Deficiencies in Solid Precipitation Measurements by Tipping Bucket Type Rain-Gauges

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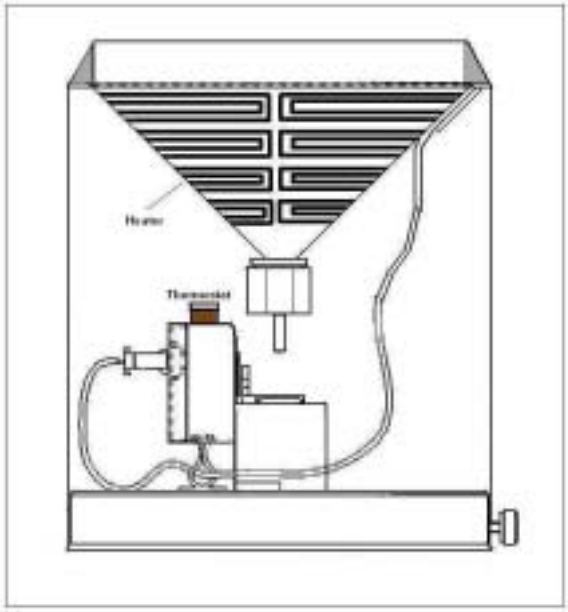
ABSTRACT

Turkish State Meteorological Service has been using tipping bucket type rain gauges of 236 units in its surface observation network. It was reported that there were significant deficiencies when comparing the measured values of solid precipitation, particularly during light snow, from tipping bucket rain-gauges and from conventional pluviometers. Our team made some research studies to find the reasons of the deficiencies and how to fix the problems. We have found out that most of the deficiencies were caused by the heaters used for melting the solid precipitation. During the melting by heaters, a significant amount of the precipitation has been evaporated due to the position of the heaters and thermostat as well as power of the heaters. On the other hand, we observed that bucket was frozen in some cases. We applied several types of methods to solve the problems to get reliable data within the limits of the acceptable tolerances. One of the solutions was to use two different heaters which shall be designed to be active in different temperatures. The other one, to separate the heater from the inside surface of the collecting funnel and mounted in a position between bucket and the surface of the funnel. In this application we also changed type of the heater and used long and narrow one. We also decreased the power of the heater. After those modifications the results of measured value of solid precipitation seem normal.

Tipping bucket type rain gauge used in Turkey

Heater is at the cone surface and thermostat is at the connection box.

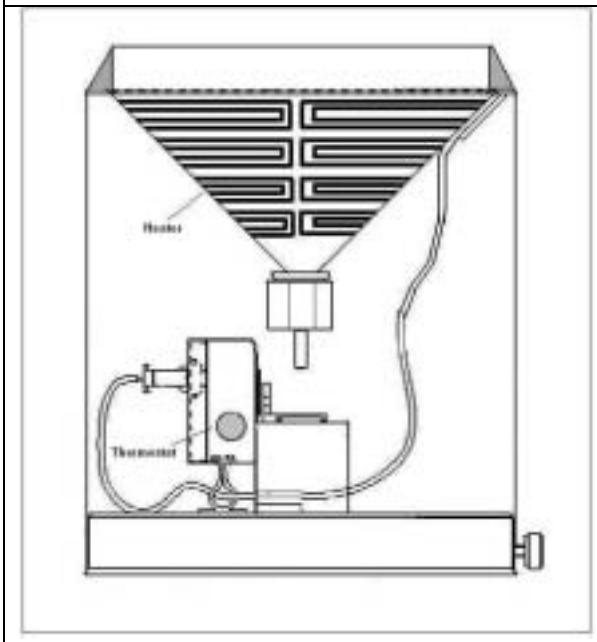


Sensor Specifications:

Operating principle :Tipping Bucket
Resolution :0.2 mm/tipping
Heater Power :24 VAC, 60 W
Place of Heater :On the cone surface
Thermostat : Runs at +4 ºC
Place of thermostat : On the connection box

Heater starts to heat cone surface. Because heating is being carried on up to the thermostat level, heater surface is over heated, temperature at the surface is very high and an apparent evaporation occurs. This causes an incomplete measurement for solid precipitations on precipitation days when heater is on.

Heater is at the cone surface, thermostat is at the level of pan (Air temperature is under 0 ºC)

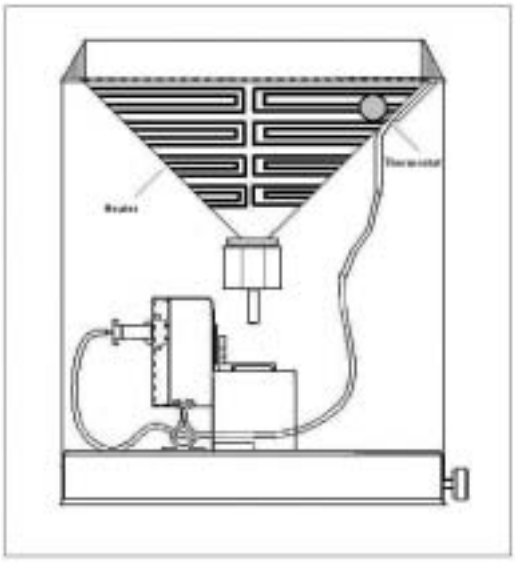


Heater power : 24 VAC, 60 W at the base
Air temperature : Between +3 – (-5) ºC

1. Thermostat is on the level of pan : The time when the heater is on increases. The surface is over heated. At the solid precipitations, there is an effective evaporation.

2. Thermostat is approached to the cone: The time when the heater is on decreases.. Amount of heating and evaporation at the surface decreases. But the temperature of pans and emptying hole decreases. There is a freezing risk at this situation.

Heater is at the cone surface, thermostat is at the cone surface(Air temperature is under 0 ºC)

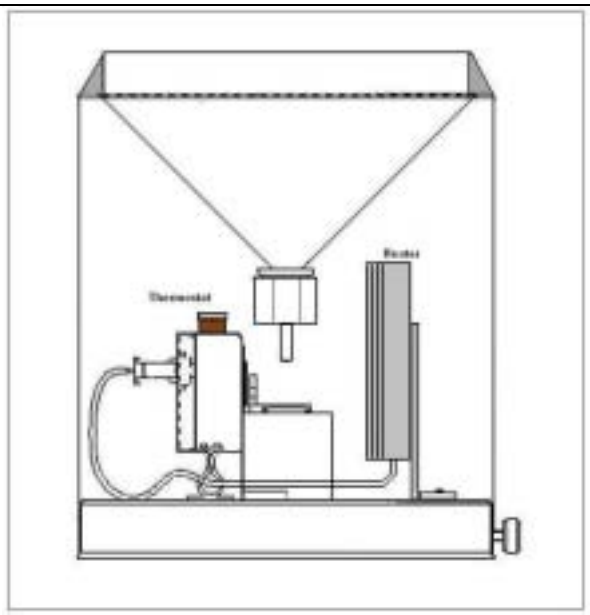


At the situation heater and thermostat are connected to the same surface, the surface temperature of water collecting cone becomes between +4 - +12 ºC.

At this situation, there is a very rare evaporation at solid precipitations. This situation seems to be an ideal solution.

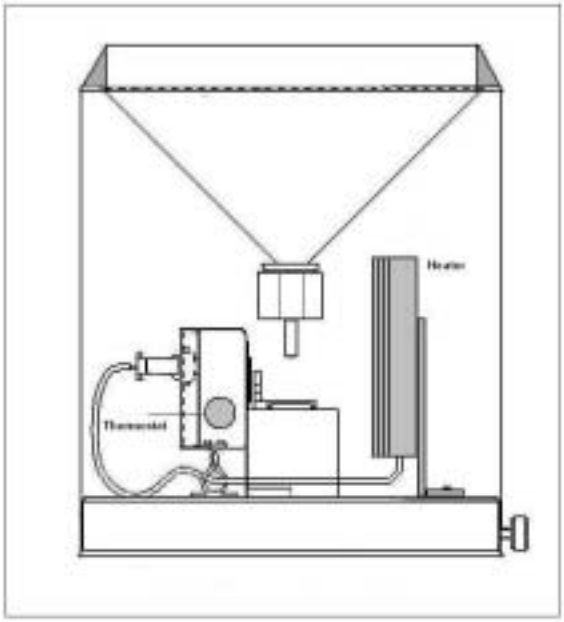
But, because pans are far away to the heater, pans cannot be heated, there will occur some icing on the pans. Because of this, motion of pan is blocked and then measurement is effected badly also. .

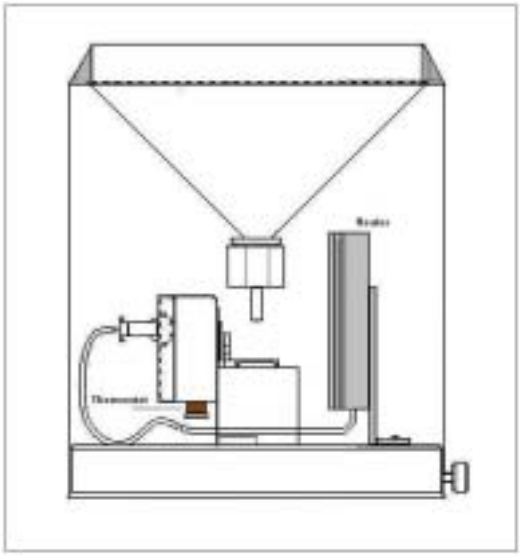
Heater is at the base, thermostat is at the connection box (Air temperature is under 0 ºC)



Heater power : 24 VAC, 43 W at the base
Air temperature : Between +3 – (-5) ºC

Evaporation is not being sensed, some icing occurs at the surface close to the cone mouth.

Heater is at the base, thermostat is at the level of pan (Air temperature is under 0 ºC)	
	Heater power : 24 VAC, 43 W at the base Air temperature : Between +3 – (-5) ºC Evaporation is not being sensed and the icing at the surface close to the cone mouth decreases considerably.

Heater is at the base, thermostat is close to the base(Air temperature is under 0 ºC)	
	Heater power : 24 VAC, 43 W at the base Air temperature : Between +3 – (-5) ºC Evaporation is not being sensed and there is no icing at the surface which is close to the cone mouth.

CONCLUSION

After studying of total 209 precipitation sensor with heater, three of them installed at the airport stations and 206 of them installed at the synoptic stations of observing network of Turkish State Meteorological Service; it is found out that:

-when the air temperature is more than +4 ºC, sensors' accuracy in the results is acceptable
-when the temperature goes under +4 ºC, we detected some inaccurate measurements originated from heater.

Especially during the light and medium intensity snow precipitations, it is observed that snow fallen to the sensor's cone is melting and some evaporation occurs because of over heating on the sensor's surface.

To solve this problem, some experiments were done by changing the thermostat's position but not sensor's heater (sensor keeps its position). Satisfactory results couldn't be obtained from these experiments.

Secondly, some experiments were done by changing the heater's position. With this purpose, a 24VAC 43W heater was prepared and mounted to the sensor's base. After installing this heater, some tests were done.

As a result, if heater is at the base and thermostat is in a position close to the base, the solid precipitation fallen into the cone is melting and a negligible evaporation is occurred which does not affect the measurement significantly. It seems that, to be able to make accurate measurements of solid precipitation in the winter time with these sensors, this heating system should be applied.