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Specifications of the SLS Front End for the Materials Science Beamline 4S

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1. Introduction

The Swiss Synchrotron light Source (SLS) is a dedicated high brightness Synchrotron Radiation Source presently under construction at the Paul Scherrer Institute (PSI) in Villigen, Switzerland. The construction started in Summer 1998. The SLS is scheduled to start operation in summer 2001.

These specifications cover the design, materials, manufacture, cleaning, testing, delivery and assembly of the Front End (X04SFE) that will be installed in the SLS Materials Science Beamline (X04S). Tenderers are requested to comment upon the specifications and are encouraged to make alternative proposals to the PSI in addition to the quotation according to these specifications. However, after the contract has been placed, departures from the then agreed specifications will not be allowed, except with written permission of the PSI.

2. General Description

The X04SFE (see drawing 30040.25.011) consists of a set of Ultra High Vacuum (UHV) components mounted on frames, with associated control cables and fluid supply.

The main functions of X04SFE are:

- Storage ring vacuum protection
- Absorption of radiation when the beamline is shut-down
- Beam definition
- Vacuum measurement
- Beam-position monitoring

The following documents are integral parts of these specifications:
- UHV materials and technologies for SLS front ends and beamlines, SLS-TME-TA-1998-0014
- Quality assurance requirements, ESRF/ENG/89/02

2.1 X04SFE components

The overall view of the front-end with the main mechanical components is shown in the drawing 30040.25.011.
The mechanical components are arranged in 5 groups:

a) Type A components:
components that define the front-end axial structure.

b) Type V components:
vacuum components connected to the A type components.

c) Type P components:
pneumatic components.

d) Type W components:
water tubing circuits.

e) Type S components:
support and adjustment components.

2.1.1 Type A components
The A type components are shown in drawing 30040.25.012.

A1. Vacuum pipe, CF40F(fixed flange)/CF40R(rotatable flange), with inner diameter 39 mm and axial length 336.21 mm.

A2. Mini gate valve, manually-actuated, VAT series 01, DN40 CF-F, with axial length 35 mm.

A3. Vacuum pipe, CF40R/CF63R, with axial length 210 mm.
The first part is a CF40 rotatable flange and a pipe with inner diameter 39 mm along a total length of 60 mm. The tube then increases to an inner diameter of 66 mm and is connected to a CF63 rotatable flange. These two parts are welded together, giving a total axial length of 210 mm.

A4. Hydroformed metal bellows, CF63F/CF63R, with inner diameter 66 mm and axial length 150 mm.

A5. Vacuum pipe, CF63F/CF63R, with inner diameter 66 mm and axial length 410 mm.

A6. Pumping chamber, CF63F/CF63R, with inner diameter 66 mm and axial length 536 mm.
Laterally, two CF63 flanges which are coaxial with the beam, are used to connect to the other parts of the X04SFE (A5, A7).
One CF150R flange is in the horizontal position. It is used to connect to an ion pump (V1) in the horizontal position.

A7. Hydroformed metal bellows, CF63F/CF63R, with inner diameter 66 mm and axial length 150 mm.

A8. Diaphragm (DI), CF63F/CF40F, with axial length 260 mm.
It must be made according to the drawing 30040.26.001, and must fulfill the following specifications:
The OFHC copper block has cylinder-shaped ends, onto which two tubes are brazed for connection to flanges. On the top of the cylinder-shaped ends, there are three 6 mm diameter holes for alignment purposes.
Inside the OFHC copper block, there is a tapered rectangular opening with dimensions at the narrowest point of 24.4 mm horizontal by 2.24 mm vertical. The angle of the wall with respect to the center line of the cone is 5° for each side wall and 2° for the upper and lower walls.
There are 12 identically configured water channels in the both the upper and lower parts of the block. Water enters through the central 6 channels and returns via the two outer sets of 3 channels.
Two covers, brazed onto the upper and lower parts of the block, cover the water channels. On each cover there is one port for water in, two ports for water out and two holes for inserting thermocouples.
There are four horizontal holes in the OFHC copper, two on each side, for inserting thermocouples. In total, there are eight thermocouples.
There are three support feet, which adjust DI to a given position within $\pm$ 0.05 mm and can be fixed in that position.
Summary of main parts:
a) two flanges, CF63F and CF40F, and their nipples
b) one OFHC copper block and two covers

c) eight thermocouples
d) support frame and feet

A9. Hydroformed metal bellows, CF40F/CF40R, with inner diameter 39 mm and axial length 126 mm.

A10. Photon Shutter (PSH), CF40R/CF40R with axial length 420 mm.
It must be made according to drawing 30040.26.002, and it must fulfill the following specifications:
The shutter essentially consists of a vacuum chamber, inside of which is placed a water-cooled copper head that can be moved in the vertical direction by means of a pneumatic manipulator.
The vacuum chamber is a cylinder of 300 mm inner diameter, on which are mounted:
-two lateral CF40F/CH40R flanges (both rotatable) coaxial to the beam, used to connect to the parts A9 and A11 of the X04SFE,
-one CF300F flange on the top for connecting the pneumatic manipulator and the water-cooled copper head system,
-one CF150R flange at the bottom with a nipple to connect an ion pump (V5), one CF63R flange on the nipple is for connecting a right-angle all-metal valve (V6), onto which a roughing pump system is mounted,
-two CF100F flanges: one with a nipple to connect to a NEG pump (V2) and another is closed by a blank flange,
-two CF40F flanges: one to mount a cold-cathode pressure gauge (V3) and another to mount a Pirani pressure gauge with a zero-length CF40/CF16 reduction (V4).
It must be possible to place the copper head in two positions: an upper position in which the diaphragm aperture is completely free and a lower position in which the diaphragm aperture is completely occluded. In the absence of air pressure and/or electrical power, the copper head must move completely down, occluding the diaphragm aperture.
The water-cooled copper head must be made according to the drawing 30040.26.003.
In the center part, the copper head surface is tilted 3° with respect to the horizontal plane and 15° in each end region. It has a rectangular shape, in order to completely occlude the diaphragm aperture.
There are water channels outside of the vacuum environment in the upper part of the head and covered by a brazed plate. There are 12 identically configured water channels, water enters through the central 6 channels and returns via the two outer sets of 3 channels.
Two long tubes are connected to the copper head for inserting two thermocouples (K type) which monitor the temperatures close to the beam spot. Their positions are indicated in the drawing 30040.26.003.
A welded bellows (Standard Bellows P/N 425-320-4-EE) with a CF300R flange and a plate is welded together to form a vacuum pipe, at whose end is a CF63R flange, which is used to connect to the CF63 flange on the water-cooled copper head. The CF300R flange is not only the cover flange of the chamber, but it is also the base plate of the manipulator.
The pneumatic manipulator basically consists of three columns, two fixed plates, a movable carriage, a microswitch box and a pneumatic actuator. The plate at the end of the bellows will be connected to the movable carriage. On the top fixed plate, there are three holes of 6 mm diameter for alignment purposes. The stroke of this manipulator should be 50 mm.
The pneumatic actuator has the following characteristics: stroke 25 mm, bore 80 mm, Viton sealed. It must have a repeatability of $\pm$ 0.2 mm when the copper head reaches the lower position.
A counter with a range of 1-10000 is installed to record the number of operating strokes.

The copper head positions must be detected by means of the positive action of two pairs (for safety considerations) of bakeable microswitches that must be activated only when the diaphragm aperture is completely closed or free. The four microswitches are mounted in a box, and their position is adjustable.
The chamber connects to the three support feet which adjust PSH to a given position within ⌖0.1 mm and can be fixed in that position.
Summary of main parts:
a) vacuum chamber
b) copper head
c) bellows system
d) pneumatic manipulator
e) vacuum components
f) thermocouples
g) support system

A11. All-metal gate valve (VG1), pneumatically-actuated, VAT series 48, DN40 CF-F, with axial length 72 mm.

A12. Vacuum pipe, CF40R/CF40R, with inner diameter 39 mm and axial length 94 mm.

A13. Fast valve (FV), VAT Series 77, DN40 CF-F, with axial length 60 mm.

A14. Hydroformed metal bellows, CF40F/CF40R, with inner diameter 39 mm and axial length 126 mm.

A15. Vacuum pipe for lead wall, CF40F/CF40R, with inner dimensions of 39 mm and axial length 200 mm.
There is a wall built of lead bricks covering this vacuum pipe. The lead brick frame is not included in this specification. The lead bricks will be mounted after theX04SFE is installed on site, therefore the space around the pipe must be free.

A16. Beam Stopper (ST), CF40F/CF40R, with axial length 372 mm.
It must be made according to drawing 30040.26.005, and it must fulfill the following specifications:
It consists of a cylindrical tungsten block that, by means of a pneumatic manipulator and movable carriage, can be moved in a vacuum chamber, occluding completely the beamline vacuum pipe.
The vacuum chamber is a cylinder of 250 mm inner diameter. Two lateral CF 40 flanges (one fixed and one rotatable) coaxial to the beam, are used to connect to the parts A15 and A17 of the X04SFE. Two CF63 flanges and the CF150R flange at the bottom of the chamber are closed by blank flanges. On the top there is one CF250F flange for connecting the manipulator and tungsten block assembly.
The manipulator is the same as that of the PSH (A10). The pneumatic actuator has the following characteristics: stroke 50 mm, bore 80 mm, Viton sealed.
The Beam stopper head - the tungsten block, shown in drawing 30040.26.006, has a minimum diameter of 50 mm and a length of 180 mm. When the pneumatic actuator shaft is extended, the beamline vacuum pipe must be completely occluded by the tungsten block, and the beamline vacuum pipe must be completely free when the shaft is retracted. In the absence of air pressure and/or electric power or vacuum, the tungsten block must move completely down, occluding the beamline pipe.

The tungsten block positions are detected by means of the positive action of two pairs (for safety considerations) of bakeable microswitches, that are activated only when the beamline pipe is completely closed or free. The four microswitches are mounted in a box, and their position is adjustable.
The chamber connects to the three support feet which adjust ST to a given position within ⌖0.1 mm and can be fixed in that position.
Summary of main parts:
a) vacuum chamber
b) tungsten block system
c) pneumatic manipulator

A17. Reducing flange, CF40/CF63, with axial length 24 mm.

A18. Hydroformed metal bellows, CF63F/CF63R, with inner diameter 66 mm and axial length 150 mm.

A19. Vacuum pipe, CF63F/CF63R, with inner diameter 66 mm and axial length 410 mm.

A20. Filter (FI), CF63F/CF63R, with axial length 410 mm.
It must be made according to drawing 30040.26.007, and it must fulfill the following specifications:
The vacuum chamber is a cylinder of 250 mm inner diameter. Two lateral CF 63 flanges (one fixed and one rotatable) coaxial to the beam, are used to connect to the parts A19 and A21 of the X04SFE. On the top a CF250F flange is covered by a CF250 flange, on which a filter holder is fixed. A water-cooling feedthrough and two CF40F flanges are also fixed onto it. As the filter holder is not included in this specification, the top CF250 flange will be a blank type.
There are two CF100F flanges on the chamber, one is for connecting to a NEG pump(V8) via a vacuum pipe, and another is closed by a blank flange. The CF150R flange at the bottom of the chamber is connected to an ion pump (V7) with a nipple.
Summary of main parts:
a) vacuum chamber and cover blank flange
b) vacuum components

A21. Hydroformed metal bellows, CF63F/CF63R, with inner diameter 66 mm and axial length 150 mm.

A22. Horizontal slit (SH), CF63F/CF63R, with axial length 410 mm.
It must be made according to drawing 30040.26.010, and it must fulfill the following specifications:
The SH system essentially consists of a vacuum chamber with two horizontal slit heatds.
The vacuum chamber is a cylinder, whose axis is horizontal and perpendicular to the beam axis, of 250 mm inner diameter. There are two CF200F flanges with nipples at the end of this cylinder, with 25 mm offset. Two CF63 flanges (one fixed and one rotatable), coaxial to the beam, are welded to connect the chamber to the other parts of the X04SFE (A21, A23).
A CF 150R flange on the bottom is used to connect an ion pump (V9) via a nipple, and a CF150F flange on the top is closed by a blank flange.

The two SH head systems are identical. Each of them consists of the following parts: a water-cooled copper head, a support pipe, a bellows (Standard Bellows P/N 325-225-4-EE), a CF200R flange and a plate.
The cooper head, shown in drawing 30040.26.011, has a similar configuration as for PSH (A10). There are 8 channels, the water enters via the central 4 channels, and it returns through the two outer sets of 2 channels. The head surface tilt angle is 10°with respect to the center line.
This rectangular copper head covers half of the beam plus 5 mm. The maximum overlap between the two heads is 2 mm. The two thermocouples (K type) are inserted to measure the temperatures close to the beam spot on the copper head.
A manipulator drives the water-cooled copper head to a certain position, and in this way the slit system can determine the center of the beam and modify the aperture to select the desired portion. The separation distance between two copper head axes is 25 mm.
This manipulator has a maximum travel of 35 mm, a resolution of 0.01 mm and a backlash of less than 0.01 mm. A load capacity of 1500 N is required. Both motorized and manual movements are necessary; the movement must be irreversible; the driving motors are stepping motors. An optical encoder with a resolution of 0.01 mm and a travel of 35 mm is used to detect the position of the copper plate. One bakeable microswitch stops the motor when it reaches the limit position. Two bakeable and UHV compatible microswitches are fixed onto the copper heads to stop the motor when the maximum overlap of the two heads is reached. A CF16 flange must be added on the top plate of the bellows; the wires of the UHV microswitches will be brought out from this small flange. The motors and encoders will be supplied by PSI.
The edges of the two copper heads must be parallel to one another within 0.01 mm. Three reference holes of 6 mm diameter on the top of the chamber serve for alignment purposes.
As the system will be installed in a horizontal position, careful considerations of the rigidity must be made.
The chamber is supported by three feet. The mechanism of these feet must be able to adjust this system to a certain position within $\pm$0.1 mm and to be able to fix it in that position.
Summary of main parts:
a) vacuum chamber
b) two SH head systems
c) two manipulators
d) vacuum components
e) thermocouples
f) support system

A23. Hydroformed metal bellows, CF63F/CF63R, with inner diameter 66 mm and axial length 150 mm.

A24. Vertical slit (SV), CF63F/CF63R, with axial length 410 mm.
It must be made according to drawing 30040.26.012, and it must fulfill the following specifications:
The SV system essentially consists of a vacuum chamber with two vertical slit heads.
The vacuum chamber is a cylinder, whose axis is vertical and perpendicular to the beam axis, of 250 mm inner diameter. There are two CF200F flanges and nipples at the end of this cylinder, with 25 mm offset. Two CF63 flanges (one fixed and one rotatable), coaxial to the beam, are welded to connect the chamber to the other parts of the X04SFE (A23, A25).

There are two flanges: one is CF100F used to connect a NEG pump (V10) through a vacuum pipe, and another is CF150 closed by a blank flange.
The two SV head system are identical, and they are similar to those of the horizontal slit SH(A22). Each of them consists of the following parts: a water-cooled copper head, a support pipe, a bellows (Standard Bellows P/N 325-225-4-EE), a CF200R flange and a plate.
The copper heads, shown in drawing 30040.26.013, are slightly different from those of the SH. The head surface tilt angle is 5°. This rectangular copper head covers half of the beam plus 4 mm. The maximum overlap between the two heads is 2 mm.
The manipulator, thermocouple and the bakeable UHV microswitches are the same as for SH.
The edges of the two copper heads must be parallel to within 0.01 mm. Three reference holes of 6 mm diameter on the top of the chamber serve for alignment purposes.
The chamber is supported by three feet. The mechanism of these feet must be able to adjust this system to a certain position within ⌖0.1 mm and to be able to fix it in that position.
Summary of main parts:
a) vacuum chamber
b) two SV head systems
c) two manipulators
d) vacuum components
e) thermocouples
f) support system

A25. Hydroformed metal bellows, CF63F/CF63R, with inner diameter 66 mm and axial length 150 mm.

A26. Vacuum pipe, CF63F/CF63R, with inner diameter 66 mm and axial length 1330 mm.

A27. Hydroformed metal bellows, CF63F/CF63R, with inner diameter 66 mm and axial length 150 mm.

A28. Vacuum chamber, CF63F/CF63R, with axial length 290 mm.
Laterally, two CF63 flanges (one fixed and one rotatable) which are coaxial with the beam, are used to connect to the other parts of the X04SFE (A27, A29).
On the top CF150F flange there is a reducing piece CF150/CF40 onto which the head of the residual gas analyzer (V11) is mounted. The bottom CF150 flange is connected to a nipple. There is a CF63 flange on the nipple, onto which a right-angle all-metal valve (V12) is mounted for connecting a roughing pump system.
There are five CF40 flanges on the chamber; they connect to:
- VAT high-vacuum sensor for a fast valve (V14)
- cold-cathode pressure gauge (V15)
- Pirani pressure gauge (V16)
- bypass circuit; the bypass circuit consists of bellows, elbows and mini gate valves (V13, V18).
- one blank flange.

A29. Plane beryllium-window, CF63, with axial length 24 mm.
This is not included in this specification, it will be sent by PSI to the supplier for final assembly.

A30. Differential pumping chamber, CF63R/CF63R, with axial length 215 mm.
The vacuum chamber is a cylinder, whose axis is vertical and perpendicular to the beam axis, of 100 mm inner diameter.
There are two CF100F flanges: the one at the bottom is used to connect an ion pump (V17) via a nipple, and the one on the top is closed by a flange through which a reducing piece connects to a cold-cathode pressure gauge (V19).
Laterally, two CF63 flanges (one fixed and one rotatable), coaxial to the beam, connect the chamber to the other parts of the X04SFE (A29, A31).
There are two CF40R flanges. Via a T-pipe CF40, one is used to connect a bypass circuit to the mini gate valves (V13, V18) on A28 and A32, respectively. The bypass, shown in drawing 30040.25.012, consist of elbows, bellows and vacuum pipes. The other CF40F flange is used to mount a thermocouple from A29.
Before evacuating with the roughing pump through the port to the valve (V11) on A28, the mini gate valve (V13, V18) must be open.

A31. Curved beryllium window, CF63, with axial length 24 mm.
This is not included in this specification; it will be sent by PSI to the supplier for final assembly.

A32. Vacuum-T, CF63R/CF63R, with axial length 157 mm.
This is a T-type vacuum component. Laterally, two CF63R flanges, coaxial to the beam, are used to connect to the other parts of the X04SFE (A31, A33).
Through a right angle elbow, a CF40F flange is connected to the mini gate valve (V18), which is on the bypass circuit.
Before evacuating through the port of valve (V12) on A28, the mini gate valve (V13, V18) must be open. In this way there is no force acting on the beryllium foils of A29 and A31 during pumping. V13 and V18 are closed when the high-vacuum is reached.

A33. UHV gate valve (VG2), pneumatic actuator, VAT series 10, DN63 CF-F, with length 70 mm.

The total axial length of X04SFE is 8081.21 mm.
The distance from the last flange of X04SFE to the middle point of the radiation source X04SID is 15800 mm.

2.1.2 Type V components

All the V type components are shown in drawing 30040.25.013.

V1. Ion Pump, Varian, VacIon Plus 300, CF150; mounted on the Pumping chamber (A6).

V2*. Non Evaporable Getter (NEG) pump, Saes Getters, CF100; mounted on the PSH (A10).

V3. Cold-cathode pressure gauge, Balzers IKR 270 DN40 CF-F; mounted on the PSH (A10).

V4. Pirani pressure gauge, Balzers, TPR260 DN16 CF-R; mounted on the PSH (A10).

V5. Ion Pump, Varian, VacIon Plus 300, CF150; mounted on the PSH (A10).

V6. Right-angle all-metal valve, VAT Series 57, DN63-CF; mounted on the PSH (A10).

V7. Ion Pump, Varian, VacIon Plus 300, CF150; mounted on the FI (A20).

V8*. Non Evaporable Getter (NEG) pump, Saes Getters, CF100; mounted on the FI (A20).

V9. Ion Pump, Varian, VacIon Plus 300, CF150; mounted on the SH (A22).

V10*. Non Evaporable Getter (NEG) pump, Saes Getters, CF100; mounted on the SV (A24).

V11*. Residual Gas Analyzer, CF38; mounted on the Vacuum chamber (A28).

V12. Right-angle all-metal valve, VAT Series 57, DN63 CF; mounted on the Vacuum chamber (A28).

V13. Mini gate valve, VAT series 01, manual actuator, DN40 CF; mounted on the Vacuum chamber (A28).

V14. Fast valve high-vacuum sensor, VAT, series 77, DN40 CF; mounted on the Vacuum chamber (A28).

V15. Cold-cathode pressure gauge, Balzers IKR 270 DN40 CF-F; mounted on the Vacuum chamber (A28).

V16. Pirani pressure gauge, Balzers, TPR260 DN16 CF-R; mounted on the Vacuum chamber (A28).

V17. Ion Pump, Varian, VacIon Plus 150, CF100. It is mounted on the Differential pumping chamber (A30).

V18. Mini gate valve, VAT series 01, manual actuator, DN40 CF; mounted on the Vacuum T (A32)

V19. Cold-cathode pressure gauge, Balzers IKR 270 DN40 CF-F; mounted on the Differential pumping chamber (A30).

* The three NEG pumps (V2, V8, V10) and the RGA (V11) will be mounted by PSI.

2.1.3 Type P components

These components constitute the pneumatic circuit, which permits the actuation of all the pneumatically-actuated components. Excluded are the pneumatic actuators mounted on A10, A11, A13, A16 and A33, which are already considered as sub-components of type A components.

PSI does not provide a detailed design of the pneumatic system of X04SFE; this is the responsibility of the supplier. The location of the pneumatic circuit main connection and the positions of each branch circuit are indicated in drawing 30040.25.014.

The functional scheme of the pneumatic system is shown in drawing 30040.25.017.

The pneumatic circuit consists of five branches which supply the pneumatic actuators of components A10, A11, A13, A16 and A33. This circuit must be connected to the main pneumatic circuit of the SLS storage ring through the connector (PC). Downstream from the connector, there is a main valve (PV), a condensation water discharger (PD) and an air treatment unit (PU), composed of a filter and a pressure switch with a pressure gauge. The condensation water discharger (PD) must be placed at the lowest point of the circuit. Two quick connectors (QC) are placed at the inlet and outlet.

In each branch there is a non-return valve (PN) and a reservoir (PR) which allow temporary operation of the components in case of pressure failure.

The pneumatic actuators are driven by means of solenoid valves. The PSH (A10) and ST (A16) actuators are driven by the five-way valves (PSV1 and PSV3). The solenoid valves are biased; in the absence of current, the solenoid valves PSV1 and PSV3 must close A10 and A16, respectively. Further downstream, the valve flow controls (PF1, PF2, PF3 and PF4) permit regulation of the opening and closing time, which must be set to 3 seconds when the components are under vacuum.

The all-metal valve (A11) and the UHV gate valve (A33) are driven by five-way valves (PSV2 and PSV4); no flow controls are required. The fast valve (A13) has its own solenoid valve, but since its working pressure is 0.5 M Pa, a pressure reducer (R) is required.

All the pneumatic components must be fixed to the same support structure as the A-type components. All tubes must be made of copper. The inner diameter of the tubes must be 8 mm. There is a long tube (FH) for extending the circuit to the outside of the SLS shielding wall; its exact length will be defined after the X04SFE is installed on site.

The system will work at 0.7 MPa pressure with the exception of the fast valve (A13), which will work at 0.5 M Pa.

FESTO pneumatic components must be used. The supplier is required to supply a list of model numbers for all the pneumatic components, together with detailed drawings of this system.

2.1.4 Type W components

These components constitute the water tubing circuit which supplies the type A cooled components (A8, A10, A20, A22, A24, A29 and A31).

PSI does not provide a detailed design of the water tubing of X04SFE; this is the responsibility of the supplier. The location of the water tubing circuit main connection and the positions of each branch circuit are indicated in drawing 30040.25.015.

The functional scheme of the water cooling system is shown in drawing 30040.25.018.

The inlet and outlet water main connectors are denoted C_{in} and C_{out}. Following the inlet connector (C_{in}) an electrically-actuated valve (G), a pressure gauge (PI) and a manual valve (VS) are placed. The valve (G) must be provided with an open/closed position microswitch (I). Before the outlet connector (C_{out}), there is a one way valve (V0) and a manual valve (VS); the end of the inlet and outlet pipes should be closed by tapped plugs.

The material of the water tubes must be stainless steel AISI 316 L; aluminum is not allowed in any component (valves, seals, etc.) of the circuit. Nitril seals must be used. All the tubes must be insulated to avoid water condensation.

The maximum inlet pressure is 1 MPa. Demineralized water will be used.

Each branch tube consists of one needle valve (V), two flexible stainless steel hoses (TF), one flow switch (FS) and one flow meter (FI) - all of these subunits are connected by the branch tube to a particular water-cooled component (A8, A10, A20, A22, A24, A29 and A31). FS and FI must be included in a single unit.

The needle valves (V) must have detachable hand-wheels.

The supplier is required to send a list of model numbers for all the water circuit components together with the detailed drawings of this system.

2.1.5 Type S components

These components support all the other components of the X04SFE.

The beam height is 1400 mm above the floor, therefore the supports must hold all the components at this height.

All the supports must be designed in such a way that they are able to position the components with travel in all directions of ±25 mm. Angular adjustments of ±2° must be possible.

All the supports must be highly stable; if a lateral load of 3000 N is applied, the supported components should not move more than 1-2 mm. All resonant frequencies of the loaded supports must be higher than 50 Hz. All the components must be attached to the support such that the vacuum forces cannot overload the bellows or move the components by more than 0.1 mm. The support must allow the disassembly of each component without the necessity of moving the others.

The supports must be made of steel; therefore surface painting is required. Each part must be painted with at least one primer and one high-grade coat of paint. The paint should be insoluble in acetone. The color will be bright violet. No painting is allowed on machined surfaces or stainless steel parts.

When all the X04SFE components are assembled, it must be possible to move all the S components in three individual modules with a crane; the supplier must provide suitable eyebolts.

Under each ion pump there is an adjustable mechanism. It will hold the pump in the normal working position, and it can be lowered and separated from the pump during the dismounting and mounting procedures.

The support system of X04SFE consists of 3 main modules (S1, S2, S3), 1 pump support (S4) and 5 pipe supports (S5). All of these should be fixed to the floor by bolts.

PSI does not provide detailed drawings of these supports; these must be made by the supplier and approved by the PSI.

In drawing 30040.25.016, the maximum dimensions of these supports are given.

S1 Support: approximate axial length 1700 mm. This component must support A8, A10, A12, A15 and A16. It must be possible to move with a crane the overall support with all the components mounted on it; it must be possible to move or replace each component and to align it with respect to the others.

There are four holes of 6 mm diameter on the top plate of the support to serve as reference points.

There are two groups of feet: three adjustable feet and two fixed feet.

The adjustable feet are attached to the floor by bolts. Using them, the support can be easily moved and fixed into position. The fixed feet are lowered down only after the S1 reaches its final position.

S2 Support: approximate axial length 1700 mm. This component must support A20, A22, A24, and must be fixed to the floor by bolts. It has the same requirements as those for S1. Since A22 and A24 must be adjusted with high accuracy, special mountings must be used.

There are two groups of feet: three adjustable feet and three fixed feet. They are the same types as described for S1.

S3 Support: approximate axial length 900 mm. This component must support A26, A28, A30, A32, A33 and the components of the bypass circuit: it must be fixed to the floor by bolts. It has the same requirements as for S1.

There are three adjustable feet. They are the same type as described for S1.

S4 Support: This is used to support the ion pump on A6.

S5 Supports: These are universal supports to individually hold A3, A5 A19, A26 and other units yet to be specified. The supported pipe diameter can vary from 35 to 80 mm.

The supports must have two directional adjustments, both perpendicular to the beam axis: ±20 mm in the vertical direction and ±15 mm in the horizontal direction.

2.2 X04SFE systems

2.2.1 Electrical system

All the vacuum instruments (such as the Pirani and cold-cathode gauges, ion pumps, etc.), motors and encoders will be connected directly to their controllers. All their cables are not objects of these specifications. PSI will provide a special set of cables for test purposes.
The bake-out heating elements, the thermocouples and the valves must be wired by the supplier.
All the metallic parts of the frame must be grounded.
Cable trays (cross-section: 200 mm x 100 mm) on the supports are requested.
The locations of cable trays and the positions for connection boxes must be approved by PSI.

2.2.2 Bake-out system

The bake-out system design is requested from the supplier. This system should be mounted in such a way that the following conditions are satisfied:
- the heaters must be strip heaters and flange heaters;
- it must be divided into a maximum 8 zones; each zone must have a K-type thermocouple and draw a maximum power of 1 kW from 220V 50 Hz;
- the maximum power should not exceed 8 kW;
- all the thermocouples used for the bake-out must be reliably fixed to the components and be easily disassembled;
- all the heaters and the thermocouples must be identified by a thermally-resistant labeling system;
- all the heaters must be covered by thermal insulation material.

The bake-out procedure will use heaters, flange heaters (CF flanges and blankets), K-type thermocouples and thermal insulation material. The temperature controllers will be supplied by PSI. Glass fiber insulation material must be avoided in this system.
The location of power connectors and the positions of thermocouples must be approved by PSI.

2.2.3 Pneumatic system

See section 2.1.3 of this specification.

2.2.4 Water cooling system

See section 2.1.4 of this specification.

2.3 Alignment and assembly

The alignment must be done by conventional mechanical and optical instruments.

2.3.1 Alignment of individual components

a) PSH assembly:

The PSH copper head center must be in the center of PSH chamber, and its tilt angle with respect to the center axis of the chamber must be 3°.

c) ST assembly:

The ST head must be at the center of ST chamber when in the lowered position.

d) SH assembly:

The tilt angle with respect to the horizontal axis of the chamber for each slit head must be 10° with respect to the center line. The two edges of two copper heads must be parallel to one another within 0.01 mm.

e) SV assembly:

The tilt angle with respect to the horizontal axis of the chamber for each slit head must be 5° with respect to the center line. The two edges of two copper heads must be parallel to one another within 0.01 mm.

f) Two Be-window assemblies:

The two beryllium windows (A29, A31) must be well-aligned when connected to the Differential pumping chamber (A30).

There are three reference holes outside of the chambers of the above components. The relative positions of the inner parts and the reference holes must be recorded in an alignment protocol for each module.

2.3.2 Module alignment and assembly

There are four reference points on the top plate for each support. Each component must be positioned according to the two reference holes on the component with respect to the four reference points on the support. The relative positions between them must be recorded in an alignment protocol. The flanges of the A-type components coaxial to the beam must be positioned to within 1 mm with respect to the beam axis. The edges of SH must be perpendicular to the edges of SV.

After DI (A8) and the chamber of PSH (A9) are connected together through a bellows, the lower position of the PSH copper head center must be adjusted to the center of the aperture of DI, and its tilt angle with respect to the center axis of the aperture of DI must be 3°.

2.3.3 Alignment and installation on site

The final alignment on site will be done by the PSI surveying group, and it is therefore not included in the quotation. The SLS alignment network should be used to install the three modules into position. Before the three modules are connected together, the alignment of the critical components DI (A8), PSH (A10), ST(A16), FI (A20), SH (A22) and SV (A24) must be rechecked.

3. Scope of Supply

3.1 X04SFE

The X04SFE, as defined in the section 2 of this specification, will be delivered to PSI. It must be fully tested and aligned and must include the bake-out, water-cooling and pneumatic systems.

3.2 Time schedule

The supplier will provide a detailed time and manpower plan for all the work in this specification within three weeks of placing the contract. The manpower plan will include and specify the key personnel concerned with this contract.

3.3 Drawings

The supplier will produce all the drawings which are necessary to manufacture each component and to assemble and align the complete X04SFE as required in this specification, including drawings of tools and temporary fixtures.

All the drawings will be sent to PSI as soon as they are available. The PSI will require approximately four weeks to check the drawings. This check is needed to verify the compatibility of the drawings with the specification, and the manufacturing of the components can only begin after completion of this check. The PSI will then take possession of all the drawings and will be free to use them to manufacture items elsewhere.

All the drawings must be classified according to the PSI classification system, which will be provided by PSI within two weeks after the contract is placed. Printed copies of the complete final drawings, together with the drawing list, must be sent to PSI at the latest one month after delivery of X04SFE.

CAD drawings are required; the supplier is asked to give to PSI floppy disks with the main drawings in DWG (Autocad ver.13 or higher) or DXF format. The PSI will provide an example of the standardized Autocad format of the drawings. The CAD drawings in electronic form must be sent to PSI together with the printed drawings.

3.4 Tools and temporary fixtures

The supplier will provide the PSI with a list of all tools and jigs required during the manufacture of X04SFE, together with drawings and descriptions of these items. After completion of the contract, the PSI will take possession of them.

3.5 Certificates and reports

The following material certificates must be provided by the supplier:

-AISI 316LN-ESR

-Copper OFHC

-Tungsten

The following set of inspection documents is required at the end of the contract:

- reports of leak test, accuracy test and vacuum test
- records of bake-out temperature, brazing process and alignment reference

-the system assembling and disassembling procedure

- technical documents concerning components purchased by the contractor

4. Standardization

4.1 Flanges and fittings

All the flanges and the gaskets must be Conflat (CF) type.
If not otherwise specified, vacuum chambers and pipes must be made of stainless steel AISI 304L, the flanges must be made of AISI 316LN-ESR, and the gaskets must be made of OFHC copper. The manufacturer must be approved by PSI; PSI reserves the right to require machining drawings for each type of flange, together with a material quality-control certificate, including chemical analysis, mechanical properties and iron content. Each flange must be stamped with the name of the producer and the material used.
All the A-type components have two flanges coaxial to the beam axis. If not otherwise specified, the beam-inlet flange must be rotatable and the beam-outlet flange fixed. Other rotatable flanges can be inserted whenever necessary.
Unless otherwise specified, the standard stainless steel bolts used for the final flange assembly shall be A4-80 Class, according to the UNI 7323 or similar standard; hexagon screw heads are requested for these bolts.
All the bolts must be silver-plated, according to UNI ISO 4521.
Bellows other than the types suggested by PSI may be used only after the approval of PSI.
In any case, bellows must never be handled without clean gloves (on both the inner and in the outer surfaces); particular care must be taken in order to avoid that machining chips or dust fall inside the bellows. Particular care must be taken during assembly to assure that they are never forced by axial torque.

4.2 Vacuum pipes and free length

The following dimensions are suggested for the standard pipe:
When the outside diameter (OD) is smaller than 100 mm, the pipes cannot be welded.
-OD 19.00 with wall thickness 1.50 mm
-OD 42.40 with wall thickness 1.60 mm
-OD 70.00 with wall thickness 2.00 mm
When the outside diameter (OD) is larger than 100 mm, the pipes can be welded.
-OD 108.00 with wall thickness 2.90 mm
-OD 156.00 with wall thickness 3.00 mm
-OD 206.00 with wall thickness 3.00 mm
-OD 256.00 with wall thickness 3.00 mm
-OD 306.00 with wall thickness 3.00 mm

The free length is the length of pipe which is welded to the flange to provide space to connect the flanges. The following dimensions are suggested to use in most cases:

-CF16	30 mm
-CF40	45 mm
-CF63	60 mm
-CF100	65 mm
-CF150	65 mm
-CF200	70 mm
-CF250	70 mm

4.3 Microswitches

All the microswitches must be bakeable types; PSI suggests to use the products of Caburn UHV, Lewes, UK : model VH5LR for external use and model VH3 for internal use.

4.4 Thermocouples

All the thermocouples are of the K-type. PSI will suply them with a diameter of 1 mm.

4.5 Identification mark

With the exception of the valves, bellows and reducing pieces, it is required that the supplier provides type-A components with an identification mark made on a stainless steel label by chemical etching or electroengraving.

The orientation of the marking must be such that it remains visible after assembly. The marking caption will be communicated by PSI to the contractor after placement of the order.

5. Inspection and Tests

All components must undergo a check of all the dimensions on the drawings, and all tolerances on the drawings must be fulfilled.

Two weeks before each test, a document with a description of the test procedure must be presented to PSI for approval. This document should describe in detail:
-test procedure followed
-time schedule of the tests
-location where the test will be performed
-instruments to be used
-list of personnel involved in the tests and their tasks
-schematic drawings of the test set-up

The following tests must be performed by the supplier:

a) Leak test and vacuum test:
as described in UHV Materials and Technologies for SLS Front End and Beamline, SLS-TME-TA-1998-0014;

b) Alignment check:
as described in section 2;

c) Accuracy test:
Accuracy tests of the SH (A22) and the SV (A24) manipulators must be performed under vacuum load according to the following procedure (displacement-resolution measurement): the specified resolution must be verified at 10 different points of the overall travel, approximately equally-spaced. It is the responsibility of the supplier to choose the proper instrumentation to perform these tests.
The accuracy test of the PSH (A10) manipulator must also be performed under vacuum load. The copper head must reach the lower position with a repeatability of $\pm$ 0.2 mm.
The supplier is required to propose and perform the tests needed to verify the fulfillment of all the requirements concerning the mounting accuracy of all components and their alignment tolerances on the frame.

d) Functional test:
It must be verified that the Diaphragm aperture will be completely occluded when the PSH (A10) is in the lower position and will be completely free when in the upper position.
The same check must be performed for the ST (A16).

e) Welding and Brazing quality check:
The copper heads for DI (A8), PSH (A10), SH (A22), and SV (A24) are brazed components, and they must be carefully checked before the support pipe is closed. A test with water circulating inside them under a water pressure 1 M Pa and flow rate 0.2 Kg/s must be made without leakage.
The specification for the brazing process must be proposed by the contractor for PSI approval. The execution of the brazing process is entirely the responsibility of the contractor.

6. Packing and Delivery

The supplier is required to take responsibility for packing and transportation of the entire X04SFE to the SLS site at PSI. The X04SFE must be equipped with blank flanges and filled with dry nitrogen. All modules must be equipped with properly-shaped covers to prevent the X04SFE from being contaminated with dust, water, etc. The handling and transportation jig must be perfectly clean and degreased. Wherever necessary, components must be covered with adequate protection. Adequate packing and protection must be provided to prevent damage during transportation. The X04SFE (with and without its packaging) must be transportable by crane.

The following is to be displayed clearly on the outside of the packaging:
-addressed to SLS/PSI CH-5232 Villigen, Switzerland
-the PSI contract number
-the weight of the loaded package
-support points for transport and lifting

7. Quality assurance requirements

PSI prefers that manufacturers are registered to comply with ISO 9001 or an equivalent national standard.
The requirements of PSI for quality assurance are stipulated in the specification ESRF/ENG/89/02 "Quality assurance requirements".

Control visits by PSI representatives must be possible, as described in the supply contract.
In addition, a mandatory control will be carried out at the following points:
-during bake-out and vacuum tests
-during the accuracy and functional test
-before the final assembly
In order to schedule such inspections, it is required that PSI receive announcements of such events with two weeks advance notice.

8. Drawings and Components supplied by PSI

8.1 List of annexed drawings

1/	30040.25.011	General layout
2/	30040.25.012	Axial component layout
3/	30040.25.013	Vacuum component layout
4/	30040.25.014	Pneumatic system layout
5/	30040.25.015	Water tubing circuit layout
6/	30040.25.016	Support component layout
7/	30040.25.017	The functional scheme of the pneumatic system
8/	30040.25.018	The functional scheme of the water tubing system
9/	30040.26.001	Diaphragm assembly
10/	30040.26.002	Photon shutter assembly
11/	30040.26.003	Photon shutter head
12/	30040.26.005	Beam stopper assembly
13/	30040.26.006	Beam stopper head
14/	30040.26.007	Filter chamber
15/	30040.26.010	Horizontal slit assembly
16/	30040.26.011	Horizontal slit head
17/	30040.26.012	Vertical slit assembly
18/	30040.26.013	Vertical slit head
19/	30040.26.020	Photon shutter head box
20/	30040.26.021	Photon shutter head cover
21/	30040.26.022	Photon shutter head pipes and plate
22/	30040.26.023	Photon shutter pipe for thermocouple
23/	30040.26.036	Photon shutter head box and cover

8.2 List of components supplied by PSI

-Plane beryllium -window	1 piece
-Curved beryllium-window	1 piece
-Balzers IKR270 DN40 CF-F Cold-cathode pressure gauge	3 pieces
-Balzers TPR260 DN16 CF-R Pirani pressure gauge	2 pieces
-Varian VacIon Plus 300 l/s ion pump	4 pieces
-Varian VacIon Plus 150 l/s ion pump	1 piece
-VAT series 48, DN40 CF-F, pneumatically actuated, all-metal gate valve	1 piece
-VAT series 10, DN63 CF-F, pneumatically actuated, UHV gate valve	1 piece
-VAT series 57, DN63 CF, manually actuated, right-angle all-metal valve	2 pieces
-VAT series 77, DN40 CF-F, fast valve high-vacuum sensor	1 piece
-VAT series 77, DN40 CF-F, fast valve	1 piece
-VAT series 01, DN40 CF-F, manually actuated, mini gate valve	3 pieces
-motors	4 pieces
-encoders	4 pieces
-K-type thermocouples	17 pieces

9.3 List of components supplied by PSI for test purposes

-Balzers pressure gauge controller
-Varian ion pump controller
-bake-out controller
-motor controller
-encoder display
-a set of test cables