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NO 1	AÑO 1984

NUCLEAR INSTRUMENTS & METHODS

Volume 220, No. 1, February 15, 1984

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The gas handling system for the 20 MV TANDAR accelerator has been successfully tested with air and SF₆. A maximum pressure of 8.8 kg/cm² (125 psig) has been reached inside the accelerator vessel. A description of the system together with the results achieved is presented.

1. Introduction

As is the case for all National Electrostatics Corporation (NEC) accelerators, the insulating gas of the Buenos Aires 20UD Tandem is pure sulphur hexafluoride (SF₆). The gas handling system for operation of the accelerator can be divided into two main sections: the transfer system, and the recirculation and purification system.

This report presents a description of the main components of the system and its operational routine as well as an account of the performance tests.

2. SF₆ transfer system

The SF₆ inventory is stored in the gaseous phase as opposed to liquid storage used in other facilities of similar size. The transfer system has been jointly designed by personnel from CNEA and TECHINT engineering company. A block diagram is shown in fig. 1. The principal components are the vacuum pumps, the compressors and the storage tanks.

2.1. Vacuum pumps

There are two groups of Roots pumps operating in parallel. Each group consists of five pumps:

- 2 × WAU 2000 (7.5 kW each),
- 1 × RAV 1000 (15 kW),
- 1 × RAV 1000 (22 kW),
- 1 × RAV 250G (7.5 kW).

They were supplied by Leybold Heraeus, West Germany. The RAV have been modified to work without rotatory pumps as boosters so allowing the system to be free from oil contamination.

The pumps were provided with their own controls to regulate the discharge pressure and the starting sequence of the group. They are all located inside an acoustic enclosure which reduces noise to below 85 db. The pumping speed is 8000 m³/h and the residual pressure is rated at 0.5 mb.

2.2. Compressors

The high pressure gas transfer to and from the storage tanks is accomplished by means of two NORWALK three stage compressors with non lubricated cylinders. The specification called for a maximum discharge pressure of 21 kg/cm² and a variable suction pressure of 1–10 atm. Each compressor requires 200 HP total electrical power and 190 l/min of cooling water for the inter- and after-coolers. One small additional unit is used to recover SF₆ leakages from in the main compressors.

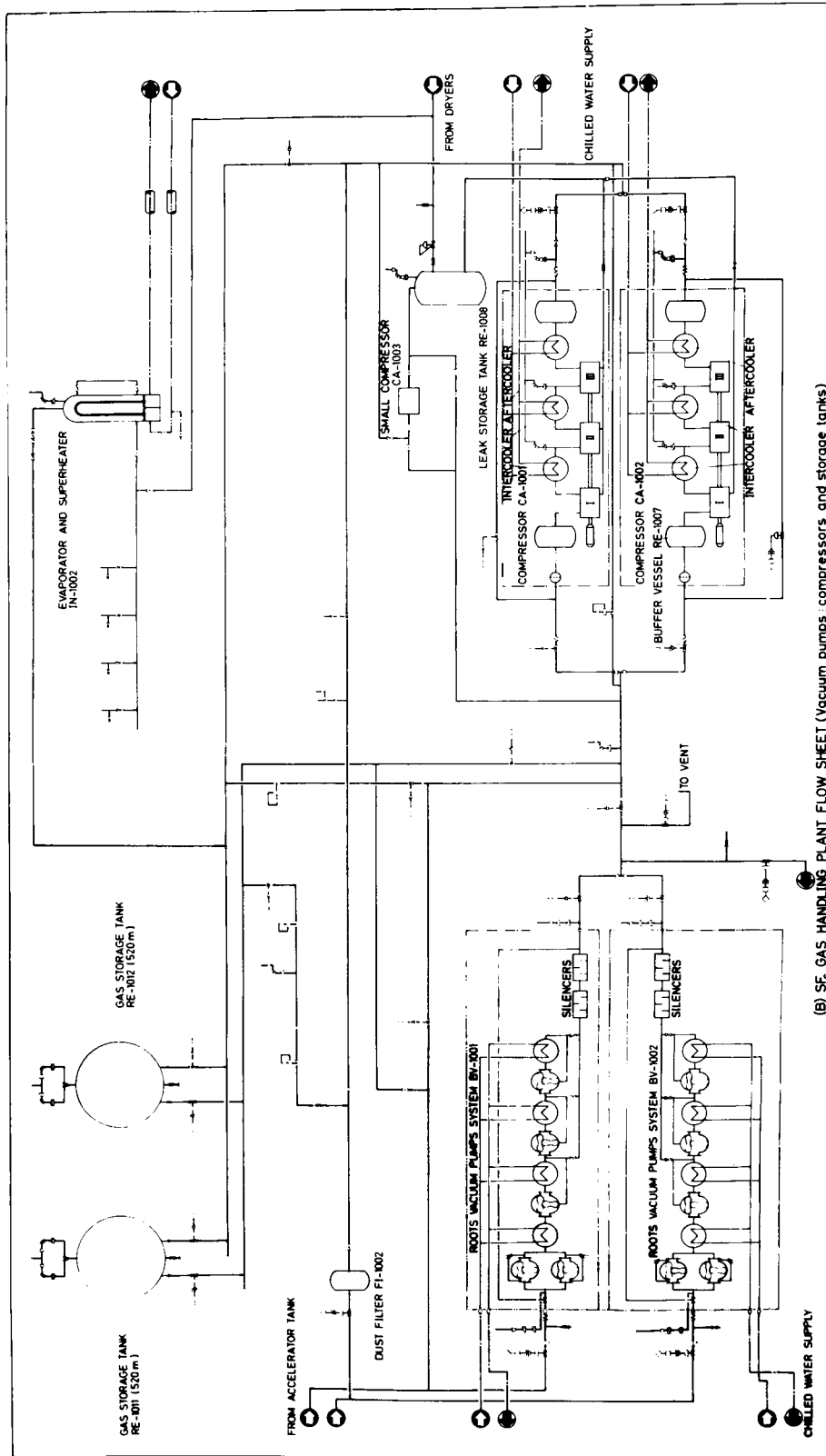
2.3. Storage tanks

The SF₆ is stored in the gaseous phase in two spherical containers 10 m in diameter with a capacity of 520 m³ each. The maximum rated storage pressure is 21 kg/cm², allowing the storage of a total of 120 tonnes of SF₆ with a 20% of air contamination.

The spheres are made of steel WELTEN 60, 31 mm thick and the design temperature range is –28°C to 80°C.

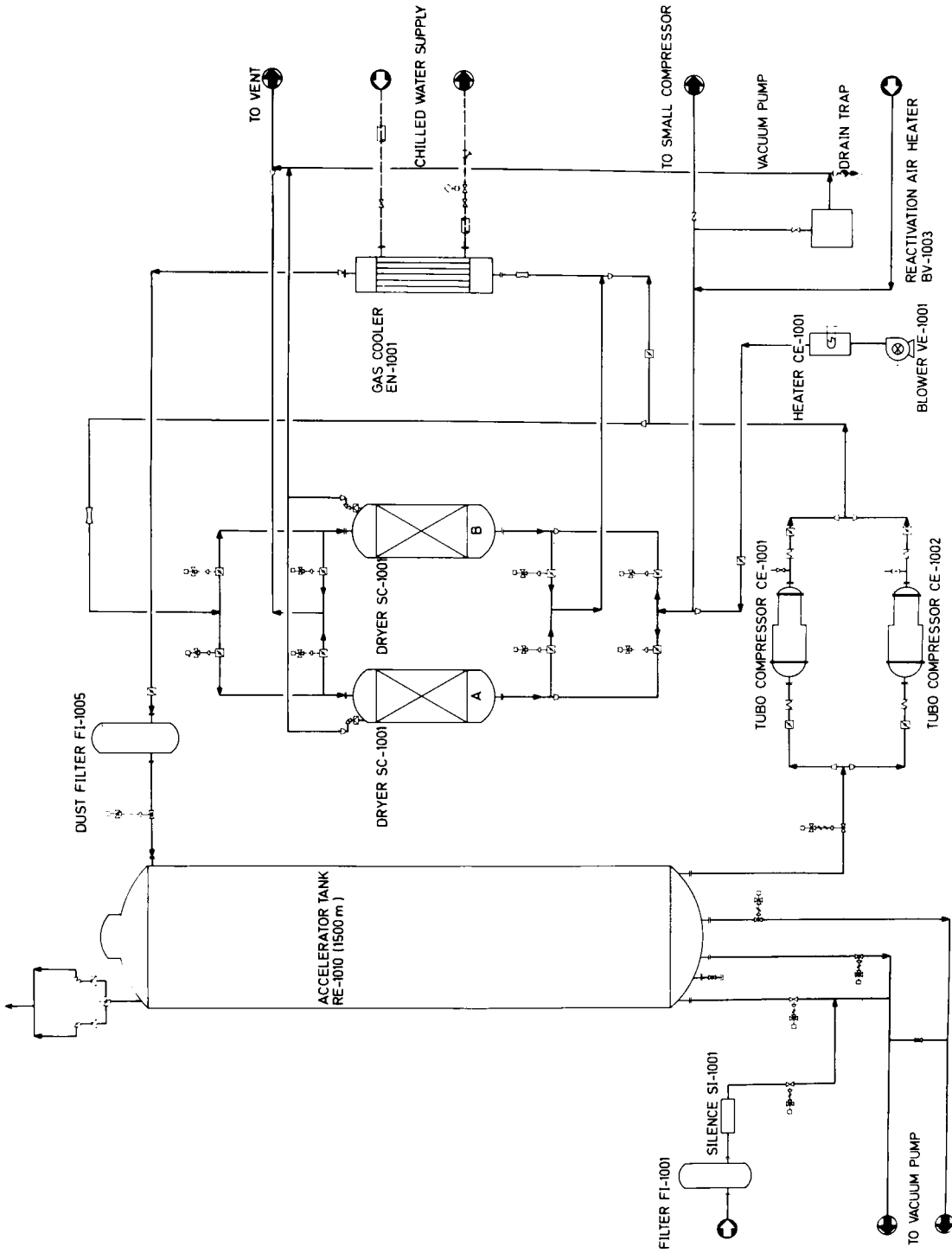
3. Recirculation and purification system

The design and the components of the recirculation system for purification and refrigeration of the SF₆ were both provided by NEC.



(B) SF₆ GAS HANDLING PLANT FLOW SHEET (Vacuum pumps; compressors and storage tanks)

Fig. 1. Block diagram of the SF₆ transfer system.



(A) SF₆ GAS HANDLING PLANT FLOW SHEET (Principal tank and recirculation system)

Fig. 2. Block diagram of the SF₆ recirculation and purification system.

A block diagram is shown in fig. 2. Two Spencer turbo compressors, 20 HP each, circulate the gas through alumina absorption beds. In addition to the elimination of the SF_6 breakdown products, these dryers also remove the moisture present in the gas. After this stage, the gas is cooled in a water-cooled heat exchanger and filtered before reinjection into the accelerator vessel.

The system includes two dryers, so while one of them is in operation the other can be reactivated by means of a hot air current at 400°C.

4. Operation of the system

Starting with 1500 m³ of air at atmospheric pressure inside the accelerator vessel, a total SF_6 transfer operation from and to the storage tanks is performed in the following steps:

Step 1: Evacuation of the accelerator vessel. The Roots pumps allow evacuation of the vessel down to a pressure of 0.5 mb in 4.5 h, using the two pumping groups simultaneously.

Step 2: Filling of the vessel free-flow regime. This

operation takes advantage of the pressure difference existing between the accelerator vessel and the storage tanks. To limit the flow velocity and the low temperatures resulting from the expansion of the gas, the system includes two valves which regulate the gas flow and pressure inside the piping line. The gas flow is normally kept at about 5.6 kg/s. Starting the operation at 0.5 mb in the accelerator vessel and 13.5 kg/cm² in the storage tanks, the pressure in the system reaches equilibrium at about 5.8 kg/cm² in 3.5 h.

Step 3: Filling with the compressors. This is performed with the two three stage compressors operating in parallel. The maximum pressure attained has been 8.8 kg/cm² in 3.75 h.

Step 4: Evacuation of the vessel free-flow regime. Operating in an inverse manner to Step 2, starting with 8.8 kg/cm² of SF_6 in the vessel and regulating the flow velocity, the pressures equalise at 5.8 kg/cm² in 1.5 h.

Step 5: Evacuation with the compressors. Operating both compressors in parallel, the vessel pressure is reduced from 5.8 kg/cm² to atmospheric pressure in about 6.5 h.

Step 6: Evacuation with compressors and vacuum

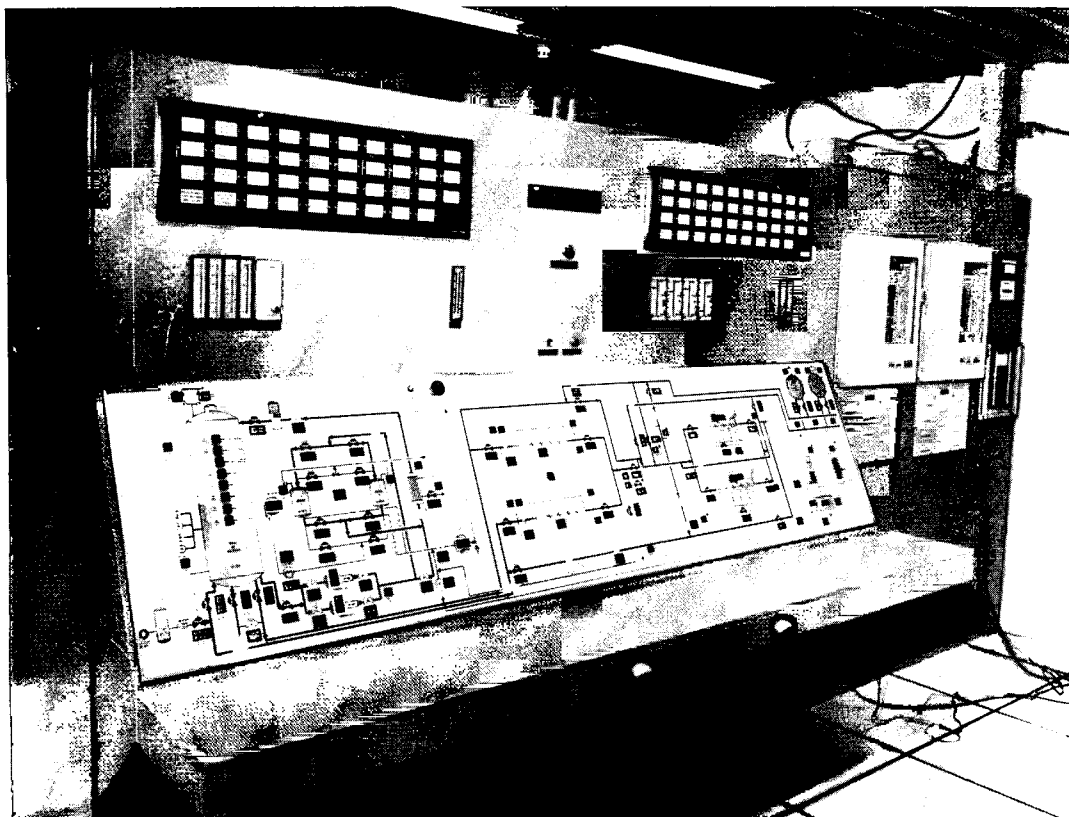


Fig. 3. Control panel of the SF_6 gas handling system. The panels on top of the figure correspond to the monitor systems of the SF_6 leaks and O_2 levels, as well as alarms indicating intrinsic failures of the system.

pumps. A partial recirculation of the gas through a by-pass valve prevents the pressure at the intake of the compressors falling below atmospheric. In the sub-atmospheric range the vacuum pumps are started, discharging into the input of the compressors. Another by-pass valve in the pumping system keeps the pressure at the compressors below 1070 mb. This combination allows the pressure to stay slightly above 1 atm. Final pressure in the vessel is 1 mbar, in 5.5 h.

Step 7: Filling with air. Clean air is injected into the vessel through a control valve. Atmospheric pressure is reached in about 45 min.

The complete operation of pressurization of the vessel with SF₆ up to 10 atm, including the transfer of the gas back to the storage tanks and filling of the vessel with air up to atmospheric pressure, takes a total of approximately 26 h. The system is operated from a remote control panel located in the plant. A picture of this panel is shown in fig. 3.

5. Initial operation and performance during the column high voltage tests

5.1. Operation with dry air

The system was first operated with dry air. The initial SF₆ inventory was stored in one of the tanks; the other was pressurized with dry air. The test allowed the checking of the control panel including the protection logic which prevents incorrect opening of the electro-pneumatic valves, calibration of all control instruments and elimination of serious leaks in the system.

Running the test was not particularly troublesome. Some water accumulation was found in the piping lines and leaks were found in several blocking valves due to spoiled Teflon seals. They were all traced back to the cleaning process carried out during the installation. The moisture sensors used in the storage tanks have been found to be inadequate and have to be replaced. Only one NORWALK compressor was available for the tests, rusting in the cylinders of the other during transportation prevented its operation.

5.2. Operation with SF₆

The first SF₆ transfer test showed up a design problem in the compressors. These were rated for a suction pressure variable between 1–10 atm and it was found that the maximum power of the drive motor current was reached at only 4 atm. The solution to this problem consisted in a sequential operation of the three stages of the compressor. Obviously this procedure made the SF₆ transfer longer than foreseen.

As expected, the heat of compression of the pumping system and compressors during the SF₆ test was lower than in the case of the operation with air. The safety system consisting of an automatic sequential sensor of SF₆ leaks and O₂ level was calibrated. The second compressor was repaired and made operational with the same restrictions as for the other. The installation was then ready to run the first SF₆ transfer for the high voltage test of the column structure of the accelerator which was successfully performed in April 1983. The accelerator vessel was first pressurized with SF₆ in 10 steps from 0.35 kg/cm² (5 psig) up to 7.0 kg/cm² (100 psig). The pressure was then lowered to 5.6 kg/cm² (80 psig) and finally raised up to 8.8 kg/cm² (125 psig).

The recirculation system was not operated at 8.8 kg/cm² (125 psig) because of lower safety calibration values of some of its components. The time intervals mentioned in §3 have been recorded while performing this test.

6. Conclusions

The operation of the SF₆ gas handling system during the two weeks high voltage column structure tests has demonstrated the reliability of the installation.

Its performance fulfils to a large extent the three basic design premises of the system, that is, to conserve the SF₆ purity, to be free of significant leaks, and to accomplish a full transfer cycle in about 24 h.