SPECIFICATION

FOR THE SPOTTER-ION PUMPS WITH POWER SUPPLIES

FOR THE VACUUM SYSTEM OF THE 800 MeV BOOSTER SYNCHROTRON (PSB)
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1. INTRODUCTION

The European Organization for Nuclear Research (CERN) in Meyrin (Geneva) is constructing an 800 MeV Booster Synchrotron (PSB) to be used as an injector for the 28 GeV Proton Synchrotron Machine (CPS). This Booster Synchrotron is part of a major improvement programme undertaken to boost the beam intensity in the Proton Synchrotron to $10^{13}$ proton/pulse. This high intensity beam will be used for experiments in high energy physics and for proton beam collision experiments in the Intersecting Storage Rings (ISR) presently in the completion stage.

The vacuum system for this Booster Synchrotron will be of a rather unique design because it consists of four superposed rings of 50 m diameter divided into 16 periods. In each period there are two tanks, called manifolds, which connect the four rings into one common vacuum system of about 630 m in length.

The proton beam is injected into each one of these four rings from the 50 MeV linear accelerator via a 77 m long injection line (see Fig. 1). After simultaneous acceleration of the 4 proton beams to an energy of 800 MeV, the four beams are ejected and recombined in a 70 m long transfer line into a single beam for injection into the CPS.

The total length of the PSB vacuum system is about 920 m and, when completed, will become an integral part of the already existing Linac, Booster, CPS and storage Ring complex forming a giant vacuum system of about 5.2 km length (see Fig. 2).

The requirements of pressure in this giant system vary considerably according to needs. For the Booster an average pressure of $10^{-7}$ Torr or less is required in order to reduce the beam losses due to gas scattering to a permissible level.

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It is planned to evacuate the Booster vacuum system with the pump arrangements shown in Fig. 3 as follows.

18 roughing pump groups to pre-evacuate the chamber down to the starting pressure of the sputter ion pumps.

50 sputter ion pumps to evacuate the system to an average pressure of $10^{-7}$ Torr or less.

8 titanium sublimation pumps to evacuate large tanks in the injection and ejection regions where very high pumping speeds are required.

This specification deals only with the sputter-ion pumps.

2. GENERAL SPECIFICATION

2.1 Scope of the contract

The contract to be placed with the successful tenderer will comprise:

a) the manufacturing and the delivery to the CERN site of 50 sputter-ion pumps and power supplies with the following performance requirements (for details see Chapter 4):

- pumping speed for air: $400 \ell$/sec at $10^{-7}$ Torr
- ultimate total pressure: $5 \times 10^{-10}$ Torr.

Each pump must be complete with mounting brackets, high voltage feedthroughs, and bakeable HV connects, the main pump flange and the blank-off flange for shipment under vacuum, bakeout equipment for bakeout to $300^\circ$C and a power supply (control unit).
b) the installation and preparation of the pumps by the contractor's staff on the CERN site for the acceptance tests.

c) the execution of the acceptance tests under supervision of CERN personnel.

d) the preparation of the accepted pumps for storage under vacuum.

e) an option for CERN to order 20 additional pumps as described in a) to d), within 24 months after placing the order with the successful tenderer.

The contract will explicitly not comprise:

- the mechanical supports for the pumps, apart from the mounting brackets,

- the test domes and gauges for the acceptance tests,

- the installation of the accepted pumps in the P83.

2.2 Proposed time schedule

September 1969 : inquiry, mailing of tenders

20th October 1969: opening of tenders

before end of 1969: placing of the order

March 1970 : beginning of delivery and acceptance tests at CERN (see below)

March 1971 : end of delivery.

It is very important that at least 8 pumps and their power supplies be delivered to CERN by March 1970. The remaining pumps can
be delivered to CERN in the following 12 months according to a time schedule that will be agreed upon with the successful tenderer.

2.3 Manufacturing programme and progress reports

The contractor will prepare a manufacturing programme and send it to CERN not later than one month after the contract is signed.

Once every two months after the manufacturing programme has been sent to CERN, the contractor should describe in the form of a short report the main progress made in procuring materials, manufacturing of components, assembly of pumps, testing them in the factory, etc.

CERN must insist that the progress reports cover also all major difficulties which might arise. If these difficulties are so serious that they risk causing a delay in the delivery schedule, CERN must be informed immediately.

2.4 Instruction manual and drawings

At the time of the first delivery of the pumps the successful tenderer must supply at least 10 copies of an instruction manual, containing a detailed technical description of the pump and power supply and all relevant information on how to use it. A complete set of copies of drawings of the pump with all its components must be attached to each instruction manual. In addition, one complete set of transparent copies of the drawings must be supplied. Similarly, a complete set of diagrams of the power supply and a parts list must be attached to each instruction manual.

2.5 Spare parts

The tenderer must include in the tender a list of spare parts which might eventually be required for repairing pumps or power supplies.
Such spare parts are: complete electrode systems, single parts of the electrode system as, in particular, sputter elements and ceramic insulators, HV feedthroughs, permanent magnets, heating elements, flanges, bolts, gaskets, electrical and electronic components of the control unit and all other parts which are not normally available on the market.

2.6 Breakdown of price

The tenderer is invited to quote the total price for all supplies and services as described in the present specifications, and to give also a detailed breakdown of the total price. This breakdown is necessary in case CERN wishes not to accept a particular item of the tender as, for instance, the HV feedthrough, the bakeout oven or the power supply. The tenderer must, therefore, quote the prices for the following individual items:

A) Unit price for one complete pump, broken down further into prices for
   1. Pump body
   2. Magnet
   3. Internal pump elements
   4. HV feedthrough
   5. Bakeout oven, complete with or without air cooling
   6. Flanges, bolts, gaskets.

B) Unit price for one complete power supply.

C) Price for packing, transport to the CERN site and insurance for 50 pumps.

D) Execution of the acceptance tests on the CERN site and preparation of the pumps for storage under vacuum (see section 6).

E) Price list for all spare parts listed in Section 2.5 (not included in the breakdown of the total price).

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2.7 Modifications

Minor modifications to the vacuum system might become necessary at any stage of the construction period. If such modifications will alter the present specification, they will be described in addenda which will form the basis of an amendment to the contract to be negotiated between the contractor and CERN.

2.8 Access to information

CERN will place only one overall contract with one pump manufacturer, who will, alone, be responsible for the whole contract. CERN demands, nevertheless, to be informed of the full technical content of any sub-contracts which the main contractor may place.

CERN also demands the right of access to all technical information obtained by the contractor in the course of manufacture.

In addition, representatives of CERN must have free access to the factories during the manufacturing and tests. Free access must also be granted to the factories of any sub-contractor.
3. TECHNICAL SPECIFICATION

3.1 Type of pump

The required sputter-ion pump can be one of the many variants of pumps based on a continuous gas discharge in a magnetic field from a permanent magnet, provided the pump fulfills the performance requirements and meets all other characteristics listed in the present specifications. The sputter material can be titanium, titanium alloy or a similar metal.

All pumps with a filament are excluded, because they cannot be expected to have the same degree of reliability as filament-free pumps.

3.2 Pump body

The body of the pump must be made of stainless steel and argon-arc welded. Acceptable steel qualities are 304, 304 L and 321 (AISI).

The design of the sputter-ion pump must allow for easy disassembly, removal and replacement of the HV interconnecting harness and electrode systems through the neck of the demounted pump. Removal and replacement shall not require grinding or welding.

The body has to be stiff enough to allow the pump to be installed with its oven in any position, bolted at the main pump flanges without any additional support.

3.3 Flange

The main pump flange has to be a standard 5"/6" ConFlat Variant flange or any other flange comparable to it.
The flange must be welded in such a way that the bolt holes are symmetrically arranged with respect to the main planes of symmetry of the pump and the planes of symmetry being disposed halfway between two adjacent bolts.

Oxygen free copper gaskets, high-tensile bolts and nuts are to be included in the offer.

3.4 Magnet

The permanent magnet of the pump must withstand safely and repeatedly for periods of several days a bakeout temperature of 300°C. At this temperature the magnetic field strength must be sufficient for operation with at least half the pumping speed specified in Section 4.5. After bakeout the magnetic field strength must revert to its former value.

The surface of the magnet must be protected against corrosion by a coating withstanding a temperature of 300°C. The colour of the protection coating will be chosen in agreement with CERN.

It is required that the magnets are marked in such a way that the polarity (north-south) can easily be recognized. The marking must be visible when the magnets are in place and the oven is removed.

There must be corresponding marks on the pump body in order to make the positioning of the magnets unambiguous.

The magnet arrangement must have a vertical plane of symmetry and, moreover, be identical on all pumps.
3.5 High voltage feedthrough

The feedthrough must stand a DC voltage of 10 kV and a DC current of 5 A.

It must be fitted onto a 2 3/4" Varian ConFlat flange in such a way that inspection and cleaning of the ceramic part is easy.

The feedthrough must be protected against accidental breakage by a metal (preferably stainless steel) sleeve surrounding the HV feedthrough and connector. The sleeve must be easily demountable for inspection and cleaning of the feedthrough.

The feedthrough must be resistant against corrosion under normal operating conditions including bakeouts at 500°C under high voltage.

3.6 Bakeout and cooling

The pump must be equipped with an electrically heated oven or heating elements permitting bakeout of the pump up to 500°C.

The heating elements might be fixed either on the pump body or mounted in the form of radiation heaters close to the inner wall of the oven. Internal heating of the pump by means of a heating tube located within the pump is excluded. A melting fuse must be attached to one representative point of the pump body. It will be set to 350°C and will cut the heating circuits when this temperature is exceeded.

The specified ultimate pressure must be obtained within 48 hours of the end of a bakeout without removing the oven (see Section 4.2). If necessary, a ventilator for air cooling may be included in the design of the oven.
It must be possible to open the oven or to remove it for leak testing without detaching the pump from the PSD.

The available electricity supply on the CERN site is 220/330 V/50 Hz.

The electrical parts of the proposed oven must comply with the safety rules in force in the tenderer's country. Before the contract is placed, CERN will check whether it complies also with the CERN safety rules.

3.7 High voltage cable and connector

The present specification covers the supply of the HV connector on the atmospheric side of the HV feedthrough. The high voltage cable is specifically not included because its length will vary for different pump set-ups and, therefore, will be supplied by CERN.

During a regenerative bakeout, essential for maximum performance of most sputter-ion pumps, the pump is baked up to 300°C with full voltage applied. Consequently, the HV plug must be of such a design as to withstand the bakeout. But it is probably not necessary that it withstands 300°C. The oven might be designed so that plug (and cable) stay outside the area of maximum temperature. However, with the chosen layout the pump must reach the specified ultimate pressure and pumping speed.

The proposed HV connector must comply also with the safety rules in force in the tenderer's country. Before the contract is signed, CERN will check whether it complies also with the CERN safety rules.
3.8 Support

The pump will be mounted as shown schematically on Fig. 4.

A mechanical support on the pump body could sometimes be necessary but it is not included in the present specification - it will be designed at CERN. It is necessary, however, to have some kind of mounting brackets welded or bolted onto the pump body.

3.9 Maximum dimensions

The outer dimensions of the pump including its oven must fall inside the outline drawing of Fig. 4.

If the outer shape of the pump with its oven is of rotational symmetry with respect to the axis of the flange, a diameter of 500 mm is acceptable.

3.10 Interchangeability

All individual components of the pumps must be functionally and dimensionally interchangeable.

3.11 Packing and delivery

For the preparation of shipment the pump must be sealed under vacuum by pinching off a copper pipe. The copper pipe must be so long that cutting, brazing and a second pinch-off is possible.

The pump must be packed in such a way that no damage occurs due to climatic influences and handling during transport and storage under cover of up to one year.
4. PERFORMANCE REQUIREMENT AND DEFINITIONS

4.1 Definition of pressures

All **total pressures** quoted in the present specification are equivalent nitrogen pressures measured by conventional Bayard-Alpert (BA) gauges of a make chosen by CERN. The gauges are thus calibrated for nitrogen and no relative sensitivity factor for a given gas is applied.

All **partial pressures** quoted in the present specification are the partial pressures measured by a residual gas analyser (RGA) which has been calibrated separately for all gases of importance to the PSB, at least, for hydrogen, nitrogen and argon. The calibration will be carried out at CERN, and if desired, in presence of a representative of the pump manufacturer. The calibration consists in the comparison of the signal (or signals) measured by the RGA for an injected gas with the total pressure as indicated by the BA gauge, taking into account, of course, the partial and total pressure as measured before the injection of the gas. Thus, the RGA is calibrated in equivalent nitrogen pressures as defined by the BA gauge and not in true pressures. CERN will endeavour, when choosing a make of RGA for the acceptance tests, to find an instrument which has approximately the same relative sensitivities as a BA gauge. This would simplify the determination of the (equivalent nitrogen) partial pressures from a recorded RGA spectrum.

4.2 Ultimate total pressure

The ultimate total pressure of the pump must be smaller than $5 \times 10^{-10}$ Torr.

The ultimate total pressure is defined as the pressure measured by a BA gauge on top of the pump 48 hours after the end of a regenerative bakeout. At this time the pressure should not have a rising trend. The end of the bakeout is the moment at which the heating elements
are switched off. During the cooling down the bakeout oven forming an integral part of the pump should not be removed from the pump.

A regenerative bakeout is a bakeout of at least 10 hours at 300°C under vacuum below $10^{-5}$ Torr with full voltage applied to the pump and with the roughing pump sealed off. Usually a regenerative bakeout is preceded by a preliminary bakeout without voltage on the sputter-ion pump and with the roughing pump in operation.

The test done for the measurement of the ultimate pressure has the form of a cylinder with a diameter equal to that of the pump neck and a height equal to the diameter. The only equipment mounted onto the test dome is a bakeable roughing valve of 25 to 40 mm aperture and a flange mounted (nude) modulator Bayard-Alpert (MBA) gauge. The dome is heated together with the pump up to 300°C.

### 4.3 Definition of pumping speed

At present, there is no international standard for pumping speed measurements on sputter-ion pumps at low pressures. CERN, therefore, specifies its own method for pumping speed measurements and defines as pumping speed the speed as measured by this method. The pumping speed test dome and the test procedure as used at CERN are specified in Section 4.4. The contractor must accept this method for the qualifying and, acceptance tests and for the settlement of possible guarantee claims.

For the purpose of the present specification two distinctly different states of sputter-ion pumps are defined.

The first one is the state after a regenerative bakeout as described in Section 4.2. It has been observed on several pumps tested by CERN that in this state the ultimate pressure is lower and the pumping speed enhanced in comparison to that of a saturated pump or to that of a pump which had a bakeout without voltage applied.
The second state is that of a pump saturated with air. We define a pump saturated if it has pumped after the last regenerative bakeout at least 25 Torr litre of ordinary laboratory air. This would be, in practice, the state of a pump which had to operate against an air leak for some time.

It is common practice to enhance the performance of a titanium sputter-ion pump by flashing it with argon or helium. Since, it is not possible to do this on the PSB in a controllable way, argon or helium flashing is excluded also from qualifying for acceptance tests.

4.4 Pumping speed test dome

The CERN standard test dome for pumping speed measurements on sputter-ion pumps is shown in Fig. 5. It has an inner diameter of 150 mm and a total height of 600 mm. The dome is divided by means of an orifice plate into a top volume of 150 mm height and a main or bottom volume of 450 mm height (equal to three diameters). The circular orifice has a diameter of 10 mm and is cut into a plate of 1 mm thickness. The molecular conductance of this orifice for air at 20°C is 8.28 l/s (where a Clausing factor of 0.91 is included). The gas is injected into the top volume through a bakeable leak valve and a narrow tube with the jet directed towards the top. Flange mounted (nude) BA gauges are connected to each of the volumes as drawn. The bottom gauge measuring the pressure $P_1$ is a modulator BA gauge (MBA), but identical to the top gauge apart from the modulator electrode. The bottom gauge is, furthermore, arranged as a so-called "pressure converter" with an inlet orifice of 10 mm diameter. The distance from the centre of this orifice to the bottom (pump) flange is 100 mm. The theoretical justification for the converter gauge arrangement and for the distance of 100 mm is given in the Internal CERN Report ISR-VAC/66-11, available on request from CERN.

The above mentioned report shows that a pumping speed very close to the "intrinsic" or "true" pumping speed can be obtained

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from measurements with the described dome by using the formula

$$ S = C \left( \frac{P_2}{P_1} \right)^{-1} $$

(1)

where $S$ is the pumping speed and $C$ the conductance of the orifice for the injected gas.

A correction to Eq. (1) is necessary if the two gauges have not the same sensitivity. The relative sensitivities of the two gauges must be checked before each series of pumping speed measurements in the following way: after a careful external bakeout and internal outgassing of the gauges the pump is switched off. Air is then injected through the leak valve in small amounts. The two pressures are recorded between the injections when the leak valve is completely closed and and equilibrium established. The BA gauge at the bottom is taken as reference and the reading of the BA gauge at the top corrected. This leads to a correction factor $\alpha$ as a function of the indicated pressure $P^*_2$ defined by

$$ \alpha (P^*_2) = \frac{P^*_1}{P^*_2} $$

(2)

where $P^*_2$ and $P^*_1$ are the pressure readings during the gauge comparison experiment. The complete formula for the determination of the pumping speed reads then

$$ S = C \left( \frac{P'_2}{P'_1} \alpha (P'_2) - 1 \right) $$

(3)

where $P'_1$ and $P'_2$ are the pressure readings during the pumping speed measurement.

On the test dome are mounted a bakeable roughing valve
for pre-evacuation and a residual gas analyser (RGA), both on the same level as the lower MBA gauge. The RGA is necessary for measuring the relative pumping speed of argon in air and for evaluating the memory effect. It is, furthermore, very useful for assessing the leak-tightness of the assembly and for the localisation of possible leaks.

4.5 Specified pumping speeds

Air

The pumping speed of an air saturated pump for air at $1.10^{-7}$ Torr must be at least 400 l/s. This should be the lowest speed recorded during a three hour period with an injection regulated so that the total pressure remains within the range $5 \times 10^{-3}$ to $2 \times 10^{-7}$ Torr.

After a regenerative bakeout the pumping speed for air at $3 \times 10^{-8}$ Torr must be at least 300 l/s. During the pumping speed measurement over a period of 24 hours, the injection of air should be regulated so that the total pressure remains within the range $2 \times 10^{-8}$ to $5 \times 10^{-8}$ Torr.

Argon

It is preferable not to measure the pumping speed for pure argon because this could cause an increase of the argon background at ultimate pressure. The only argon which will be pumped during the normal operation of the Booster will be the argon from the atmospheric air (about 1%) present during a pump-down and entering through leaks.

It is specified that during the pumping speed measurement of air in the neighbourhood of $10^{-7}$ Torr the partial pressure of argon should never be larger than 10% of the nitrogen partial pressure.
4.6 Starting properties

The pump must have an "easy start" under the following conditions:

- pump connected to a volume of less than 5 litres beyond the pump flange and to a hydrocarbon free mechanical pump group of about 3 litres effective pumping speed for air at $10^{-1}$ Torr and of an ultimate total pressure of less than $10^{-4}$ Torr,

- pump baked at 250°C to 300°C for four hours with the roughing pump in operation and without voltage applied to the sputter-ion pump.

An "easy start" is defined by the fact that the pump, after switching on at $10^{-3}$ Torr, reaches in five minutes a pressure below $10^{-3}$ Torr and, after the roughing pump is sealed off, in 20 minutes a pressure below $10^{-5}$ Torr.

4.7 Memory effect

One calls memory effect the re-emission of a gas which has been pumped some time during the life of a pump but is not being injected at the time of observation.

It is very important, that the memory effect should be reduced or eliminated by a regenerative bakeout. It is, therefore, specified that a pump which has first been saturated with at least 25 Torr litre of air and has afterwards, gone through a careful regenerative bakeout, reaches the ultimate total pressure of less than $5 \times 10^{-10}$ Torr as specified in Section 4.2.
4.8 **Lifetime**

It is specified that a pump which has operated for at least three months (> 2000 hours) against an air leak at a pressure between $2 \times 10^{-6}$ and $6 \times 10^{-6}$ Torr still satisfies all the performance requirements as quoted above.
5. **Power Supply**

5.1 **General description**

The power supply for a sputter-ion pump must be built on a chassis for standard 19'' rack mounting. The front panel should not exceed 266 mm in height and the depth, not including the connectors and cables, should be less than 456 mm.

5.2 **Front panel**

In the front panel there should be incorporated the following:

a) A multi-position selector switch and a meter for the direct measurement of the ion pump current, voltage and pressure. The full scale deflection in the most sensitive current range should be of the order of 100 μA. In addition to the linear ranges, one logarithmic range from \(10^{-5}\) to \(10^{-8}\) Torr should be available for pressure measurements.

b) One recorder output for the recordings of pressure and current (0 - 100 mV).

c) Access holes for the adjustment of all threshold values for automatic switchover, controls and interlocks etc.

d) ON - OFF push-button.

e) Status signal for the 'ON' and for the 'Protection' position of the power supply.

f) A switch allowing the interruption of the automatic Start-Protect function.

g) One fuse with manual reset.
5.3 **Rear panel**

The rear panel should include:

a) A multi-pin (28) connector to be agreed upon between the manufacturer and CERN (recorder output, status signal, Start-Protect control, etc.).

b) A high voltage connector to be agreed upon between the manufacturer and CERN (including additional contacts for the high voltage interlock).

5.4 **Voltage versus current characteristics**

- **Power input single phase**: 220 V 50 Hz
- **Output voltage**
  - *(at no load conditions)*: 5 - 8 kV
- **Short circuit current**: 0.8 - 1.6 A

Continuous operation at any current between zero and short circuit current will be permissible without overrating any component.

5.5 **High voltage generator**

The required output characteristics shall be obtained by using a magnetic shunt transformer followed by a full wave bridge rectifier or a voltage doubler circuit. Whenever the HV is turned off without external load connected to the power supply, the high voltage should fall below 50 V within 5 seconds.
5.6 Protection circuit

The power supply will incorporate an over-current protection circuit. When the power supply is in the position 'Protection', the HV power should be turned off as soon as the pump current exceeds a pre-adjusted upper limit. The upper limit will be specified before the order is placed. The protection circuit should not be influenced by temporary current peaks occurring between the electrodes of the pump. The HV can only be re-established by pushing in the ON button.

It must be possible to suppress this protection during the starting of the ion pump.

5.7 Electrical diagrams and parts list

A detailed schematic of the power supply as well as a description of the principal circuits and parts list is required.

Except for the high voltage cable to be furnished by CERN and the above mentioned connectors to be chosen in agreement with CERN, all components used in the electrical circuits must be determined by the successful tenderer. It should, however, be noted, that CERN uses 48 VDC for its control circuits. Moreover, CERN reserves the right to modify the selection of certain relays, particularly if the chosen relays generate an excessive amount of heat.

6. TESTS

6.1 Qualifying tests

On the basis of the tenders received and possibly further information CERN could select one or may be two tenderers who would be asked by CERN to supply a prototype pump with power supply, the latter
to the tenderer's choice, and to delegate an engineer or senior technician to the CERN site for qualifying tests. The prototype pump must be in all essential parts exactly of the type proposed by the tenderer. The pump must have the complete bakeout and cooling equipment, but if the latter is of a more provisional character, this is still acceptable.

The purpose of the qualifying tests is to show that the pump is within the specifications. In addition, they will give an opportunity to discuss minor modifications as to details of the supporting brackets, fixation of the power cable for bakeout, cooling etc.

CERN will make available two test domes as described in Section 4.4 complete with calibrated gauge heads, gauge controls, residual gas analyser, roughing system, etc. These two test domes will be equipped with 8" O.D./6" I.D. Varian ConFlat flanges.

The tenderer must supply together with the prototype pump three additional HV feedthroughs of the type used on the pump. On these feedthroughs CERN will carry out separate tests with the purpose of evaluating their quality and reliability.

If a prototype pump does not fulfil the specifications or if it has not arrived on the CERN site three weeks after it has been called for, CERN may ask another tenderer to supply a prototype pump for qualifying tests. The rejected pump will be returned.

The prototype pump and power supply of the successful tenderer will be kept at CERN in good operating condition and will serve as a reference pump during the acceptance tests on the 50 pumps when they are delivered. On completion of the acceptance test, it will be sent back to the contractor.
6.2 Tests in the factory

The contractor must decide which tests he thinks are necessary during the manufacturing and on the finished pumps before they are shipped to CERN. The more carefully these tests are done, the lower will be the rate of rejections during the acceptance tests on the CERN site. CERN would like to discuss these tests beforehand but it does not wish to impose a programme for the factory tests. CERN demands, however, that the contractor prepare a standard test form, which has to be filled out for each manufactured pump. This implies that every manufactured pump must be marked by serial number. A copy of the test form must be handed over to CERN with each pump delivered.

6.3 Acceptance tests

The acceptance tests on all pumps to be manufactured and delivered by the contractor will take place on the CERN site in Geneva.

The pump will be delivered sealed off and under vacuum. The first test will consist in connecting a power supply to the pump for at least 24 hours and in recording the behaviour of the pump current.

The second test will be a general inspection with the pump open. It must show that the pump is complete, clean and corresponds physically in every respect to the specifications and later agreements. This test will also include a measurement of the magnet fields.

The third test will consist in the attainment of the specified ultimate total pressure of $5 \times 10^{-10}$ Torr. This test will at the same time show that the pump is leak-tight, has an "easy start" as defined in Section 4.6 and that the bakeout equipment works satisfactorily. This test will be carried out with a small test dome as described.
in Section 4.2. CERN will hold ready 2 such test domes complete with all accessories and spares so that at any time 2 pumps can be tested simultaneously.

While the first test will be carried out on every pump without exception, the second and the time consuming third test on ultimate pressure, are foreseen only for a fraction of all pumps. In a first stage every single delivered pump will be completely tested, in the second stage only every second pump, selected at random. The transition from one stage to the next will depend on the actual results of the tests.

The first stage will comprise at least 4 pumps selected by CERN out of the first batch of at least 8 delivered pumps. If all the 4 pumps pass the tests, one will go over directly to the second stage. If one or more pumps of the first batch do not pass, a second batch of 6 pumps will also be tested. The first stage will be abandoned if out of the total number of pumps tested in the first stage (at least 10) more than 90% have passed.

In the second stage the pumps, as they are delivered, will be grouped in lots of 20 pumps. Out of each lot 10 pumps will be selected by CERN and tested. The remaining 10 pumps will be regarded as accepted if at least 9 pumps out of the 10 pumps tested have passed. If two or more pumps do not pass, the 10 remaining pumps will also have to be tested.

The time required for the ultimate pressure test, including the general inspection (second test) on one single pump should not exceed 15 working days. Working days lost through no fault of the contractor will be taken into account. A pump has failed the acceptance test and will be rejected if in 15 working days after the beginning of the test it has not reached the specified ultimate pressure.
The first day of the test is the day when the pump flange is opened for the first time after delivery.

Using a test dome as described in Section 4.5 the pumping speed for air will be measured on all pumps which have reached the specified ultimate pressure.

CERN has the right to carry out tests beyond this scheme by its own personnel or to ask for tests beyond the scheme to be carried out by the contractor at CERN’s cost.

The contract will include the following commitments on the part of the successful tenderer for the acceptance tests:

- unpacking of the pump,
- carrying out the first HV tests,
- opening the selected pumps for inspection by CERN inspectors,
- preparing and carrying out the ultimate pressure tests until the CERN inspectors conclude that a test is successful,
- providing the necessary pump power supplies for the ultimate pressure tests,
- carrying out the pumping speed measurements in close collaboration with CERN staff,
- demounting the test domes, remounting the blank-off flanges, pumping and pinching-off under vacuum for storage until they are needed for the final installation.

CERN will make available the following facilities in conjunction with the acceptance tests:

- providing the necessary laboratory and storage space for all the tests and related work including room heating and light,
- providing the necessary electrical power (220/380 V/50 Hz) for the tests,
- providing a sufficient number of ultimate pressure test domes complete with flanges, gaskets, bolts, nuts, bakeable roughing valve, modulated BA gauge head and BA control unit,
- providing pumping speed test domes, complete with gauges, etc.,
- providing a sufficient number of roughing pumps,
- providing enough heating elements for the domes with the exception of all heating equipment for the pumps,
- providing the roughing pumps and other equipment for preparation of the sputter-ion pumps for pinch-off under vacuum for storage.
7. GUARANTEED

7.1 4 years' guarantee of permanent magnets

During the qualifying tests before the adjudication of the contract, CERN and the tenderer must agree on a minimum magnetic field strength in the centre of the gap of the permanent magnets.

If the magnetic field strength of a magnet is found to be lower than the agreed minimum before the end of four years after the acceptance the contractor must replace it free of charge.

7.2 Normal 2 years' guarantee

All parts of the pump will be covered by a guarantee against material and manufacturing faults. The guarantee time of two years starts with the completion of the acceptance tests for all pumps.

If a single component fails the contractor must replace it.

If the pump as a whole is found not to satisfy the specified performance requirements before the end of two years after acceptance the contractor is free either to repair the pump at his own cost or to replace it by a new pump.

The guarantee also extends to any material or manufacturing fault which can be imputed to suppliers or sub-contractors to the main contractor.

7.3 Guarantee and availability of spare parts

The contractor must guarantee that the spare parts as listed according to Section 2.5 will be available during a period of 10 years after the acceptance of the pumps.

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3. **QUESTIONNAIRE**

The tenderer is asked to answer as fully and precisely as possible the following questions:

1. How many sputter-ion pumps and of what pumping speed does the tenderer manufacture per annum?

2. What is the exact type of pump (diode, triode, etc...) proposed in the tender?

3. What is the chemical composition of the sputter electrode?

4. What is the recommended HV voltage?

5. What is the quality of steel used for the pump body?

6. What is the cleaning procedure applied to the interior of the pump body?

7. What is the magnet material?

8. What is the normal magnetic field strength?

9. How does the magnetic field strength depend on the temperature of the magnets?

10. What is the procedure and what equipment is required for remagnetisation of the magnets, if necessary?

11. Can the magnets be remagnetized without demounting the pump body from the vacuum chamber?

12. What type of HV feedthrough is fitted on to the pump?

13. What is the type of brazing technique used for the HV feedthrough?
14. What kind of heating elements are fitted?

15. What is the average consumption of electric power of the oven for a temperature of the pump body of 300°C?

16. Give an outline diagram of the pump including oven.

17. What is the total weight of the pump (in kg)?
   a) with oven
   b) without oven

18. What is the ultimate total pressure of the type of pump proposed by the tenderer and measured under optimal conditions?

19. What pumping speed measurements, in particular at low pressure, did the tenderer carry out on the proposed pump? Which method is used and what are the results?

20. What are the recommended characteristics of a power supply required for an "easy start" as defined in Section 4.6?

21. Is the prototype pump, as mentioned in Section 6.1, ready for shipment, or how long will it take to make it ready?

22. Does the tenderer agree with the proposed procedure for acceptance tests?

23. What is the proposed procedure for the preparation of the pump for shipment under vacuum? (Bakeout at what temperature, at what pressure, for how long, etc.)

24. What are the dimensions and the weight of the power supply?

25. Please give details of the mechanical design and the proposed front panel layout.

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26. What will be the voltage versus current characteristic of the power supplies? Please give details such as maximum power output and voltage and current values at which it occurs.

27. What is the approximate amount of power dissipated in the control unit? (please state under which conditions).
LIST OF DRAWINGS

Fig. 1. Schematic arrangement of Proton Beam in the Synchrotron Injector.

Fig. 2. Overall layout of the improved Proton Synchrotron.

Fig. 3. Vacuum pump arrangement for Booster.

Fig. 4. Maximum pump dimensions and typical method of mounting.

Fig. 5. Test dome for sputter-ion pumps.
SCHEMATIC ARRANGEMENT OF PROTON BEAMS IN THE SYNCHROTRON INJECTOR
INTERSECTING STORAGE RING
300 m

SYNCHROTRON INJECTOR (BOOSTER)
800 MeV

PROTON SYNCHROTRON
28 GeV

OVERALL LAYOUT OF THE IMPROVED PROTON SYNCHROTRON
fig. 4
fig. 5: SPUTTER-ION PUMPS TEST DOME

FROM ORIGINAL DRAWINGS CERN ISR
№ 220-400-3 and 220-405-4