# Humidifier for RPC gas mixture for bakelite RPCs

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Bakelite RPCs are very sensitive to environmental parameters [1], especially the relative humidity (RH) and temperature. As the name suggests, bakelite RPCs are basically fabricated from high quality 2 mm thick high pressure laminates (HPLs). For operating the RPCs in avalanche mode of operation, a typical mixture of R134a. Iso-butane and $SF_6$ is used in a particular combination of 96.2 : 3.5 : 0.3 in order to achieve an optimal signal output. If the gas mixture inside the gas-gaps has a different humidity, which in case of dry gases is typically of the order of 0.4 - 0.5 ppm, then a drastic change in the humidity inside and outside of the bakelite sheet starts affecting the resistivity of bakelite which in turn has an adverse effect in its performance characteristics. Due to variation of the bakelite resistivity, electric field inside the gas gaps of RPC changes in an uncontrolled fashion which is very unsatisfactory in the proportional mode of operation [2]. Simple estimation for RPC operating at high rate (~ 1 $kHz/cm^2$) shows that variation in resistivity can cause noticeable voltage drop in electrodes which is resulted by the flow of current across the plates [3].

The sensitivity of a bakelite gas-gap to environmental humidity in RPC Lab., in NPD-BARC is shown in Fig.1. In this case, a dry RPC gas mixture is flown inside the bakelite gas-gap continuously for three days and nights and the data was recorded at an interval of every hour. The data for leakage current and relative humidity was recorded by two independent equipments in the lab. The plot clearly shows the correlation in leakage currents (closed squares) with the relative humidity (open squares) inside the lab., which varies just by switching on the centralized AC during daytime and switching it off during the night. The leakage current is shown in µA on the left axis and the RH is represented in (%) on the right axis. Therefore it is imperative that the dry gas mixture injected inside the bakelite gas-gaps has a humidity matching with that of the environment external to the gas-gaps. Efforts are underway to control the external RH by having a dedicated air-conditioning system (RH ~ 40% and Temp ~ 21$^o$C), working round the clock, whenever required. Once the external RH and temperature is known, then one only needs to generate an equivalent RH for the dry RPC gas mixture.

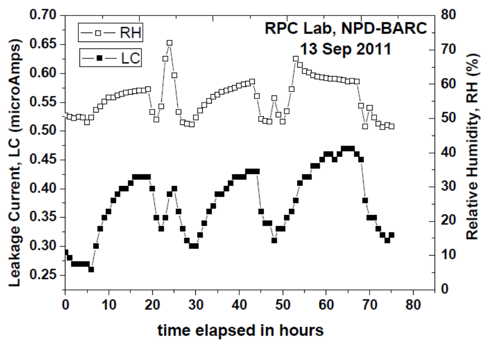


**Fig. 1** Variation of leakage current of a bakelite gas-gap with environmental humidity

A newly designed humidifier controller is recently installed at RPC Lab., in NPD-BARC for the dry RPC gas mixture. This equipment is designed to achieve a controlled humidity (typically 40% RH) at working temperature of RPC detectors. The humidifier controller installed at lab is capable of handling more than equivalent of 8 channels RPCs each at 6 litres per hour (lph) minimum. Hence the total capacity is 50 lph of RPC gas mixture. The humidifier controller basically consists of three parts, viz., humidifier, condenser cum saturator and a bypass line, shown schematically in Fig. 2. The humidifier section is maintained at same temperature at which RPC detectors are operated i.e. 25$^o$ C , It contains about 300 cc of water and can be used till about 50 cc of water remains in the column. The inlet RPC gas mixture coming into humidifier is dry (dew point -79° C, corresponding to a water content of 0.5 ppm), due to passage of individual gases through molecular sieves (4A+13X). The RPC gas mixture bubbles through the humidifier water column and resides sufficiently long to get saturated. The gas mixture leaving the humidifier is saturated at 25°C (typical room temperature, with centralized AC on). The total moisture content of saturated gas mixture is 23.5 g/$m^3$. To maintain a relative humidity of 40 % at 25°C, 60 % moisture must be removed. and only 40 % should remain in the gas mixture, which amounts to about 9.4 g/$m^3$.

The condenser is maintained at a temperature lower than 25°C so that extra moisture can be separated from the gas mixture. At 9°C the saturated gas mixture shall contain 9.4 g/$m^3$ of moisture. The excess moisture shall collect at bottom of the condenser. The gas mixture leaving the condenser is at 9°C and saturated with moisture content of 9.4 g/$m^3$. The gas is brought back to 25°C by heat transfer through passage. The gas still contains 9.4 g/$m^3$ moisture but is at 25°C (40% of saturation value at 25°C). The gas mixture therefore now has an RH of 40 %. A temperature of 9°C is obtained by placing the condenser cum saturator inside a refrigerator, whose temperature can be controlled externally, as shown in Fig. 3.

Two, 3-way, by-pass valves are provided at humidity controller's input and output so that a dry gas mixture, whenever required, can also be made available, especially for glass RPC operation, which does not require a humid gas mixture. The three way valves facing each other, allow the dry gas mixture to pass through and close the path to the humidifier, while, when they are turned facing opposite to each other, the passage for dry gas mixture is closed and then the dry gas mixture goes through the humidifier, condenser and saturator to provide a humid gas. Efforts are underway to augment the gas mixing system in such a way, so that one can have both the dry gas and humid gas available, either for glass RPC or for the bakelite RPC, parallely. Data taking with the present system is under progress and the effect on bakelite gas-gap performance with humid RPC gas mixture in terms of its leakage currents, noise and efficiency shall be presented during the symposium.

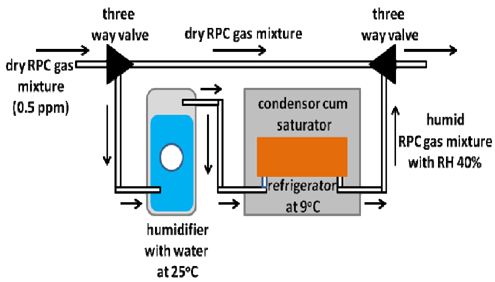


**Fig. 2** Schematic of the humidifier for RPC gas mixture

**Fig. 3** The condenser cum saturator inside the refrigerator maintained at 9°C

## References

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[3] CMS, The Muon Project, Technical Design Report, CERN/LHCC 97 32