December 1994								
Goldizen	#2	8.26	63.50	27.62	0.559	141.7	81.5	6.1
Walker Way off Farmers Loop	336.4	18.31	63.50	22.59	0.559	141.7	87.4	4.0
Grenac Road	#1/0	10.11	177.80	83.85	0.406	1063.1	105.7	25.6
Farmers Loop near Ski Boot	336.4	18.31	190.50	86.09	0.406	963.9	84.0	21.0
Haggman Road at Old CHSR	#2	8.26	101.60	46.67	0.406	340.2	103.9	13.4
9 January 1995								
Dennis Manor	#1/0	10.11	76.20	33.05	0.406	99.2	54.5	5.5
Peede & Nordale	#1/0	10.11	165.10	77.50	0.406	198.4	22.9	8.9
18 January 1995								
Curry's Corner	Telephone	25.40	228.60	101.60	0.381	935.5	60.6	19.2
Badger Road	6a/8a	7.70	228.60	110.45	0.381	850.5	54.4	24.3
Persinger Drive	Telephone	25.40	215.90	95.25	0.381	609.5	44.3	14.1
Ballaine Road	#1/0	10.11	203.20	96.55	0.406	935.5	71.2	23.7
Stoney Hollow-Goldstream	#1/0	10.11	203.20	96.55	0.406	637.9	48.5	18.9
Woodbine –Goldstream	Telephone	25.40	203.20	88.90	0.406	1105.6	85.2	20.6
Lineman off Dawson Road	#1/0	10.11	203.20	96.55	0.381	708.7	57.5	20.9
23 January 1995								
Repp Road	#1/0	10.11	203.20	96.55	0.356	652.0	56.7	20.7

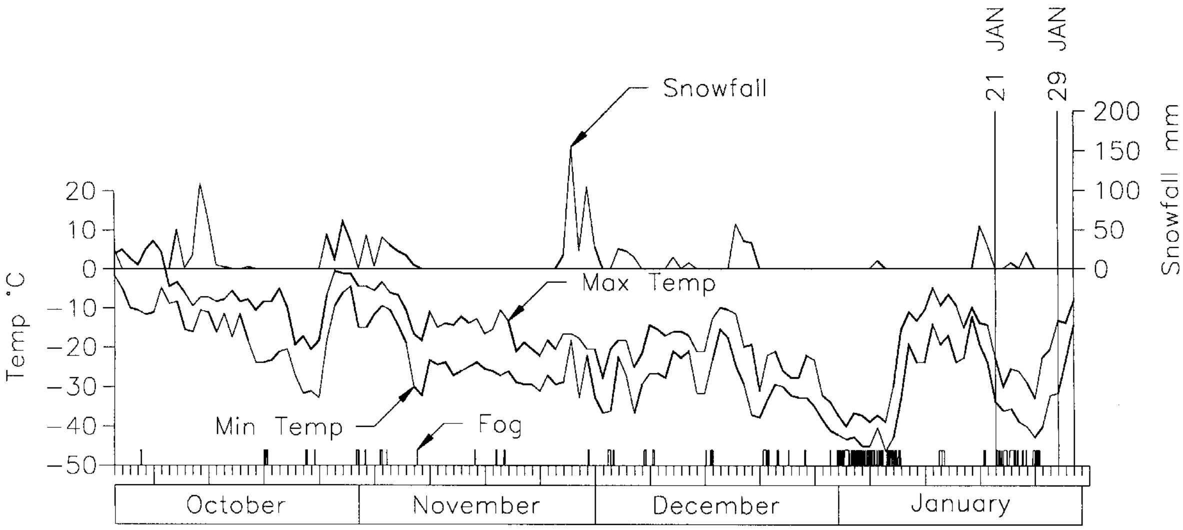

Fig. 4 Weather Conditions in Fairbanks Winter of 1996-97

TABLE 2
ATMOSPHERIC ICING MEASUREMENTS IN THE WINTER OF 1994-95

Location	Wire Type	Wire Diameter mm	Snow Diameter mm	Radial Snow mm	Sample Length m	Sample Mass gm	Sample Density Kg/m^3	Equivalent Radial Glaze Ice mm
21 January 1997								
Steelhead/ChenaSmall Tracts	#1/0	10.11	139.70	64.80	0.610	822.1	88.4	17.2
Poplar & Teal	#1/0	10.11	139.70	64.80	0.610	779.6	83.9	16.7
Conor Road	#6A	7.70	76.20	34.25	0.610	297.7	108.2	9.8
Lismore Circle	#1/0	10.11	114.30	52.10	0.610	751.3	121.1	16.3
27th & Mercer	#4	6.35	127.00	60.33	0.610	921.4	119.6	20.0
Farewell & Eureka	#1/0	10.11	76.20	33.05	0.610	241.0	88.2	7.7
College & Katheryn	#4	6.35	50.80	22.23	0.610	155.9	128.2	6.8
29 January 1997								
Van Horn Rd & 30th	336	18.31	127.00	54.34	0.610	737.1	97.5	13.3
Van Horn behind Sourdough Fuel	25pr 2x1	25.40	139.70	57.15	0.610	595.3	65.9	9.7
Miller Hill Ext.	336	18.31	203.20	92.44	0.610	1771.8	90.4	24.0
MUS Power Plant	25 pr 1.5"	38.10	150x230	86.26	0.610	1559.2	75.9	16.4
Miller Hill Ext.	25 pr 2x1	25.40	100x230	73.28	0.610	425.2	30.7	7.4

V. DISCUSSION OF THE DATA

At the time of sampling in the winter of 1994-95, the temperature had not reached 0 C for over a month, and had been below freezing practically all of the time since mid October. In the winter of 1996-97, the temperature had remained below freezing from early October until the samples were taken at the end of January. The accretions were reported as snow by the crews making the measurements, which is consistent with those winters' weather. The highest wind speeds recorded during periods of snow and fog in both winters were less than 10 m/s and usually less than 5 m/s. The fog that was reported generally coincides with very cold temperatures below -30 C. The fog is typically classed as "ice fog" which is defined by the American Meteorological Society as [5]:

> "A type of fog, composed of suspended particles of ice, partly ice crystals 20 to 100 μm in diameter, but chiefly, especially when dense, droxtals 12–20 μm in diameter.
> It occurs at very low temperatures, and usually in clear, calm weather in high latitudes. The sun is usually visible and may cause halo phenomena. Ice fog is rare at temperatures warmer than -30°C, and increases in frequency with decreasing temperature until it is almost always present at air temperatures of -45°C in the vicinity of a source of water vapor. Such sources are the open water of fast-flowing streams or of the sea, herds of animals, volcanoes, and especially products of combustion for heating or propulsion."

It is clear that the ice accretions sampled are from snow falling at temperatures below freezing with very light or no wind. The equivalent glaze ice thicknesses are up to two times the 12.7 mm glaze ice thickness required by the U.S. National Electrical Safety Code for Fairbanks.

Recent modeling of glaze ice accretion due to freezing rain in this area performed by Kathy Jones for inclusion in an upcoming edition of ASCE 7 [6] estimates the 50 year mean recurrence interval radial glaze ice thickness as 6.35 mm. In interior Alaska, ice accretions due to snow are the major ice loads on the transmission and distribution system.

VI. Acknowledgements

The authors thank Kathy Jones for providing the data showing the occurrence of fog and Golden Valley Electric Association for collecting the snow accretion data and encouraging its publication. Temperature and snowfall data are from [7].

VII. References

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