# NEXT GENERATION ALL WEATHER PRECIPITATION GAUGE

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## ABSTRACT

The new Vaisala weighing precipitation gauge features technical innovations providing high quality measurements in all weather conditions and low life-cycle cost. Highlights of the gauge design and operation are presented, as well as first results obtained in the field tests at the Finnish Meteorological Institute's test field in Jokioinen.

## 1. INTRODUCTION

Accurate measurement of precipitation has been a challenge, especially in climatic conditions where both liquid and solid precipitation (snow, sleet) occur. In principle weighing gauges are the most suitable point precipitation gauges for these conditions due to the fact that melting of snow is not required for the measurement.

However, conventional weighing precipitation gauges are impaired by a multitude of errors. These include the error sources common to all point precipitation gauges - wind, evaporation and wetting errors - which all tend to cause systematic deficits. In winter conditions instrumental errors related to accumulation of snow and ice on rim and funnel parts of the gauge, as well as complete filling of the gauge with snow may result in severe underestimation. These problems are only partially solved using antifreeze solution in the container and applying rim heating.

The new Vaisala all weather precipitation gauge features technical innovations providing higher quality of measurement and lower life-cycle cost in all weather conditions. The design of the gauge is based on Vaisala's long experience of precipitation measurements and sensor design for meteorological applications.

This paper highlights the gauge operation and the aspect of lower life-cycle cost. It also presents preliminary results obtained at the Finnish Meteorological Institute's test field in Jokioinen.

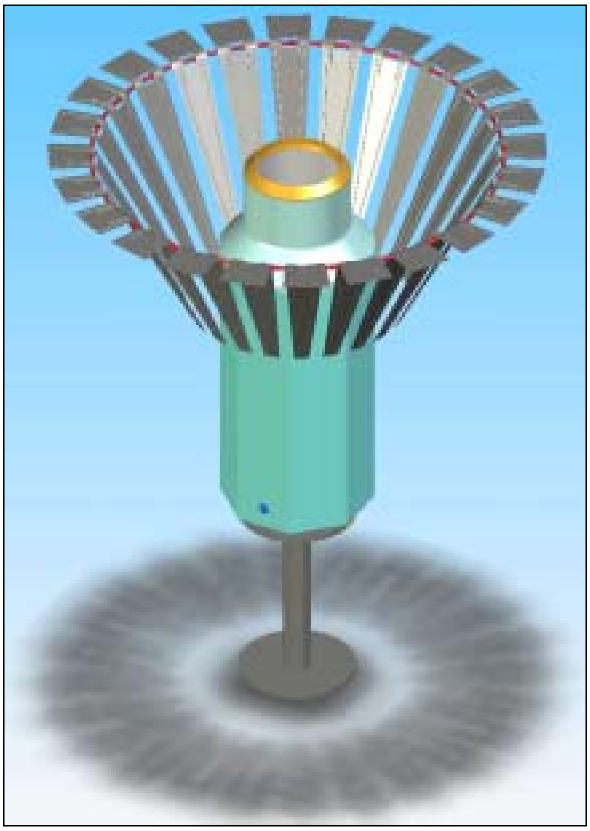

**Fig. 1.** Vaisala all weather precipitation gauge with wind shield.

## 2 TECHNICAL HIGHLIGHTS

### 2.1 Weighing method

The gauge utilizes latest high-accuracy, temperature-compensated load cell technology. The single point - type load cell is designed for direct mounting of the weighing platform. Eliminating levers and flexures, this allows simple, robust and low cost mechanics.

The load cell is insensitive to eccentric loading. Therefore, unlike some other types of weighing gauges, unsymmetrical distribution of snow in the collecting bucket (typical for winter conditions) does not introduce measurement errors.

Another error source which is eliminated by enhanced mechanics is the deficit caused by water and snow sticking on the inner surfaces of the gauge inlet funnel. In conventional designs this mass is not measured and eventually evaporates. In Vaisala's design the funnel element is resting on the collector container. All water and snow on it's surface will be included in the measured mass.

### 2.2 Gauge heating

Optional rim heating is recommended whenever solid precipitation measurement is needed. Heating prevents accumulation of snow and ice on the rim and collecting funnel. To prevent extraneous evaporation error caused by heating, as well as to minimize power consumption, the heating is controlled by the gauge software. The control algorithm is based on ambient temperature and precipitation status.

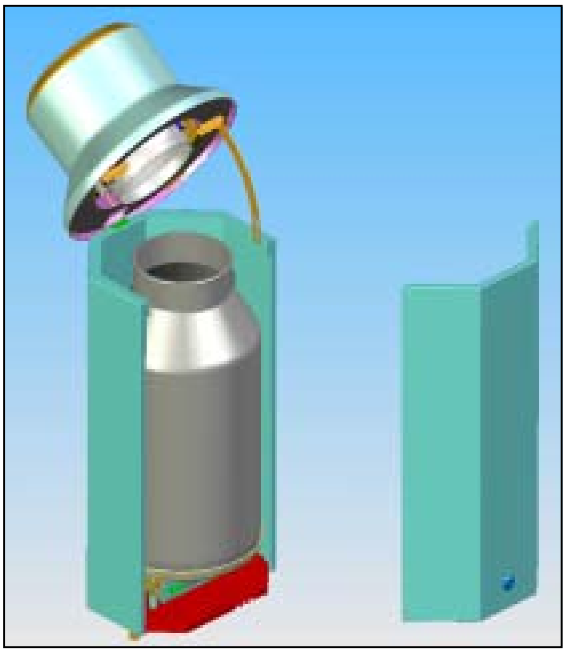

**Fig. 2.** The gauge with enclosure opened.

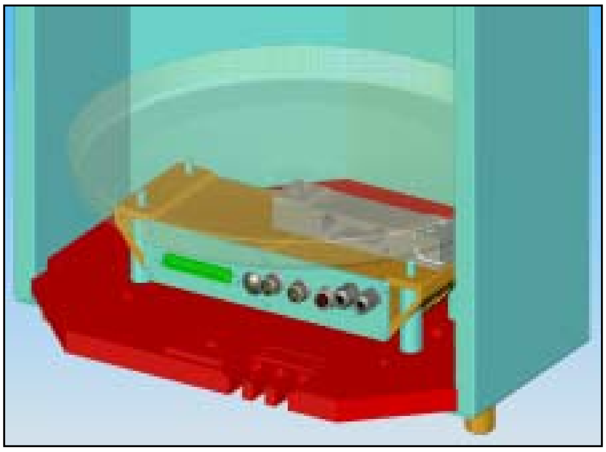

**Fig. 3.** Electronics unit and load cell are situated under the weighing platform.

### 2.3 Ease of maintenance

In the design special emphasis has been put on easy maintenance and extended service interval.

The hinged upper part (rim and collecting funnel) and detachable enclosure door allow smooth access for performing maintenance or adding antifreeze agent, as well as easy removal of the collector container (see fig. 2)

The electronics unit, including the load cell is field-removable (fig. 3). Replacement of the electronics is straightforward and quick causing minimal data loss, i.e. there is no need to transport the whole gauge to the laboratory for calibration. If needed, field calibration can be done using calibration weights.

Selection of optional features enhance performance and extend service interval.

## 3. TEST RESULTS

The gauge was tested at the Finnish Meteorological Institute's (FMI) test field in Jokioinen in Southwestern part of Finland. The test field is a grass-covered field about 60m x 100m in size (fig.4). For comparison the unit under test was installed in the middle of the field with it's orifice at 1.5 m height (fig. 6). Wind shield was not used in the first tests.

The Vaisala gauge was compared with the FMI's double fence intercomparison reference (DFIR): a high accuracy weighing gauge with orifice at 3 m height, surrounded by an octagonal vertical double fence. The reference is located at the north-west corner of the field, the distance between the gauges being approximately 50 meters.

**Fig. 4.** Jokioinen test field

The comparison started on 20.8.2004 and it will be continued until spring 2005. Rainfall data as well as temperature, humidity, wind speed and direction at the height of the gauges orifices was collected with 1-min intervals. Using the 1-min dataset daily totals of precipitation were calculated. In this poster the first preliminary results from liquid precipitation, obtained in autumn 2004 are presented.

Table 1 shows daily total values divided in three categories (slight rain, rain and heavy rain). Additionally it shows that Vaisala gauge's catch ratio was highest in slight rain and decreased with increasing rainfall rate.

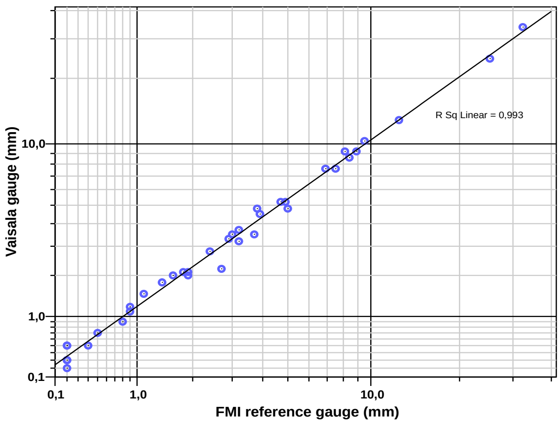


**Fig. 5.** Daily totals, Vaisala gauge versus FMI reference gauge (DFIR)

Since the end of August and throughout November 2004 the total precipitation measured was 176.9 mm. Daily total values varied from 0.2 mm to 32.3 mm.

Overall, the Vaisala gauge caught 6 % more precipitation compared to the FMI reference gauge (DFIR). The catch ratio ranged from 80% to 150 % in a single rainfall, being highest in slight rains.

**Fig. 6.** The Vaisala gauge installed on the FMI Jokioinen test field.

The observed differences between values obtained with the Vaisala gauge and the FMI reference gauge (DFIR) are possibly due to different construction of the gauges. The Vaisala gauge has a larger catchment area (400 $cm^2$ versus $200cm^2$). Additionally, the inlet funnel of the the Vaisala gauge is a part of the instrument weighing system, whereas this is not the case for the reference gauge. Therefore water droplets caught on the surface of the inlet of the reference gauge cause a loss in rain totals.

Table 1. Summation of daily precipitation

| | Number of events (Days) | FMI reference gauge (DFIR) | Vaisala gauge |
|---|---|---|---|
| TOTAL | 37 | 176.9 mm | 188.1 mm |
| | | 100 % | 106 % |
| RDay < 1 mm | 10 | 4.5 mm | 6.2 mm |
| | | 100 % | 137 % |
| RDay 1-4,4 mm | 15 | 38.5 mm | 43.0 mm |
| | | 100 % | 112 % |
| RDay > 4,4 mm | 12 | 133.9 mm | 138.9 mm |
| | | 100 % | 104 % |

**4. CONCLUSIONS**

The Vaisala all weather gauge represents a new generation of weighing precipitation gauges. Simple and robust mechanics, large collecting area, latest high-accuracy load cell technology and advanced measurement and heating control algorithms ensure high performance, both in liquid and solid precipitation and in all weather conditions.

Preliminary test results from liquid precipitation show that undercatchment of the Vaisala gauge is very low - in fact it measured few percent more precipitation than the FMI reference gauge at the Jokioinen Observatory. The tests will be continued. More results, including solid precipitation data and a more thorough analysis of the observed differences will be presented at the conference.

**Fig. 7.** The gauge on the Vaisala test field with wind shield.