MORU Cardington Technical Note No. 16

Performance of sensors used in Met Office Research Unit, Cardington turbulence probes

by

M.J. Brettle

2 March 1993

Met. Office Research Unit
RAF Cardington
Shortstown
Beds, MK42 0TH

MORU CARDINGTON

Note

This paper has not been published and PMetO(Cardington) should be consulted before quoting from it.

MORU Cardington Technical Note No. 16

Performance of sensors used in Met Office Research Unit, Cardington turbulence probes

by

M.J. Brettle

2 March 1993

Met. Office Research Unit
RAF Cardington
Shortstown
Beds, MK42 0TH

Note

This paper has not been published and PMetO(Cardington) should be consulted before quoting from it.

Performance of Sensors used in Met Office Research Unit, Cardington Turbulence Probes

M.J. Brettle

2^{nd} March 1993

1 Introduction

This is intended as a basic guide to sensor performance. Performance will be quantified as absolute accuracy, relative accuracy, drift and response time or frequency response. Accuracy will be based on calibration procedures, results from intercomparison flights or other experience of actual use. Relative accuracy, where different from absolute accuracy, is based on the spread of values from several sensors when they are expected to give the same results or some other stated criterion. It is therefore a measure of random error and excludes any systematic error that may occur. If no systematic error is identified then relative and absolute accuracy are the same. Drift is based on changes between calibrations. The response time is based on laboratory trials, data from actual flights, manufacturers specifications, time constants in probe circuitry or some combination of these.

2 Pressure Sensors (Digiquartz)

2.1 Absolute Accuracy

This is estimated at $\pm 0 \cdot 5$mb based on checks during actual use. Temperature effects are corrected for in processing and the figure given allows for this.

2.2 Relative Accuracy

As absolute accuracy. Calibrations are regarded as independent and are based on a standard instrument at the Met. Office test lab. in Bracknell and checks are made during use against PAB's also tested against the Bracknell standard therefore no systematic errors are expected. The spread of values during intercomparison flights is consistent with this.

2.3 Drift

About $0 \cdot 25$mb/year based on changes between calibrations. There is some variation between sensors and most drift less than this figure.

2.4 Time Constant

The sampling time used by the probe circuitry is 2·5 seconds and this is the limiting factor. These sensors have no detectable "warm-up" period after being switched on.

3 Wind (Analogue Gill Anemometers)

3.1 Absolute Accuracy

This is estimated at $\pm 0 \cdot 2 \text{ms}^{-1}$. This is based on the wind tunnel calibration procedures and is larger than any possible deviation of the actual angular response from the manufacturers non-cosine response or variations covered by different propellers of the same type.

3.2 Relative Accuracy

As absolute accuracy.

3.3 Drift

Over one year this is usually less than the sensor accuracy unless a part is worn or faulty when changes may be large.

3.4 Response Time

The sensor have a length constant of 1·0m, using polystyrene propellers type 08274, (the older type 21282 had a length constant of 0·8m) giving a 10Hz frequency response in a 10 ms^{-1} wind. This is the frequency at which the probe circuitry filters the Gill output.

4 Inclinometers

4.1 Absolute Accuracy

Estimated at about $\pm\frac{1}{2}^{\circ}$ from calibration procedures. Inclinometers are calibrated against spirit levels that are assumed to be free of systematic error. Possible misalignments between sensors and probe bodies are checked or allowed for in the calibration procedure.

4.2 Relative Accuracy

As absolute accuracy.

4.3 Drift

About $\frac{1}{4}^{\circ}$ per year based on changes between calibrations.

4.4 Response Time

This is limited by an electronic filter in the probe with a corner frequency of $0 \cdot 6$Hz. The sensor itself is claimed by the manufacturer to operate to about 80Hz.

Note

Probe orientation error is not necessarily the same as inclinometer or magnetometer error. For more information refer to CTN No 14 (An error analysis of the Cardington turbulence probe orientation algorithm by A.L.M. Grant, 4 Dec. 1992).

5 Magnetometers

5.1 Absolute Accuracy

Calibration of each channel is estimated to be accurate to $\frac{1}{2}^\circ$. Errors are expected to be random rather than systematic.

5.2 Relative Accuracy

As absolute accuracy.

5.3 Drift

Less than $0 \cdot 2^\circ$/year based on changes between calibrations.

5.4 Response Time

This is limited by the rate of data collection. The manufacturers claim a 60Hz frequency response. Probe circuitry filters at 28Hz.

Note

Probe orientation error is not necessarily the same as magnetometer or inclinometer error. For more information refer to CTN No. 14 (An error analysis of the Cardington turbulence probe orientation algorithm by A.L.M. Grant, 4 Dec. 1992).

6 Platinum Resistance Thermometers (PRTs)

6.1 Absolute Accuracy

$\pm 0 \cdot 3^\circ$ C from repeat calibrations, spread during I.C. flights and PRT/slow dry differences. Note that the manufacturers emphasise that these sensors are only designed for measuring rapid fluctuations and claim no absolute accuracy.

6.2 Relative Accuracy

As absolute accuracy.

6.3 Drift

Typically 0·1° C/year or less. This is less than the error in calibration so cannot be accurately judged.

6.4 Response Time

Manufacturers claim 0·1s. This is faster than can be tested at Cardington.

Note

PRTs and the PRT bridges inside probes are calibrated separately. This enables new pre-calibrated sensors to be used when a probe PRT is broken without any need for new calibration. PRT bridge calibrations are believed to be extremely accurate and calibration error is almost entirely due to sensor calibrations.

7 Thermistor Temperature Sensors

7.1 Absolute Accuracy

$\pm 0 \cdot 2°$ C.

7.2 Relative Accuracy

As absolute accuracy. Note however that the true calibration curve involves exponential functions of temperature. In practice a parabola is fitted for processing and this introduces an error of about 0·1° C around temperatures of 5° C and 17° C. Thus actual relative accuracy (as might be used when probes are separated at different temperatures) is worse than might be deduced from the spread between sensors reading the same temperature.

7.3 Drift

No consistent drift has been measured. Sensor calibrations vary in an apparently random manner by about 0·1° C over a period of several months.

7.4 Time Constant

As measured in the laboratory this is about 4 seconds.

8 "Humicap" Humidity Sensors

8.1 Absolute Accuracy

This is about ± 2% (this means ±2% in RH not as a percentage of value, for example a reading of 50% RH would indicate a true RH between 48% and 52% RH). Systematic errors in calibration are considered to be very much less than this as there is a high

level of confidence in the Michell Dew-point hygrometer used for calibration. The quoted accuracy assumes that temperature corrections are made.

8.2 Relative Accuracy

As absolute accuracy. See note below however.

8.3 Drift

This is about 4% in RH per year maximum. Note that offset, slope and temperature sensivity can all drift.

8.4 Response Time

About 2 seconds from laboratory trials.

Notes

1. "Humicap" sensors respond to RH rather than the more meteorologically significant mixing ratio. However over the range of values of interest the absolute accuracy is equivalent to about $\pm 0 \cdot 2$ gm/Kg. Relative accuracy between sensors at different heights, temperatures and mixing ratios may be up to $\pm 0 \cdot 4$ gm/Kg^{-1} however.

2. CTN No 6, "An evaluation of "humicap" sensors for use on balloon-borne turbulence probes" by M.J. Brettle, September 1992, has more information on "Humicap" performance.