COMMONWEALTH BUREAU OF METEOROLOGY

Regional Instrument Centre

Instrument Test Report - 672

EVALUATION OF THE RIMCO

PRECIPITATION GAUGE

TIPPING BUCKET MODEL 7499

J.D. Gorman
Regional Instrument Centre
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Authorisation

Dr Bruce Forgan
SRLR
Regional Instrument Centre

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Aim

The aim of this report is to describe and discuss the testing of Rimco Tipping Bucket Rain Gauge (TBRG) Model 7499 supplied by McVann Pty Ltd against the Bureau specification for tipping bucket rain gauges [1]. To this end the structure of this document parallels that of the specification. This report contains references to sections of the Bureau TBRG specification considered relevant for RIC testing and does not include testing against all criteria outlined in the specification.

Experimental

The two testing rigs employed in this study are known within the RIC as Squiddly and Rex. Both systems are fully automated in terms of water delivery, tip counting and data logging. The two systems employ differing techniques to arrive at the same experimental value – *the number of tips for a fixed volume of water at a particular rainfall rate*.

Squiddly uses a Boyle bottle to deliver a fixed volume of water through fixed diameter nozzles under gravity. Hence the bottle volume determines the volume delivered and the 'rainfall rate' is determined by the nozzle diameter.

Rex employs a peristaltic pump to deliver water into the gauge, which is positioned on a weighing tray. A volume of water is delivered and then the tray is weighed allowing an accurate determination of both the volume delivered and the delivery rate. The 'rainfall rate' is determined by setting the RPM of the peristaltic pump.

The Squiddly system has been employed within the RIC for some time while the Rex system has been recently developed based on overseas work [2] to achieve higher testing rates and greater flexibility of testing and is described separately [3]. The results of both testing systems were put into the same form, *corrections required per 100 tips* for each gauge at various rainfall rates producing graphs, which are employed to evaluate the gauges against the specification [1].

The water used in these tests was Melbourne tap water filtered through an Aquapure AP124 in-line water purification filter. Previous work has established that testing with filtered water does not significantly alter testing results when compared with distilled water [4].

20 gauges (Serial numbers 84065 through 84084) were received for testing. All were tested on either Squiddly or Rex or both.

Throughout this document the term 'as received' is used to mean individual gauges that had not been bedded-in or previously tested by the RIC.

For these experiments 10 Rimco model 7499 gauges were tested by Rex 'as received' and 10 were tested by Rex after they had been tested by Squiddly.

Results

1. **Climatic Conditions** – Not evaluated in this study.

2. **Reliability**
   The rain gauge must be capable of resolving rainfall events of 0.6 mm and greater.
   Pass – that is, one or more tips were detected from a 'dry' gauge for an injection of 20ml of water into the gauge funnel.

3. **Tolerance** – See Section 9.

4. **Rainfall capability.**

For these tests Rex was employed, as Squiddly does not have the capability of programmed rainfall events. This test is designed to evaluate whether the gauge will overfill during expected short duration intense rain events.
The gauge must accept water up to an equivalent rate of 350mm/hour without the collecting funnel starting to fill. Pass.

4.1 The gauge must accept volumes of water equivalent to the following extreme rainfalls without overflow of the collecting funnel:
a) 30mm of rain over 1 minute = 970 ml/min for one minute Pass.
b) 85mm of rain over 5 minutes = 550 ml/min for five minutes Pass.
c) 130mm of rain over 10 minutes = 420 ml/min for ten minutes Pass.
d) 250mm of rain over 30 minutes = 270 ml/min for 30 minutes Pass.

5. **Collector Details**

5.1 *Cross Section of rim between 200 and 205 mm in diameter* – Pass.

5.2 *The overall height of the gauge must be between 250 and 360mm ±0.5 mm*- Pass.

5.2 *The gauge must be suitable for installing on a flat metal plate or concrete slab. Three mounting holes of 8 to 10mm diameter shall be placed at 120° intervals on a 254mm pitch circle diameter at the bottom of the gauge. The holes may be in three separate legs or in a circular base.* – Pass.

6. **Durability of materials** – Not evaluated in this study

7. **Measuring system details**

7.1 *The bucket mechanism must not retain more than 0.2 ml of water on the surface of the bucket side after its water has been discharged. A suitable coating such as Teflon may be used if necessary, in order to minimize the amount of water retained.* Pass.

7.2 *A surge suppression device of the Metal Oxide Varistor (MOV) type must be connected across each contact set. The MOV should have a voltage rating of not less than 25 volts but no more than 50 volts.* - Pass.

8. **Data Logger Cradle** – Pass.

9. **Calibration and performance**

For these procedures the volume delivered, the diameter of collection area and other characteristics of the mechanism were used to calculate the expected number of tips. Only data from 'as-received' gauges were used in the determination of a pass or fail with respect to the Bureau specification. The criterion is the difference between the gauge under test and the ensemble mean, that is, the average correction for all gauges of that type for the set rainfall rates of 25, 52, 125, 250 and 300 mm/hr. The average of all corrections, for all gauges, at all applied rainfall rates was calculated and the Bureau specification of ± 3 tips up to a rainfall rate of 250 mm/hr and ± 4 tips up to 350 mm/hr applied to that mean. This is illustrated in Figure 1.

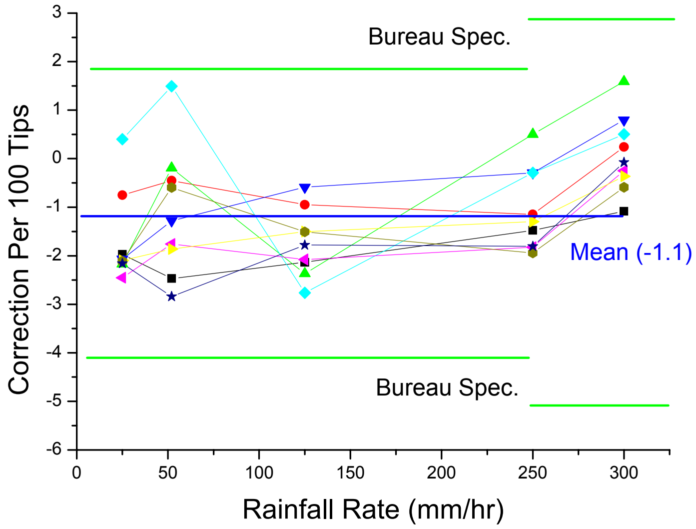

Figure 1. 'As-received' test of ten 7499 gauges tested by Rex. The blue horizontal line is the ensemble mean. The horizontal green lines are the Bureau specification [1].

In figure 1 it can be seen that all of the ten 7499 gauges passed the Bureau specification. Some gauges were selected for extended testing to determine if the characteristics of the gauge altered as a result. The results of this testing for two 7499 gauges are shown in figure 2.

Figure 2 shows the drift in corrections during the 'bedding-in' of a 7499 gauge. The plot consists of the corrections calculated for successive test as the gauge is repeatedly cycled for 300 tips runs at 25, 52, 125, 250, 300 and 500 mm/hr. It can be seen that for 25 and 52 mm/hr the gauge correction moves significantly during early testing. The correction at all rainfall rates drifts down by a number of tips. This change of the correction implies that before 'bedding-in' a gauge initially adjusted to meet the specification may fall outside the specification after more water has passed through the gauge. It should be noted that the gauges shown in figure 2 had approximately 2000 tips put through by the manufacturer when adjusting the gauge.

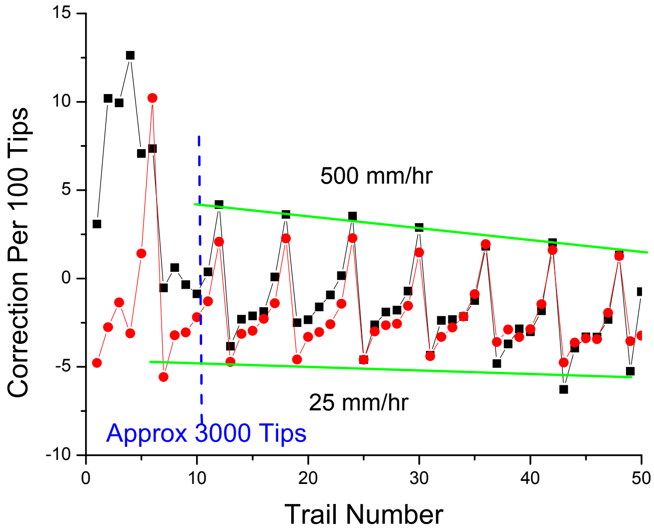

Figure 2. Correction versus Rex trial number showing drift in correction versus total number of tips for two 7499 gauges (black and red). 25 and 500 mm/hr data points associated with the green lines. Other rainfall rates between 25 and 500 mm/hr are given by the intervening points.

The Bureau specification also includes a test of the reproducibility of the gauge type. After a large amount of water has passed through the 7499 gauges (5000 tips) the behavior of the gauges was seen to alter (figure 2) indicating that the 7499 gauges are not fully bedded in on arrival at the Bureau. A distinctive 7499 model sensitivity vs rainfall rate characteristic was evident after ~4000 tips and is demonstrated by the close correspondence between the black and red lines in figure 2.

Table 1 summarizes the group statistics for 10 Rimco 7499 gauges 'as received' and tested by Rex. The standard deviations calculated were then employed to calculate the 95% confidence levels for the expected mean at each rainfall rate for the group of 'as received' gauges [5] shown as vertical bars in figure 3. The data points are the mean corrections for the 10 gauges tested while the bars are the 95% confidence levels calculated from the group corrections at each rainfall rate. These show that there is an expectation that *less than* 5 % of 7499 gauges will fall outside the Bureau specifications (shown in green in figures 1 and 3) at the rainfall rates tested.

Table 1. Combined average correction and standard deviation

Rate	Avg Corr.	Std Dev
26.12	-1.77385	0.896
52.02	-1.18314	1.277
127.78	-1.74437	0.648
255.49	-1.01628	0.815
306.05	0.146609	0.778

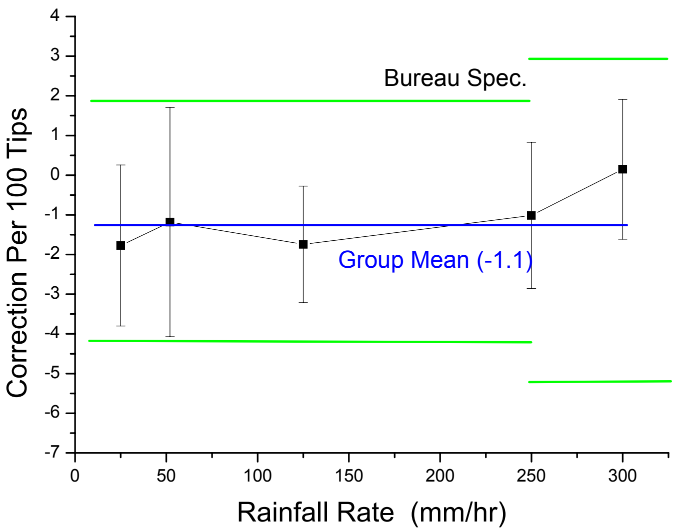

Figure 3. Plot of the mean corrections for the 10 'as received' 7499 gauges at testing rainfall rates with the Rex system. The bars are the 95 % confidence levels derived from the test data.

As *less than* 5% of the 'as received' gauges failed the Bureau specification the 7499 gauges Pass the section 9 component of the specification.

Discussion

A bedding-in process is shown in figure 2. The gauges clearly increase in sensitivity, that is, the corrections become more negative after bedding-in. When questioned the manufacturer advised that the gauges had been bedded in with approximately 2000 tips which concurs with figure 2, suggesting a further 3000 tips were required before the gauges bedded in, that is, a total of 5000 tips.

10. Packing and Marking – Not relevant to this testing

11. Conclusion

The Rimco Model 7499 TBRGs met those Bureau specification [1] criteria tested. However, the gauges were not 'bedded-in' before delivery resulting in a drift in characteristics with increasing total tips. It is difficult at this time to determine why bedding-in is necessary. However the effects of previous exposure are significant and have been reported earlier [4] for other Rimco model 7499 gauges. This drift can impact on both the variability of the gauges and their offsets.

The manufacturer of these gauges had been requested to bed the gauges in before delivery with approximately 5000 tips. This does not appear to have occurred and raises concern about the manufacturer's ability to supply gauges set up as requested.

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[1] *Precipitation Gauge Tipping Bucket Type*, Equipment Specification A 1980 Revision 3, Bureau of Meteorology, 2002

[2] M. D. Humphrey and J.D. Istok*, A New Method for Automated Dynamic Calibration of Tipping-Bucket Rain Gauges,* , Vol. 14 Atmos and Oceanic Tech., Dec. 1997, p. 1513 - 1519

[3] J.D. Gorman, *Evaluation of the RIC Designed Pumped Rain Gauge Tester*, Bureau of Meteorology ITR 671, 2003

[4] M.Berechree, *Stability of Five McVann Model 7499 TBRG*, Instrument Test Report 660, Aug. 2001

[5] *Uncertainty Measurement, The ISO Guide, Monograph 1.* NML Publication No. TIP P1337 2001