COOLING SYSTEM FOR 3 MeV, 30 kW DC AND 10 MeV, 10 kW RF ACCELERATORS

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Abstract

A cooling system has been used for the 3MeV, 30kW, DC and 10MeV, 10kW RF accelerator [1] to remove heat dissipation due to joules heating. Electrical currents flowing in the accelerating structure and in electromagnets coils, Triode tubes are high enough that this heat must be carried off by a cooling system. For many parts of the accelerator there is an additional problem such as temperature increase causes metal to expand, so changes in temperature changes the size of the cavities, waveguides, etc. and the frequency at which a cavity resonates changes with temperature. Demineralised water (DMW) is used as cooling medium. This paper describes selection of piping, Polypropylene Filters and test experience of components, used in existing DMW cooling system during accelerators commissioning and testing.

INTRODUCTION

DMW is used as cooling media as it helps in avoiding corrosion and scaling on heat exchanging surfaces. It will give water with very low silica content (<0.01ppm). Silica content also increases the leakage current when used as cooling media at 10kV potential or higher level. Anode jacket of triode tube (2 Nos.) used in 3MeV; 100kHz oscillator is operating at 10kV dc and hence insulating piping is adopted for triode tube cooling. Two sets of nylon braided insulated PVC pipe of 13m long, 25mm diameter is used to reduce the leakage current (less than 10μA) through the water to an acceptable level. Minimum length of 1 meter per kV of anode voltage should be adequate. If shorter lengths are used then the electrolytic corrosion caused by higher leakage currents may be significant. The leakage current will also depends on the pipe bore, length and also on conductivity of the water. Typical values of water characteristics obtained from these systems are conductivity ≤1μS/cm, total dissolved solids < 1ppm and pH variation is within 6.8 < pH< 7.2. The DMW system is used for cooling approximately 20 components of the accelerators viz. klystron collector, circulator, water load, linac cavity, klystron body, pulse transformer plus 9 wave guide components, triode tubes of oscillator, scan horns, beam dumps etc and is designed for 160kW heat removal, with pumping capacity of 300lpm (18m^3/ hr).

More than 100m of metallic piping ranging from 1” to 2” and 26m, 25 mm diameter of nylon braided PVC piping carry the treated deminaralized water from recirculation system to various components of the accelerator. The piping is made up of SS-304L stainless steel since iron steel, galvanized steel, or cast iron, are not suitable for use in demineralised water systems. They deteriorate rapidly, the conductivity of the water is raised, and corrosion products plug small lines, orifices, and equipment. All piping which is exposed to ozone is made of stainless steel to prevent rapid corrosion. Other important parameters to be considered are the effect of radiation on a particular material. This information should be obtained through empirical testing. The cooling system parameters are listed in Table 1.

Table 1: Cooling system parameters of 3MeV and 10MeV Accelerators.

Induced draft type cooling Tower capacity	215kW
Flow (Cooling Tower water)	610 lpm
Water storage Tanks	2000 litres each (2 Nos.)
Flow (Demineralized)	300 lpm
Inlet temperature (system)	30^{o}C
Outlet Temperature	35 ^{o}C
Supply Pressure Range	8kgs/cm^2
Pumps	3 Nos.
Flow (Polishing and make-up system)	25 lpm
LCW conductivity	1 μS/cm
Polypropylene Filters	10-25 micron (6 Nos.)

GENERAL DESCRIPTION

The cooling system has four loops like (I) primary loops of DMW which extract the heat generated in various subsystems of the accelerators, (ii) secondary loops of soft water which exchanges heat from primary loops through plate type heat exchangers (PHE) and dissipate to cooling tower water, (iii) DM loops (make-up system) provides a initial charge of DMW which is to be stored in the storage tank through the ion exchanger stage, and (iv) conductivity improving (polishing) system. Fig.1 shows the schematic diagram of the cooling system. The raw water containing 120 ppm total dissolved solid (TDS) is initially passed through polypropylene cartridge filter (5 micron size), activated carbon filter, cation, anion and mixed bed exchanger by means of raw water pump (2 hp,

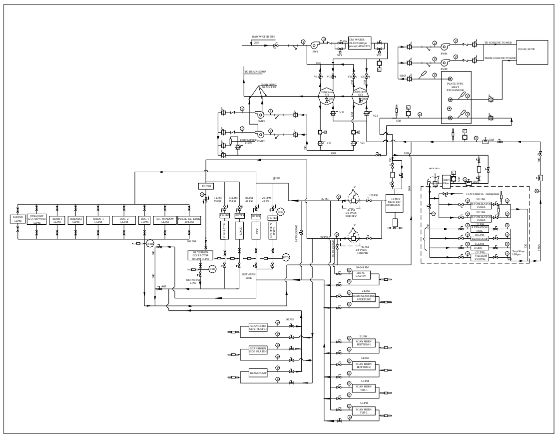

Figure 1: Schematics of the demineralised water cooling system for 3MeV and 10MeV Accelerators.

1.5 M^3/hour). Here all H+ ions released in water by cation exchanger react with O-H ions released by anion exchanger to form water. Thus all ions or minerals from water are removed by the two exchangers and the water is stored in SS-304 storage tanks (2000 litres' capacity each) and circulated through fully closed type centrifugal pump (20HP, 15kW), to provide 300lpm flow at 8kgs/cm^2 pressure to cool various components of the accelerators.

SELECTION AND TESTING

Header pipe line connections are modified during this period and are made through rigid SS304L tube which can be bended to required radius for shortest connections and thus reduces pressure drop in the pipe line. The SS304L tube samples have been tested for chemical composition by X-ray fluorescence spectrometric analysis method and subjected to hydrostatic pressure test at 13 kgs/cm^2. Physical, chemical and IGC tests are performed and witnessed for all sizes of piping and flange material as per the code and standards viz. A.S.M.E. and IS. Proper care has been taken during TIG welding of the pipes flanges etc. Grinding to a minimum of 1.6 mm (1/16 inch) are used for removing weld defects, cleaning out roots of welds and preparing plates for welding. Various tests viz Hydrostatic Test, Pneumatic Test are performed after completion of welding to check leakages. Six numbers of polypropylene filters have been incorporated in the pipe lines to remove suspended particles present in the water. For this purpose two numbers of bucket type polypropylene filters (disposable type) are used in main pipe line of the both accelerators to remove impurities present in the water. Remaining four filters are used for circulator, Klystron collector, load and Klystron body. Based on the test results of water sample from laboratory, it has been observed that particle size greater than 10 micron was found to be 7 particles per ml and 100 micron size particles were nil. Keeping this fact in mind 10-50 microns size filters were incorporated in the pipe line. The 72 hours endurance test has been conducted on cooling system comprising of DMW system, re-circulation system, cooling tower, heat exchanger, condenser pumps, piping system, ozone blower system, air ventilation system during intial commissioning. Acoustic sound level measured in the cooling system was measured and was found to be 72dBA. The water cooling system for the 3MeV dc accelerators and 10MeV RF accelerators are operated successfully during operation.

MEASUREMENTS, INTERLOCKS AND OPERATION

Parameters like temperature, conductivity and flow rates are monitored at various points on the distribution line. RTD based digital temperature Indicator, and conductivity meter provides analogue signal (4-20mA/0-10V dc) for remote transmission. Table 2 gives the details of the monitoring parameters for accelerator cooling system.

Table 2: Monitoring parameters for accelerator cooling system

Temperature transmitter	4-20mA / 0-10V	Inlet/Outlet of PHE Heat exchanger
Flow switches	ON/OFF	Outlet of subsystems of the Accelerator source (20Nos.)
Conductivity Transmitter	0-10V dc	Outlet of Mixed Bed

CONCLUSIONS

The operation of cooling system has shown a good adequacy to the required tasks and permitted successful achievement of accelerators project important goal. The corrosion is inevitable in cooling systems has been recognized as one of the main problem. By proper maintenance and filtering, the failure rate of the system can be reduced.

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