

# OTT Pluvio<sup>2</sup>: Weighing Precipitation Gauge and Advances in Precipitation Measurement Technology

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## Summary

OTT MESSTECHNIK has developed the most advanced precipitation measurement technology available. The initial version of the instrument offered users much greater resolution and accuracy across a broader range of weather conditions in comparison with older techniques, and the latest version provides even better performance at a significantly lower cost.

This article will illustrate the advantages of the new technology over techniques that have existed for centuries.

## History

The first known records of rainfall were kept by the Ancient Greeks about 500 B.C. This was followed 100 years later by people in India using bowls to record the rainfall. The readings from these were correlated against expected growth, and used as a basis for land taxes.

Subsequently, graduated cylinders were employed to collect precipitation that could be inspected daily for the manual collation of precipitation records.

## Automatic Raingauges

Sir Christopher Wren was a 17<sup>th</sup> century English designer, astronomer, geometer, and one of the greatest English architects of his time; he is best known for the design of 53 London churches, including St Paul's Cathedral. However, one of his lesser known achievements was the creation in 1662, of a rain gauge that did not require daily visits - the world's first tipping bucket raingauge. The real advantage of this technique was that it enabled a clock work chart to record rainfall so that Sir Christopher did not need to read and record every single day's data.

Astonishingly, the same basic principle survives to this day in rain gauges currently operating in many countries world-wide.

## The Tipping Bucket Raingauge (TBR)

The TBR consists of a funnel which is mounted in the top of a cylinder set into the ground or standing upon it. The funnel collects precipitation and passes it on to one of two small buckets which are balanced upon a pivot.

After a specific amount of precipitation (typically 0.1 or 0.2 mm) falls, the bucket tips and an electrical signal is sent to a recorder or data logger. This process tips (almost all of) the water from the bucket so that it is ready to repeat the process.

Anyone that has been responsible for the collection of data from a tipping bucket raingauge (TBR) will be well aware of its disadvantages which requires almost high maintenance interval and results finally in non recorded but most important precipitation data.

In summary, whilst the TBR was a brilliant invention in 1662, meteorologists have been looking for something more accurate and less labour-intensive for over 300 years!

## New Technology

OTT MESSTECHNIK has developed a raingauge ('Pluvio') that addresses the weaknesses of the TBR by collecting precipitation and weighing the collected liquid with a highly accurate load cell.

The Pluvio was first launched in 1994 and there are now more than 5000 units in operation all over the world. However, the first version of the OTT Pluvio was expensive. So the company has developed a successor, 'OTT Pluvio<sup>2</sup>', which provides even better precipitation measurement but at significantly lower cost, which makes it accessible to a much larger range of applications.

## OTT Pluvio<sup>2</sup>

The key advantages of OTT Pluvio<sup>2</sup> are that it can measure precipitation accurately and reliably in all weather conditions. OTT Pluvio<sup>2</sup> is able to record the smallest amount of precipitation at exactly the moment that it takes place.

The instrument's accuracy is not diminished by the intensity of precipitation - the measurement range extends from 0.1 to an impressive 30 mm/min.

This technology is also well suited to freezing conditions. The collection chamber contains antifreeze liquid which prevents the accumulation of hail and snow. As a result, the OTT Pluvio<sup>2</sup> is able to offer an accurate measurement range of minus 40 to +60 °C. OTT Pluvio<sup>2</sup> is available with a choice of two collection orifices; a 200 cm<sup>2</sup> orifice offers a collection capacity up to 1500 mm of precipitation and a 400 cm<sup>2</sup> orifice offers 750 mm capacity. This is a greater capacity than

was offered by the original Pluvio which extends the period of operation even further. An optional heating ring is available for the smaller of the two orifices to prevent snow capping.



*Illustration Pluvio<sup>2</sup>\_200 and \_400*

During the summer months, most of the collected water evaporates which extends the measurement period further.

Older technologies such as the TBR occasionally include thermostatically controlled internal heaters to address the problem of snow/ice accumulation, but this can incur a delay in the measurement and may be impractical in remote locations for reasons of power consumption.

In contrast, the OTT Pluvio<sup>2</sup> operates on very low power – typically 12 mA at 12V DC and the power requirement is 9.6 to 28 V DC.

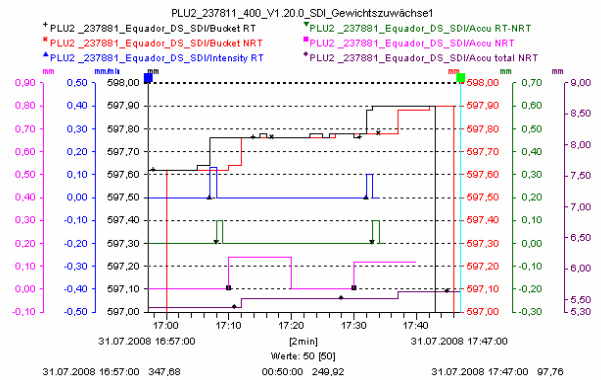
The weighing precipitation gauge provides real time data and non real time data as well according to WMO guideline No8:

- Intensity data, gliding and based on 1 minute interval
- Simulated tipping bucket data based on sampling of 0,1 mm
- Accumulated precipitation data with 5 minutes delay
- Total accumulated precipitation data with 5 minutes delay
- Real time bucket content precipitation data
- Bucket content precipitation data with 5 minutes delay
- Temperature data of load cell
- Status data of Pluvio<sup>2</sup> and optional heating

The delay is related to internal pre processing of 6 Seconds and additional filtering time of max 20 seconds and can be considered for all real time data

monitoring and time critical online application like weather radar calibration and Z/R correlation. The bucket data can even be used as raw precipitation data for individual algorithm of weight to precipitation data.

The constant time delay of 5 minutes for accumulated provides precise and temperature compensated precipitation data which can be back shifted later on in the recorded data base in order to achieve precise precipitation by corrected time stamps.



*Illustration Time Series Pluvio<sup>2</sup>*

A sophisticated software filter eliminates the potential effects of wind and each OTT Pluvio<sup>2</sup> is individually temperature calibrated. In contrast with TBRs, this is a life-time calibration so users can expect long-term accurate data throughout all weather conditions.

The OTT Pluvio<sup>2</sup> weighing measuring principle is based upon an edge compensated and sealed single load cell, overload protection, direct mounting on the weighing platform and highly sophisticated electronics and algorithm features. The individual temperature characteristics of the load cell are memorised in the electronics and corrected by in-situ temperature compensation. This achieves precise weight measurements with incremental accuracy of 2 grams equal to 0.10 mm and provides an impressive resolution of 0,01 mm of precipitation. The load cell is insensitive to eccentric load that may occur for example, as a result of unsymmetrical distribution of snow in the buckets.

Designed and built by OTT MESSTECHNIK in Germany, the OTT Pluvio<sup>2</sup> complies with WMO guideline No.8 and is built to high engineering standards to provide a long working life. Cost of ownership is minimised because there are no tipping buckets to clean and no filters to unblock; an annual maintenance check is all that is required. A calibration check can be performed with a calibration weight set according to ISO standards.

OTT Pluvio<sup>2</sup> has a USB interface that is employed for configuration and monitoring either with a PDA or computer running the Pluvio Operating Program. This

also provides convenient service access to the instrument.

The Pluvio design team has also taken into account the possibility of a need to repair the instrument, should damage or a fault occur in the field. The electronics unit can be easily removed and replaced on site and data loss and maintenance costs are reduced to a minimum, because it is not necessary for the whole gauge to be transported to a service laboratory.

One of the ways in which OTT MESSTECHNIK has been able to reduce the cost of OTT Pluvio<sup>2</sup> has been to make the internal datalogger optional. Many customers have their own loggers or simply wish to attach the OTT Pluvio<sup>2</sup> to an existing monitoring station, and for this reason OTT Pluvio<sup>2</sup> can be supplied with one of the company's own low-power dataloggers or with an impulse, SDI -12, or RS 485 output.

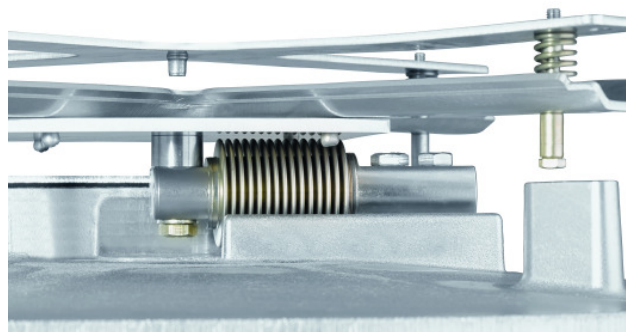
Many OTT customers purchase the OTT Pluvio<sup>2</sup> as part of an environmental monitoring system which may include other meteorological or hydrological sensors in conjunction with a datalogger, a field power supply and a data communication technology. Such systems can be configured prior to delivery so that monitoring can begin immediately.

As a specialist in environmental monitoring, OTT is able to offer a range of low power data communication technologies from hand held devices to GSM, radio or satellite transmitters.

#### **Life time calibration and field replaceable unit FRU**

OTT reflects to an very long term experience to design, produce and calibrate weighing precipitation gages can be considered as the genuine invention company which has collaborated the first weighing precipitation gauge in the beginnings of the 90 s in collaboration with the German Weather service, DWD. OTT has selected the best available and precise load cell which is hermetically sealed by a stainless steel housing in order to maintain the individual temperature versus load characteristic and to improve the repeatability and incremental accuracy of an 50 kg load cell by in situ calibration in the unique OTT temperature weight calibration chamber at its out performance which is needed for a weighing system with resolution of hundreds and accuracy of one tenth of millimetres of precipitation. The instrument is designed for a long term deployment and high MTBF of more than 100 years which practically guarantees a trouble free operational and meat time to repair time of more than 10 years. All interfaces and power lines are in general well over voltage and surge protected according EN 61000 regarding EMC/EMI CE standards.

The PCB with recorded individual calibration coefficients in the non volatile memory and the load cell can be applied as an replacement set as immediately remedy by damages impacted by direct lightning stroke or vandalism.



*Illustration load cell*

#### **Applications**

The OTT Pluvio<sup>2</sup> is the preferred instrument in applications for which users require accuracy and reliability in all weather conditions. It is particularly popular in remote locations for which frequent visits would be impractical. These include national monitoring networks for meteorological forecasting and flood alerts, research, agriculture, irrigation, airports and many more.

The enhanced real-time data collection capabilities of the OTT Pluvio<sup>2</sup>, providing both intensity and precipitation accumulation information, make the instrument an ideal tool in risk management for flood warnings and other weather related emergencies, particularly those involving extreme precipitation events.

Highly accurate precipitation data can be produced for climatological and synoptic purposes to facilitate the exchange of meteorological data with other weather services worldwide.

#### **International project for Supply and Installation of Hydrological Network – 174 stream flow gauging stations in Afghanistan**

OTT has been selected as partner for delivering Pluvio<sup>2</sup> for a network of remote and unattended station for liquid and solid precipitation and stream flow powered by solar panel and data transmission by satellite. The wide orifice of 400 cm<sup>2</sup> prevents snow capping even by an unheated version with rim heater and allows the deployment on high mountains areas without any mains. The added anti freeze agent turns the solid precipitation into liquid without any evaporation loss normally applied by electrical power dissipation of heated tipping bucket gages. The intelligence of the gage with logical determination of

measured weights and identification of objects instead of precipitation performs simplicity of an applied precipitation instrument in the field like known from any conventional mechanical device in the past. The operator can drain the bucket and set it on top of the weighing platform carelessly and without generating any false reported precipitation data. Pluvio<sup>2</sup> has been selected because of its high sophisticated electronically design, long term unattended application at very remote sites and its reliable and easy to use handling.



*OTT Pluvio<sup>2</sup> Mountain application*

### **WMO Intercomparison for Rainfall Intensity Gauges and conclusion**

In correlation to the negative comment in the laboratory test report regarding an observed delay for several minutes for intensity data the German Weather Service DWD and OTT has set up an improvement for the tested Pluvio1-DWD according to the WMO requirements and provided this improved precipitation gauge for the second part of the WMO field intercomparison at Vigna di Valle. After long term test and trial and approval by the DWD it is planned to update all deployed Pluvio1-DWD in the AMDA network which is prepared in such a manner to perform it automatically through the network by remote updating the firmware of the instruments. So far the lab test has been repeated and it is expected to be published as an updated report considered as an on time correction upon report and comments.

Pluvio<sup>2</sup> as successor of Pluvio1 series maintains the same data processing and algorithm but with state of the art hardware design with high data acquisition of 500 Hz which performs the new Pluvio<sup>2</sup> generation to faster data processing and nearly non delayed response time.

As result the Pluvio<sup>2</sup> will follow consequently in time and accuracy any simulation of rainfall intensity and of course the natural precipitation event from drizzle to extreme rainfall up to 1800 mm/h.

### **The Present and the Future**

The OTT Pluvio<sup>2</sup> will continue to replace older technologies as the standard instrument for precipitation measurement. In Germany, for example, it is the method by which all others are judged. In the United States the Pluvio outperformed competing products in recent testing by several government agencies; the National Weather Service selected the Pluvio for use in key airport facilities, and the USGS has completed an extensive testing program to assist the National Atmospheric Deposition Program (NADP) in determining the appropriate precipitation gauge for the National Trends Network.

The release of OTT Pluvio<sup>2</sup> with a lower cost will enable many countries to adopt the new technology, particularly those with extensive networks of TBRs with continuity of comparable data being preserved through the creation of appropriate comparative trials. In summary, Sir Christopher Wren invented the first TBR because he could see a need for automatic measurements and with the benefit of many decades of instrument design, at OTT we believe that if he was alive today he would be rather surprised to learn that it has taken so long for a better technology to emerge!

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*Note: The deployed and added weighing precipitation Gauge OTT Pluvio Type AWPAG at ASOS and COOP sites is manufactured by OTT MESSTECHNIK GmbH & Co. KG and not as stated by Vaisala*