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EVALUATION OF WINDSHIELDS FOR USE IN THE AUTOMATED SURFACE OBSERVING SYSTEM (ASOS)

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1. INTRODUCTION

The National Weather Service (NWS) ASOS Product Improvement (PI) Program is currently investigating All-Weather Precipitation Accumulation Gauges (AWPAG). The specification for this new sensor states that its performance is to be compared to a standard 8" NWS non-recording gauge. In previous testing, the reference 8" gauge was equipped with a metal Alter shield for improved snow catch during windy conditions. However, one study (Goodison, 1978) has shown that the Alter shields may not produce an accurate measurement of Liquid Water Equivalent (LWE). Another study (Hamon, 1973) showed that actual precipitation could be computed from data collected with one shielded and one unshielded gauge, known as the “dual gauge procedure”. This procedure also accounts for precipitation losses due to the influence of wind. The dual gauge procedure was chosen as the reference for this test because of its documented ability to provide the most accurate measurement of LWE.

2. TEST APPROACH

Testing was performed at the Johnstown Cambria County airport in Johnstown, PA. Only shields that were considered viable for ASOS, because of size and cost, were tested. The internationally accepted Double-Fence Inter Comparison Reference (DFIR) was not considered due to its excessive size. The Johnstown test bed consisted of ten standard NWS non-recording 8" precipitation gauges (NWS SPEC # D040). Two were equipped with single metal Alter shields (Figure 1), two with ASOS vinyl shields (Figure 2), two with Tretyakov shields (Figure 3), two with double Alter shields (Figure 4), and two unshielded (Figure 5).

The gauges were aligned from northeast to southwest with a 15 meter (50 foot) separation between each row. The rows were referred to as the Northwest (NW) and the Southeast (SE) rows. Within each row the gauges were spaced approximately 5 meters (15 feet) apart.

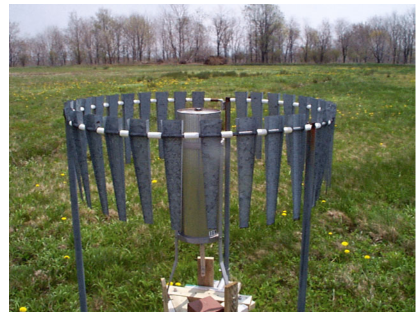

Figure 1 Single Metal Alter Shield

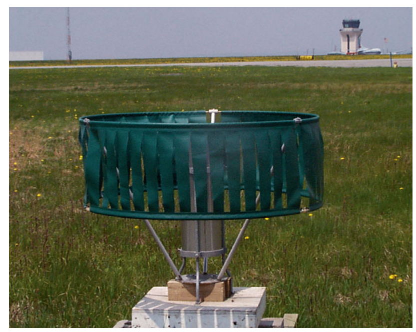

Figure 2 ASOS Vinyl Shield

Figure 3 Tretyakov Shield

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Figure 4 Double Alter Shield

Figure 5 No Shield

3. 1999-2001 RESULTS

The following results are based on the combined winters of 1999-2000 and 2000-2001. There were 7 events over the course of the two years with total snow board measurements of 71cm (28 in). The analyses were typically performed only in events where the winds were 10 knots or greater, but some exceptions were made in an attempt to increase the number of events available for analysis. Most of the events were light snow with winds varying from 7 to 17 knots.

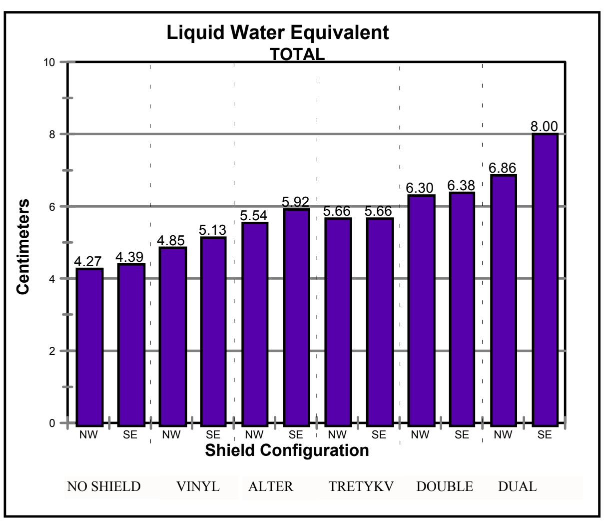

Figure 6 NW/SE Side

The shields in the southeast row had consistently higher LWEs than the northwest row, except for the Tretyakov, which caught the same amount on both sides. The following bullets list the order in which the gauges performed, starting with the gauge that caught the most precipitation and decreasing to the gauge that caught the least:

<u>Southeast side</u>

- Dual gauge procedure
- Double Alter shield
- Single metal Alter shield
- Tretyakov
- ASOS vinyl
- Unshielded

<u>Northwest side</u>

- Dual gauge procedure
- Double Alter shield
- Tretyakov
- Single metal Alter shield
- ASOS vinyl
- Unshielded

The following graph shows the catch efficiency of each gauge and shield combination when compared to the dual gauge procedure. The one hundred percent line represents the dual gauge procedure.

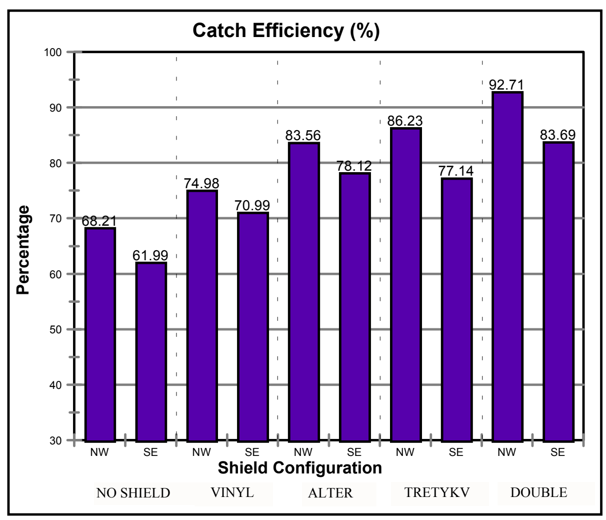

Figure 7 Catch Efficiency (NW/SE Side)

The dual gauge procedure indicated the most LWE on both sides. When comparing each side of the test bed, the gauge/shield combination that caught the most precipitation was the double Alter shield.

4. EFFECT OF WIND SPEED

Increasing wind speed causes increasing catch losses, especially in solid precipitation. This conclusion is extensively documented in Goodison, et. al. (1998) and Rasmussen et. al. (2001). While the sample used in this study was comparatively small, the results provided in this report are representative of their results.

Figure 8 shows the events segregated by wind speed. The choices for the segregation were: 1.) Wind speed less than 10 knots, 2.) Wind 10 to 14 knots, and 3.) Wind greater than 14 knots. Results were based on the average of the same two gauges on both sides of the test bed as a percentage when compared to the dual gauge procedure. The one hundred percent line represents the dual gauge procedure. Data were based only on the seven events for which all five gauges were installed. The results show the dramatic reduction in total catch that is suffered by all gauges with increasing wind speed when compared against the theoretical "true" precipitation computed using the dual gauge procedure. The catch in unshielded gauges, in fact, was a small fraction of the true precipitation in windy conditions.

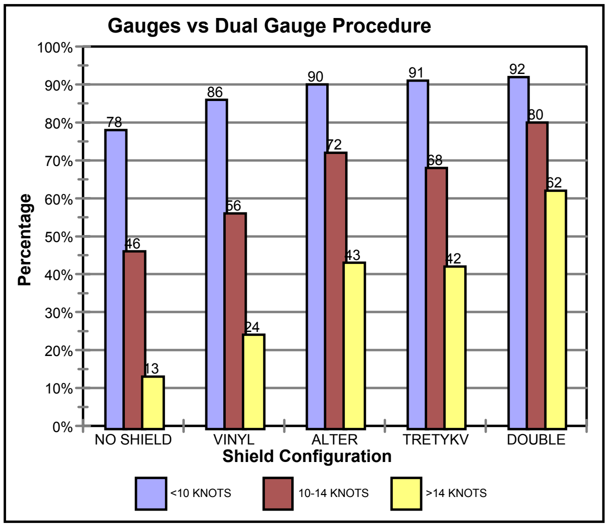

Figure 8 Performance of gauges vs. dual gauge procedure with increasing wind speed

The results reinforce the conclusion that accurate measurement of precipitation in windy conditions is very difficult unless extreme measures are taken to reduce the wind speed across the orifice of the gauge.

5. CONCLUSIONS

The dual gauge procedure indicated the most precipitation. Of all the shield configurations, the double Alter caught the most precipitation. The single metal Alter and the Tretyakov caught less than the double Alter, but more than the ASOS vinyl. The unshielded gauges caught the least amount of precipitation, which was expected.

One problem that was encountered were the differences between the catch on the southeast and northwest sides of the test bed. With the exception of the Tretyakov shield, whose totals were equivalent, the shields aligned to the southeast had consistently higher LWEs than the northwest row. One particular event that occurred on March 5-6, 2001 was an example of this problem. The greatest difference was between the single metal Alter shields, which caught 0.48 cm and 0.20 cm on the southeast and northwest sides, respectively. The winds during this event were higher than most events and were out of the northwest. One possible reason for the discrepancies could be shadowing from the airplane hangar, which is located approximately 122 meters (400 feet) to the north-northwest of the windshield test bed. Another possibility for these discrepancies could be blowing snow. This phenomena may have caused some event variabilities, but should not have changed the final outcome of this test.

For all events, the undercatch of the unshielded gauges (65% of the dual gauge procedure) was not surprising, dramatically demonstrating the importance of shielding precipitation gauges even in snow with light wind (10 knots). The undercatch of the gauges with the ASOS vinyl shield (73% of the dual gauge procedure) is an indication that this shield begins to suffer catch losses even in light winds and is a strong argument against using this shield operationally for winter season precipitation. The best performing shield, the double Alter shield, may be impractical for ASOS because of its size. The Tretyakov shield performed slightly above (0.08%) the single metal Alter shield. This statistic suggests that it may be an acceptable alternative to the single metal Alter shield.

Of the shields tested, the double Alter shield would maximize catch efficiency, but space may be an issue because of its large size. If this is the case, the single metal Alter shield or the Tretyakov shield would be a suitable alternative shield.

6. FUTURE WORK

This winter the National Climatic Data Center (NCDC) intends to conduct a study of precipitation gauges with DFIRs. The NWS plans on using the NCDC DFIR test bed to conduct its own study of precipitation gauge catch efficiency. A possible approach to this test would be to configure an AWPAG with a Tretyakov or a single metal Alter shield outside the DFIR and an AWPAG with the same chosen shield inside the DFIR in an attempt to characterize the wind speed on gauge catch efficiency.

7. References

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