CONTROL SYSTEM FOR THE TURBOMOLECULAR PUMPING STATIONS AND SECTOR VALVES OF THE CERN INTERSECTING STORAGE RINGS

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The turbomolecular pumping stations of the ISR ultra-high vacuum system form an operational unit together with the sector and roughing valves. The design criteria leading to the final concept of the valve control system are determined by the necessary bake-out of the chamber and the intense stacked proton beam.

Introduction

The vacuum system of the CERN Intersecting Storage Rings (ISR) consists of a tubular structure forming two quasi-circular rings of nearly 1 km circumference.[1] The average pressure is in the low 10^{-10} torr range resulting in a theoretical lifetime of many hours for the circulating proton beam. This low pressure can only be obtained after baking the entire chamber including all equipment forming part of the vacuum system. A new bake-out becomes necessary whenever the chamber has been let up to atmospheric pressure for repair or for installation of new equipment. Sector valves have been introduced to subdivide the system into 28 sectors which can be treated separately. The sector valves must, furthermore, isolate a region in which a pressure rise above a critical value occurs from the rest of the UHV system. The effectiveness of the protection against a sudden pressure increase depends mainly on the closing speed of the valves which is of the order of 1 sec for the present type. To cope with rapid pressure increases which could be caused by very large leaks, special fast acting valves, closing in about 20 msec are being designed.

Sector Valve and Turbomolecular Pumping Station

In total 40 sector valves are installed in the ISR dividing the chamber into sectors of about 60 m length and also separating equipment which will need more frequent interventions. The sector valve consists of a pivoted arm with an expandable gate mounted at its end[2] The valve is pneumatically operated and closes in two stages. First, the gate is moved upwards blocking the aperture of the vacuum pipe followed by the expansion of the gate which establishes an ultra-high vacuum tight seal. To reduce the total leak rate from one side of the valve to the other still further, the dead volume between the seals is pumped by a turbomolecular pump via an additional vacuum valve (V6). Fig. 1 shows the different components of the combined system, pumping station and sector valve. There are two additional roughing valves (RV) connected to the two sectors on both sides of the sector valve. Depending on the requirements, the pumping station can be connected to either sector. As operational modes are foreseen:

- evacuation of the sector to start the sputter ion pumps
- venting of the sector via V4
- connection of a leak detector
- pumping of the sector valve

Two gauges are mounted on the pump manifold and are used to interlock the opening and closing of the roughing valves with the pressure in the pump. The thermo-couple gauge G3 covers the pressure region 10 torr to 10^{-3} torr. The ionization gauge G2, which is equiped with a burn-out proof filament in addition to its low pressure tungsten filament permits measurements down to 10^{-9} torr. The interlock level of 10^{-5} torr for the two roughing valves is set on this gauge. Gauge G1 can be used in the range from atmospheric pressure to 1 torr.

Operation of pump and valves is done manually on a local control unit in the ring tunnel or on the remote unit in one of the equipment buildings. The controls do not provide for an automatic pumping cycle but require the operators intervention to start the pump or open and close roughing valves. A number of interlocks have been introduced which will close the valves in case of malfunctionning of the pumps or unexpected pressure rise.

Fig. 2 shows the front panel layout of a pumping station control unit. On the left is the control logic for the rotary and turbomolecular pump. The right hand unit contains the logic for the roughing valves and the sector valve.

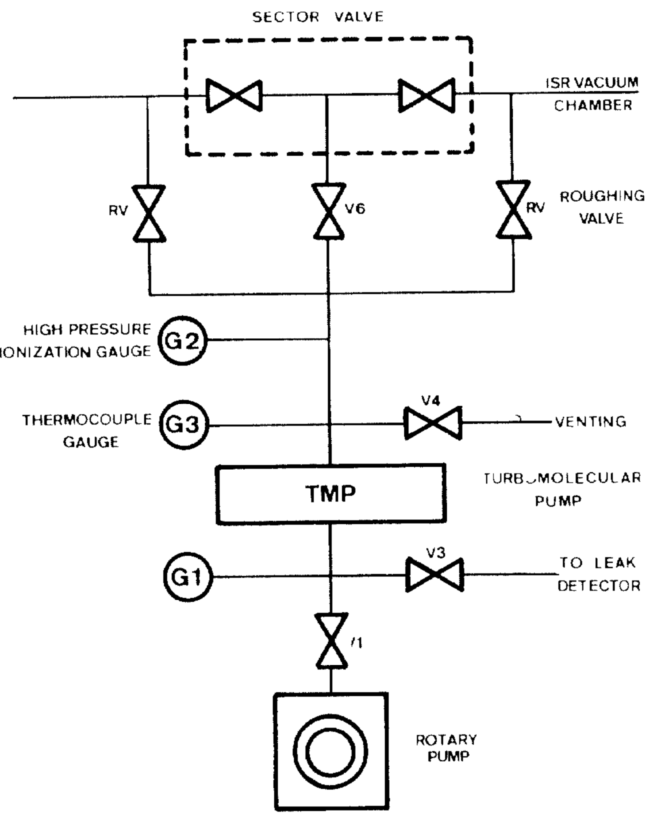

Fig. 1. Turbomolecular pumping station.

During the design of the control logic special attention has been given to the protection of the ultra-high vacuum against failures of the pumping stations or the possibility of accidental opening of roughing valves. Interlock signals from the pumping station (Fig. 2) or a pressure increase in the pump manifold close immediately the roughing valves. For the purpose of rough pumping of the chamber, this pressure interlock may be suppressed temporarily but it is re-established automatically as soon as the pressure in the ISR vacuum chamber falls below a preset level.

Sector Valve Interlocks

The controls foresee an automatic starting of the pumping station, and the opening of the separation valve V6 whenever the sector valve is closed. An interlock taken from gauge G3 permits the opening of V6 only below 10^{-2} torr. When opening the sector valve, the sequence is reversed, first closing V6 before depressurizing the gate. An important requirement is to maintain a given status of the sector valve during bake-out or during machine operation irrespective of a local power cut since in both cases a change of the valve position would be undesirable. Therefore, the selected position is stored in the control logic and maintained when the power fails. Furthermore, bi-stable electromagnetic valves are used in the pneumatic control system.

Two interlocks are provided to guarantee safe operation of the valves. A pressure interlock triggers the closing of the valves in case the pressure on one side exceeds a preset value of 10^{-7} torr. However, to avoid loosing the circulating beam or damaging the valve, its closing is inhibited while a beam circulates. The pressure interlock is derived from the current in the sputter ion pumps. The signals from 5 out of the 10 to 14 pumps per sector are connected to a level detector, set equivalent to 10^{-7} torr. Since one must avoid triggering the interlock due to a local pressure increase which does not affect the functionning of the machine, the signals from at least two out of the 5 pumps must exceed the set value. If this is the case, the sector valves on either side of the high pressure region close. Due to the conductance limitation of the ISR vacuum chamber, it is possible to protect the adjacent sectors effectively even in case of a substantial leak. This was proved when a broken feedthrough caused a hole of about 2 mm diameter.

To avoid loss of the stored beam due to accidental closing of a sector valve, a beam interlock has been provided. It derives its signal from the circulating beam current monitor[3] and inhibits manual as well as automatic closing of the valves. Contrary to accelerators where operation can be resumed without delay, the loss of the stored beam in the ISR may cause a much longer interruption. If the pressure interlock is triggered while a beam is circulating, a fast kicker deflects the circulating protons onto a dump block. Once the "zero beam" signal from the current monitor is obtained the valves close. The additional time delay which is introduced by first dumping the beam can be neglected compared with the valve closing time.

All relevant data from the pumping stations such as position of valves, status of the turbomolecular pumps or the pneumatic pressure are connected to a digital scanning system and transferred to a control computer. It is envisaged to have a continous supervision of the complete vacuum system including sputter ion pumps and ultra-high vacuum gauges. Any fault or major change on any one of a thousand individual components can be detected and signalled to the operator.

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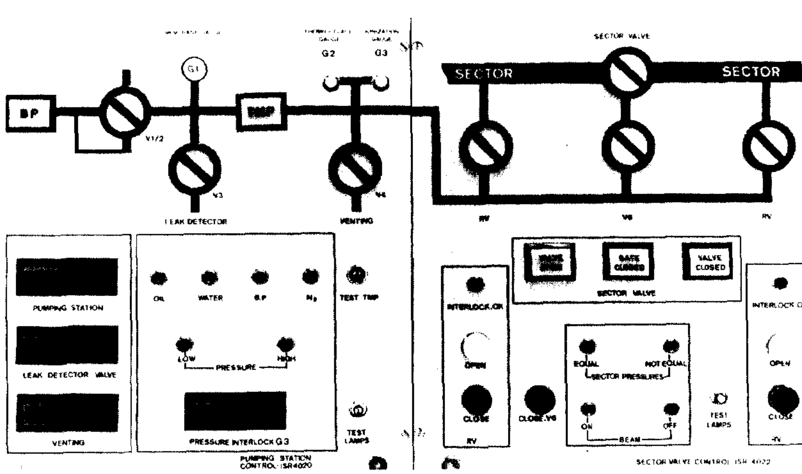

Fig. 2. Pumping station and sector valve controls. The diagonal position of the valve indicators signals a fault or power cut.