SF_6 GAS MONITORING AND SAFETY FOR DC ELECTRON BEAM ACCELERATOR AT EBC, KHARGHAR, NAVI MUMBAI

Suneet Kumar Srivastava , Shyam Rao Ghodke , Satyanarayan Acharya, Srutarshi Banerjee, Rajesh Barnwal, Dhruva Bhattacharjee, Nishant Chaudhary, Ramchandra B. Chavan, Kavita P Dixit, Sirisha Gade, Lalit Mohan Gantayet, Seema Gond, Israel Bakhtsingh, D. Jayaprakash, Nagesh Lawangare, Kumar Mahendra, Radhelal Mishra, Kailash Chander Mittal, Biswaranjan Nayak, Susanta Nayak, Rupesh Patel, Rehim Rajan, P C Saroj, D K Sharma, Vijay Sharma, Mukesh Kumar Srivastava, Suryaprakash Dewangan, Nitin Thakur, Rajnish Tiwari, Abhay Waghmare
Accelerator & Pulse Power Division, Bhabha Atomic Research Centre,
Mumbai - 400085, INDIA
sunsri1@rediffmail.com, ghodke_barc@yahoo.co.in

Abstract

A 3 MeV, 30kW DC Industrial electron beam accelerator has been designed, commissioned and tested at Electron beam centre, Kharghar. The accelerator has been tested up to 10 kW power level with SF_6 gas at 6 kg/cm^2. The accelerating column, high voltage multiplier column, electron gun and its power supply are housed in accelerator tank, which is filled with SF_6 gas as gaseous insulator at 6 kg/cm^2. The SF6 gas is being used due to high dielectric strength and excellent heat transfer characteristics. The SF6 gas is non toxic and non carcinogenic. The SF6 gas replaces oxygen and OSHA has established the permissible TLV of 1000ppm. The SF6 gas is being green house gas, leak tightness has to monitor in the system and leak if any should be repaired. The gas should be used, recycled and reuse and thus saving the environment. This paper describes the safety and monitoring of the SF6 gas leak, quality and precautions in 3 MeV accelerator.

INTRODUCTION

A 3 MeV, 30 kW DC Industrial electron beam accelerator has been designed, commissioned and tested at Electron beam centre, Kharghar. Fig 1 shows the schematic of the same. The multiplier column required the input voltage of 150 kV-0-150 kV at 120 kHz. The class C push pull power oscillator coverts the 10kV DC into 120 kHz, 10kV RF and air core RF transformer step up the voltage to 150kV-0-150 kV and fed to the two cylindrical shaped RF electrodes. The accelerator tank will house the high voltage multiplier columns, RF electrodes, corona shields, high voltage terminals, electron gun, accelerating tubes, heat exchanger, RF transformer etc. Normal operating pressure inside the accelerator is 6 kg/cm2 of SF6 gas. It is 7 meters long has a maximum outer diameter of shell is 2.16 meters and volume of 26 m3. The SF6 gas supply is contained in two storage tanks whose total capacity is 32 m^3 [3]. Fig 2, Fig 3, and Fig 4 shows the RF Electrodes, RF Transformer and SF_6 Gas Storage tanks respectively. SF6 gas is inert, stable, colourless, nontoxic and non-flammable gas at temperatures below 500C

It is easily liquefied at room temperatures by application of pressure. It is approximately five times heavier than air and displaces air in confine areas. It is the most suitable medium for insulation and cooling purpose. This gas is having excellent arc quenching properties.

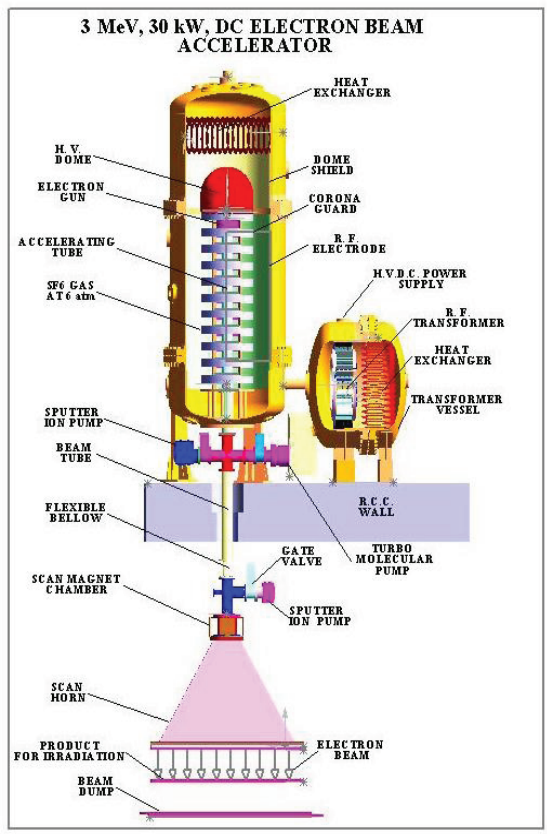

Figure 1: Schematic of 3 MeV DC Accelerator

SF6 gas when released into the atmosphere, has a relatively long life, contributes to green house. The environmental protection agency (EPA) has identified SF6 as green house gas with global warming potential 23900 times more effective than carbon monoxide and

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ISBN 978-3-95450-142-7

atmospheric lifetime of 3200 years. Hence SF6 gas should be used recycled and reused and thus saving the environment [1] [2].

Figure 2: RF electrode assembly

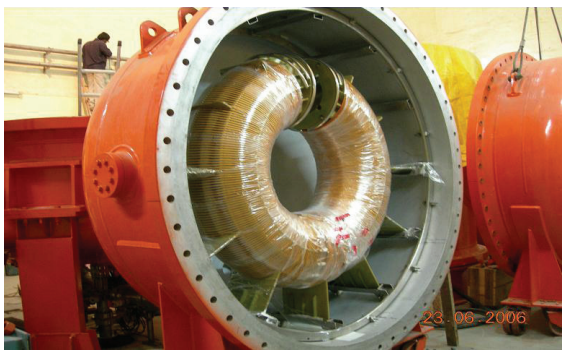

Figure 3: Transformer installed inside pressure vessel

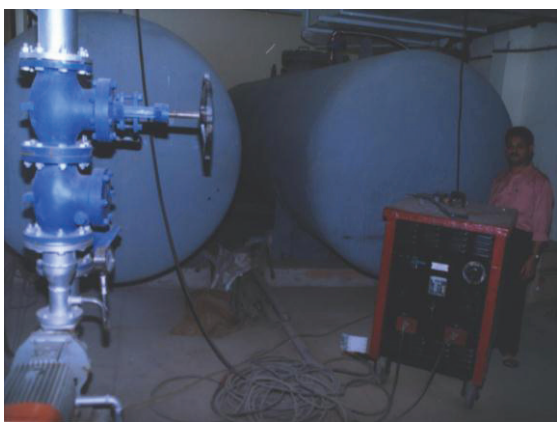

Figure 4: SF6 gas storage tanks

SAFETY OF SF6 GAS HANDLING SYSTEM

SF6 gas handling system transfers the SF6 gas to accelerator tank at high pressure and bringing back the gas into storage tank with minimum loss. The main objectives of the SF_6 gas handling system are listed below

Evacuation of Accelerator tank, Storage tanks and associated pipe lines.

Transfer of SF_6 gas from SF_6 gas cylinders to SF_6 storage tanks for storage

Transfer of SF_6 gas from storage tank to accelerator tank while starting the accelerator

Transfer of SF_6 gas from accelerator tank to storage tank for maintenance

Recirculation of SF_6 gas during accelerator operation for removal of moisture and secondary products.

THE SF_6 GAS MANAGEMENT

SF_6 gas handling and recycling system are to be managed considering the environmental concern and reducing the cost of gas.

MSDS are kept at easily accessible location so that awareness can be spread out.

Training in SF_6 handling, recycling, reusing, transporting, controlling leakage and minimising SF_6 release.

The gas management during operation, maintenance, testing, recycling and transfer through cylinder has been done.

The maximum permissible leakage of 0.5% per year should be allowed as per IEC standard.

Area monitoring systems with 0-2000 ppm range based on infrared absorption spectroscopy have been installed at the various locations of the accelerator and gas storage rooms.

Portable leak detectors with 0-50 ppm range based on infrared absorption spectroscopy has been used for detecting the leak tightness. Some of the leaks have been repaired and helium leak tested to ensure no leak.

The SF_6 gas quality should be monitored for use as high voltage insulation gas. The purity, moisture level and SO_2 content should be monitored as per CIGRE B3.02.01 and IEC standards.

The moisture affects the electrical insulation and must be avoided at any cost. SF_6 decomposition products combine with water to form hydrofluoric acid (HF) and sulphuric acid (SO_2).

The purity should be more than 97%, the moisture should be $>-36^0$C and SO_2 should be less than 50 ppm. (1 ppmv = 8. 0 ppmw).

In order to avoid the contamination of the atmosphere, recycling of the SF_6 is essential. The gas quality has been monitored for purity, moisture and acid after recycling the gas through moisture removal system.

Minimizing the use of oil and grease as lubricants and sealant in the system since contamination with lubricant oil is difficult to remove.

Provision for Gas cart filling and evacuation of SF_6 gas equipment has been kept.

The SF_6 gas pressure meters have been mounted at pressure vessel and SF_6 gas storage tanks with bourdon type pressure gauge and pressure transmitter. It is

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monitoring in day and week basis to see whether any pressure drop is there.

The temperature inside the RF transformer is being monitored by RTD sensors.

The accelerator machine is being de-energized before filling SF_6 gas in accelerator pressure vessel.

PROVISION FOR SAFE WORKING WITH SF_6

Equipment has been classified, labelled and numbered. The Handling procedures and instructions manual has been prepared, reviewed and put in place. Risk and Warning signs has been provided. The transportation and storage temperature kept less than 52^o C

SF6 gas if releases, tend to accumulate initially in low-laying areas where there is no natural ventilation and may cause asphyxiation. SF6 gas monitors are provided at proper location and sensor kept at low level. Personal protective equipments like hand gloves, breading apparatus and goggle are used.

SF6 gas decomposes into by-products viz. SF4, SiF4, SO2F2, SO2 and HF when exposed electrical discharges. Precautions are taking to avoid frequent discharges

ACCELERATOR OPERATION AND TESTING

The accelerator has been operated at 10 kW power and experiments have been done for simulated flue gas experiment at 5kW for SO2 and NO2 reduction and demonstrated.

CONCLUSION

The SF6 gas is being used in accelerator considering 3R (Reduce, Recycle, Reuse) methodology. The moisture is removed before filling in the pressure vessel. The corona detection and Photo multiplier tube (PMT) based safe accelerator tripping has been implemented. The increase use of SF6 gas applications in electrical systems will increase the climate change. Kyoto protocol has strongly recommended the elimination of use of SF6 gas. The alternative to SF6 gas will be future of insulation medium in accelerator systems.

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ISBN 978-3-95450-142-7

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