INDEX OF SPECIFIC TECHNICAL PRESCRIPTIONS FOR THE DRAWINGS AND MANUFACTURE OF THREE WIRE SCANERS FOR THE ESS MEBT

MEBT-BI-WS90-05

Content of the document

1 Object

The purpose of this document is to define the technical and functional characteristics of three Wire Scanners together with their actuators and a Wires Alignment Toolkit, which must be delivered by the contractor. These three Wire Scanners are part of the MEBT that ESS-Bilbao will deliver as part of the "in-kind" contribution to the European Spallation Source project.

ESS Bilbao will deliver the complete 3D model, which should be taken as the final conceptual model from which the contractor should make the tolerance adjustments and the fabrication blueprints before launching the fabrication itself. Both Wire Scanners and Actuators have the same geometry in the three cases. Any modification the contractor needs to make in the design in order to comply with the requirements and functionality of the instrument must be consulted and approved by ESS-Bilbao.

This document includes the following list of tasks to be carried out by the contractor:

- Realization of the fabrication blueprints of all the pieces present in the 3D model.
- Study of manufacturing procedures based on the specification given on this document.
- Procurement and supply of all materials
- Machining and manufacturing of all the components.
- Realization of all the measurements and tests to ensure compliance with the specifications.
- The guarantee of the geometrical conformity of the components following the specifications.
- Cabling in and out vacuum.
- Cleaning and storage according to specifications.
- Packing and shipping to ESS-Bilbao facilities.
- Complete manufacturing documentation and verifications including complete metrology reports.

2 Technical requirements

ESS-Bilbao is responsible for the final conceptual design of Wire Scanners, Actuators and Wires Alignment Toolkit and will provide the 3D files for all the components. The contractor will be responsible for the tolerance adjustment of the final 3D model, for the slight modifications needed to made when necessary in the conceptual design to reach the final 3D model to mechanize fulfilling the functionality of the instrument and for defining the manufacturing requirements to fulfil the specifications. The contractor will be also responsible for the definition and application of the necessary controls to ensure a quality assurance plan during the fabrication. **Once the instrument has been machined and assembled the contractor should assure the positioning of the wires according with the specifications described on section 2.2** Specifications**.**

2.1 Wire Scanner Instrument

Wire Scanners have been successfully used since decade in accelerators like a choice for beam profile measurement. Their principle consists in moving a wire across the beam pipe while measuring the current signal inducing into it. This signal is proportional to the numbers of beam particles interacting with the wire. Three wire scanners will be installed on the MEBT.

The figure 1 shows a scheme or this functionality as well as the different parts of the system.

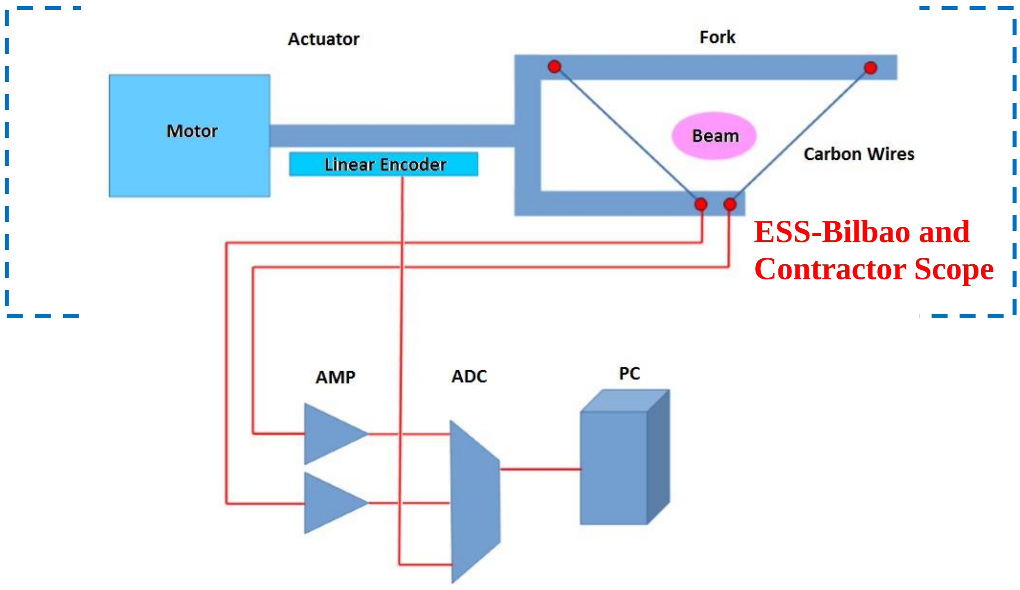

Figure 1: Wire Scanner components

2.2 Specifications

A collection of the mechanical error between the different mechanical parts is shown in Figure 2. The description of all this errors is shown on Table 1 as well as the responsibility.

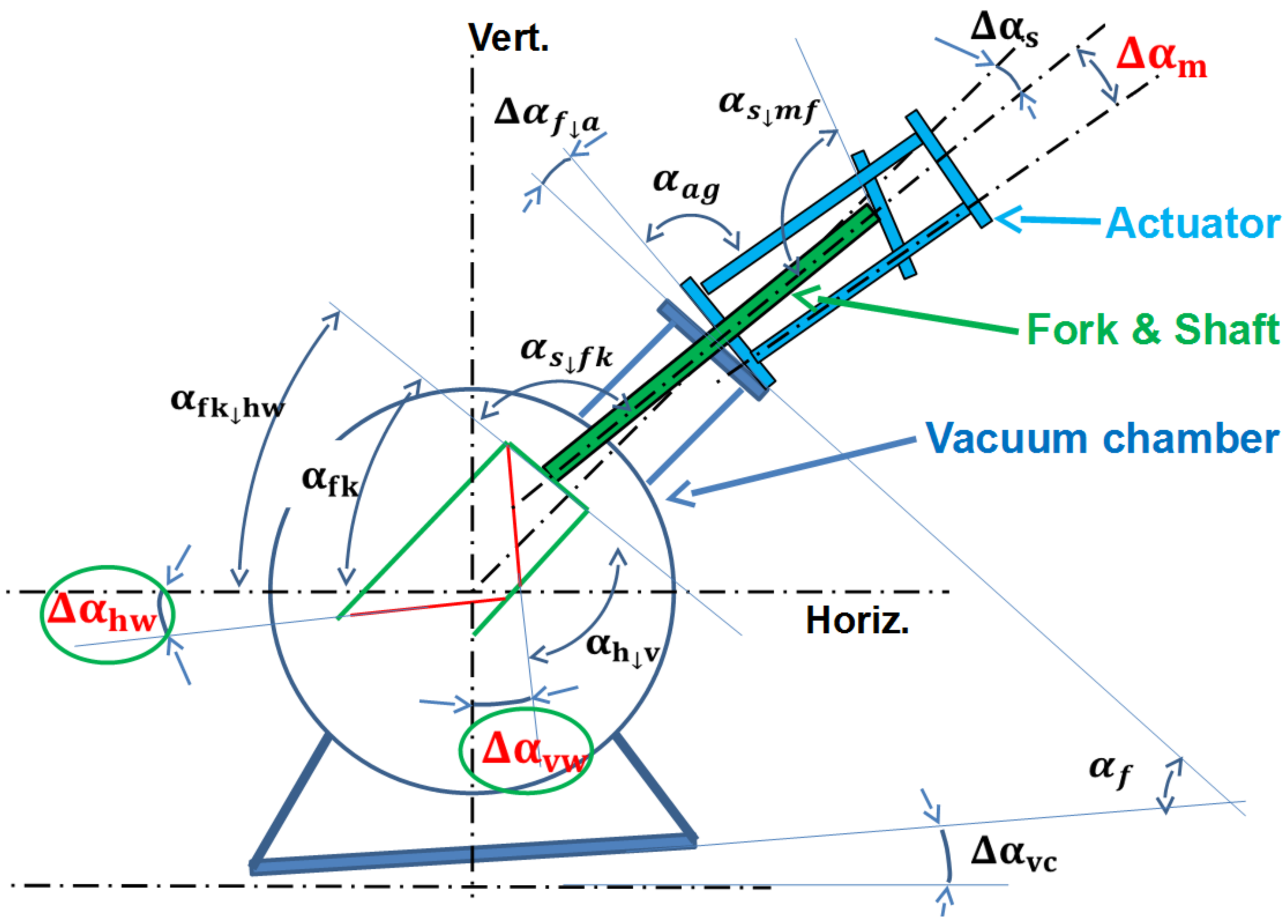

Figure 2: Angular Error Budget

Table 1: Error descriptions and responsabilities

Error	Description	Responsible
$\Delta\alpha_{vc}$	Angular error between the vacuum chamber horizontal reference and the horizontal plane.	ESS-Bilbao
$\Delta\alpha_{f}$	Angular error between the flange and the horizontal reference of the vacuum chamber.	ESS-Bilbao
$\Delta\alpha_{fa}$	Error induced by machining flatness between the flange and the actuator connection.	ESS-Bilbao
$\Delta\alpha_{ag}$	Angular error between actuator guides and fix actuator flange.	Contractor
$\Delta\alpha_{m}$ (*)	Motion direction angular error.	Contractor + ESS-Bilbao
$\Delta\alpha_{smf}$	Angular error between shaft and movable flange of the actuator.	Contractor
$\Delta\alpha_{s}$ (*)	Shaft orientation error.	Contractor
$\Delta\alpha_{sfk}$	Perpendicularity between fork and shaft.	Contractor
$\Delta\alpha_{fk}$ (*)	Resulting angular error between the fork reference and the horizontal plane.	Contractor
$\Delta\alpha_{fkhw}$	Angular error between the fork reference and the horizontal wire.	Contractor
$\Delta\alpha_{hw}$ (*)	Horizontal Wire angular error.	Contractor
$\Delta\alpha_{hv}$	Angular error between the horizontal and vertical wire.	Contractor
$\Delta\alpha_{vw}$ (*)	Vertical Wire angular error.	Contractor

All the error marked with a (*) on the Table 1 are calculated based on the summations of all the previous errors. The equations are:

$$\Delta\alpha_{m} = \Delta\alpha_{vc} + \Delta\alpha_{f} + \Delta\alpha_{fa} + \Delta\alpha_{ag} \quad (1)$$

$$\Delta\alpha_{s} = \Delta\alpha_{m} + \Delta\alpha_{smf} \quad (2)$$

$$\Delta\alpha_{fk} = \Delta\alpha_{s} + \Delta\alpha_{sfk} \quad (3)$$

$$\Delta\alpha_{hw} = \Delta\alpha_{fk} + \Delta\alpha_{fkhw} \quad (4)$$

$$\Delta\alpha_{vw} = \Delta\alpha_{hw} + \Delta\alpha_{hv} \quad (5)$$

Considering the previous information, **the contractor will be responsible of fulfil a Horizontal and Vertical Wire angular error of no more than 15 mrad between the relative position of wires and actuator flange.**

2.3 Mechanical description

A picture of the whole system is shown in Figure 3. The main components of the system are Wire Scanner and Actuator. Due to space limitations with the integration of all the instruments in the MEBT the dimensions of this device should be restricted to a projection volume of a surface of 100 to 140 millimetres.

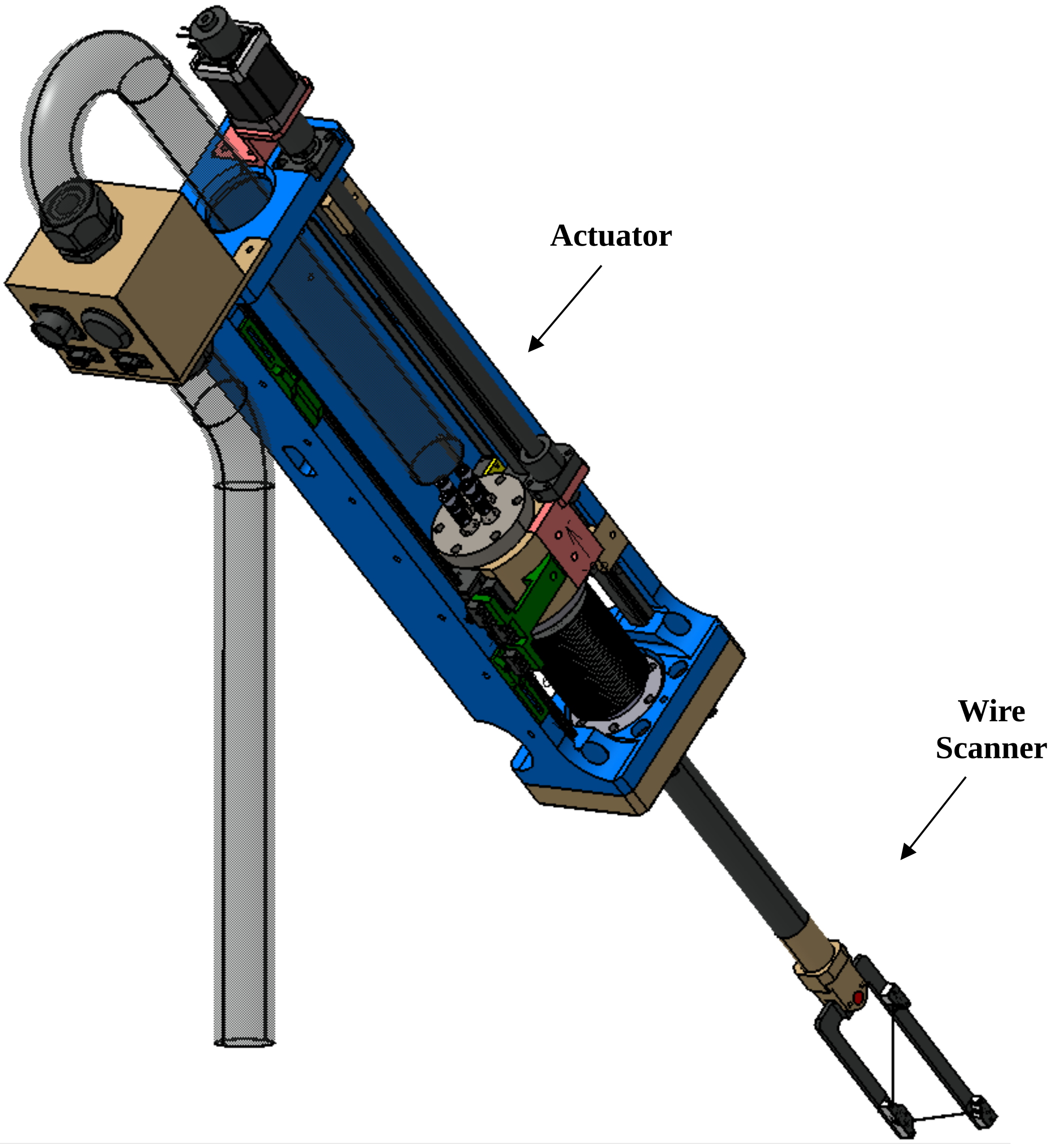

Figure 3: Actuator and Wire Scanner mechanical design

2.3.1 Wire Scanner

A picture of the Wire Scanner is shown in Figure 4.

The main components of the Wire Scanner are:

- A) Carbon Wires
- B) Carbon Wires Holders
- C) Fork
- D) Alignment System
- E) Shaft
- F) Shaft Holding Piece

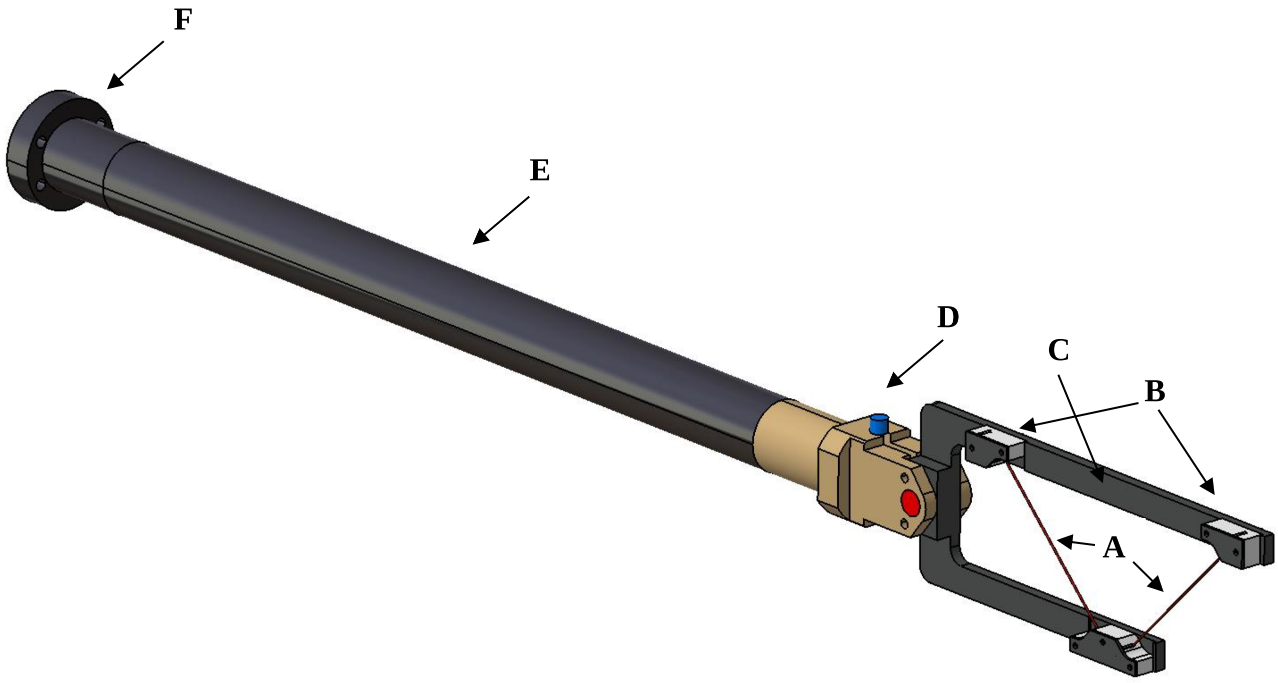

Figure 4: Wire Scanner Mechanical design

The carbon wires should be placed with an angle of 90º between them. This wires will be used to measure the vertical and horizontal transverse beam profile. The wires need to be placed with a mechanical tension to keep the straight shape during the operation. To keep this tension the wire is fixed mechanically in the Carbon Wires Supports. A detailed view of the Carbon Wires Holders is shown in Figure 5.

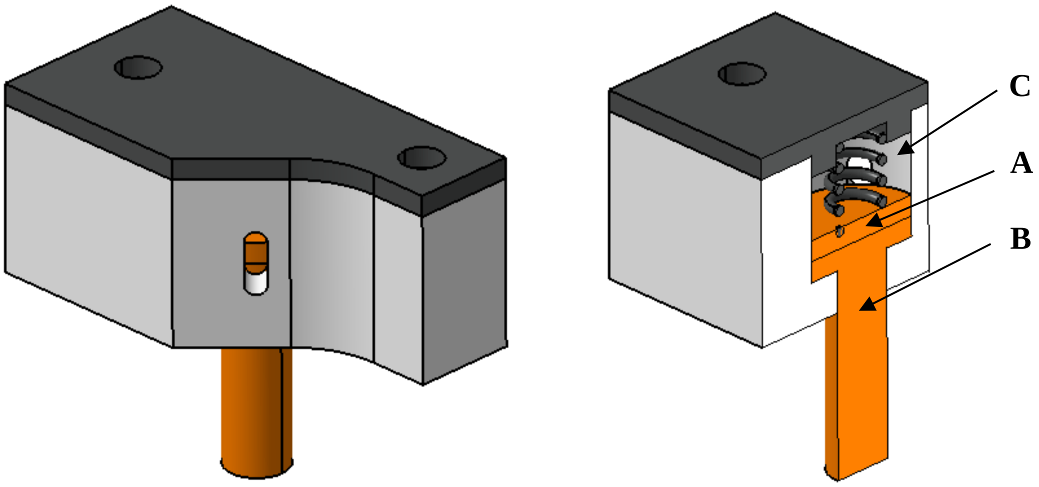

Figure 5: Carbon Wires holders mechanical design

The carbon wire is fixed between the copper pieces A and B with a mechanical tension given by the compression of the spring C. The current signal acquiring by the wire is measured through the copper pin B.

The Carbon Wires supports are holding in position by the Fork. A detailed view of the fork is shown in Figure 6. The main parts of the Fork are the mechanization to hold the Carbon Wire Supports (A) and the precision hole used to insert a precision pin to be used like a rotation axis by the Aligment System (B).

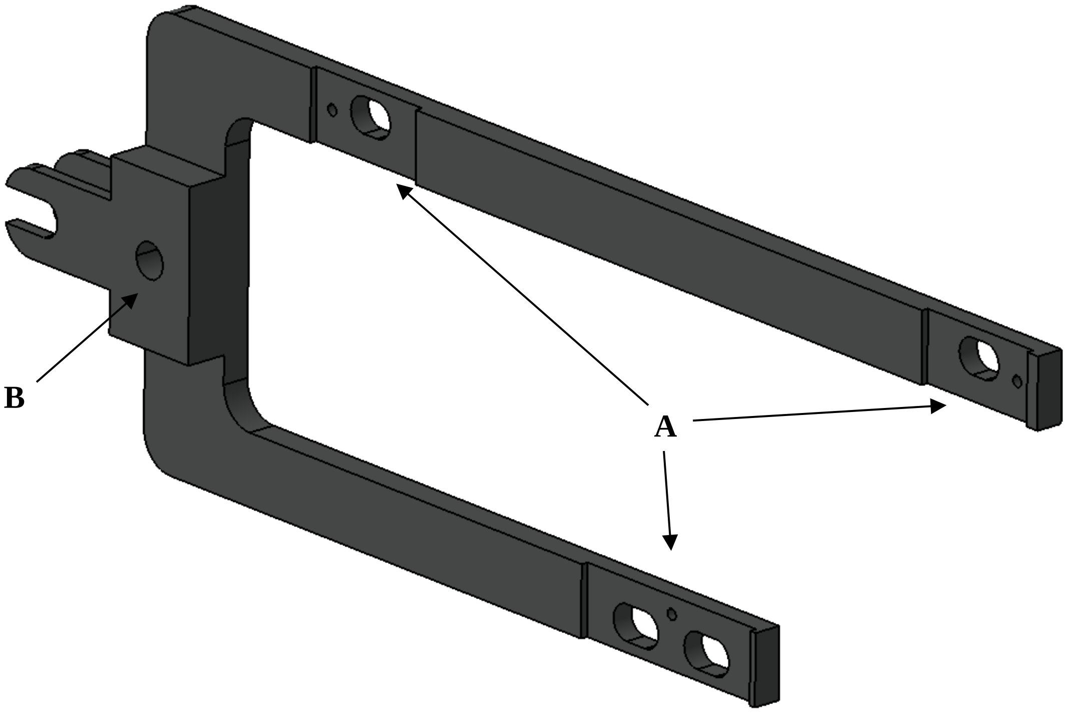

Figure 6: Fork mechanical design

A detailed view of the Alignment System is shown in Figure 7. The whole fork could be rotated with this system to compensate possible misalignment due to the fabrication or the assembly process. The rotation axis is given by a precision pin (A) and the alignment is driven by a screw (B). When the screw (B) is rotated clockwise the guide (C) is displaced to the up direction, rotating the fork also clockwise with a rotation axis given by the precision pin (A).

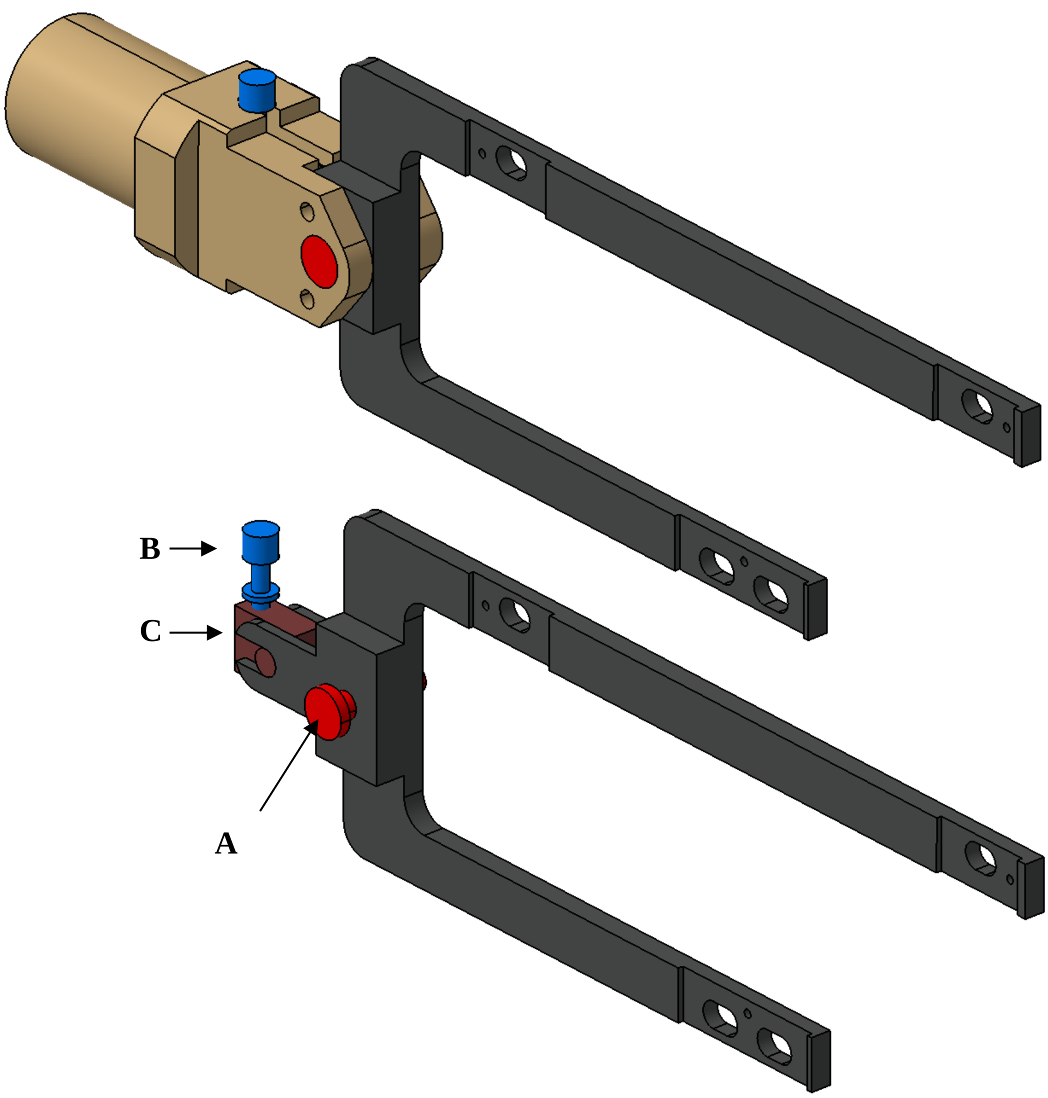

Figure 7: Alignment System mechanical design

A detailed view of the shaft is shown in Figure 8. The shaft should be hollow to place the signal cables through it. The shaft should be welded to the alignment system in one side and to the holding piece in the other side. The welded should guarantee the relative position of all the components to fulfil the horizontal and vertical wire angular error.

Figure 8: Shaft mechanical design

A detailed view of the holding piece is shown in Figure 9. This piece has a pattern (A) with four screws to fix the wire scanner to the actuator. These four holes should be threaded. A circular shape (B) is also machined in this piece to have only one possible position of fixation.

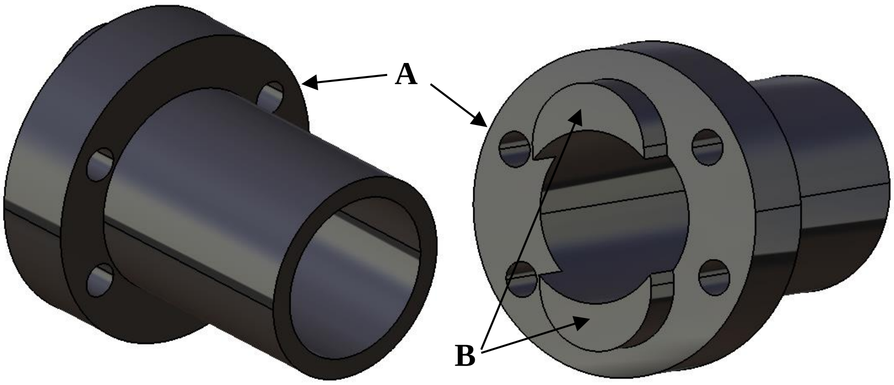

Figure 9: Shaft Holding Piece mechanical design

2.3.2 Actuator

A picture of the Actuator is shown in Figure 10.

The main component of the Actuator are:

- A) Rectangular Flange
- B) Bellow
- C) Guides Support
- D) Shaft Support
- E) Spindle Support
- F) Vacuum Feedthrough
- G) Linear Guides
- H) Spindle
- I) Travel Limit Switches
- J) MPS Limit Switch
- K) Limit Switches support
- L) Limit Switch triggers
- M) Motor
- N) Break
- O) Linear Encoder
- P) Patch Panel
- Q) Cables protections
- R) Mechanical Limits

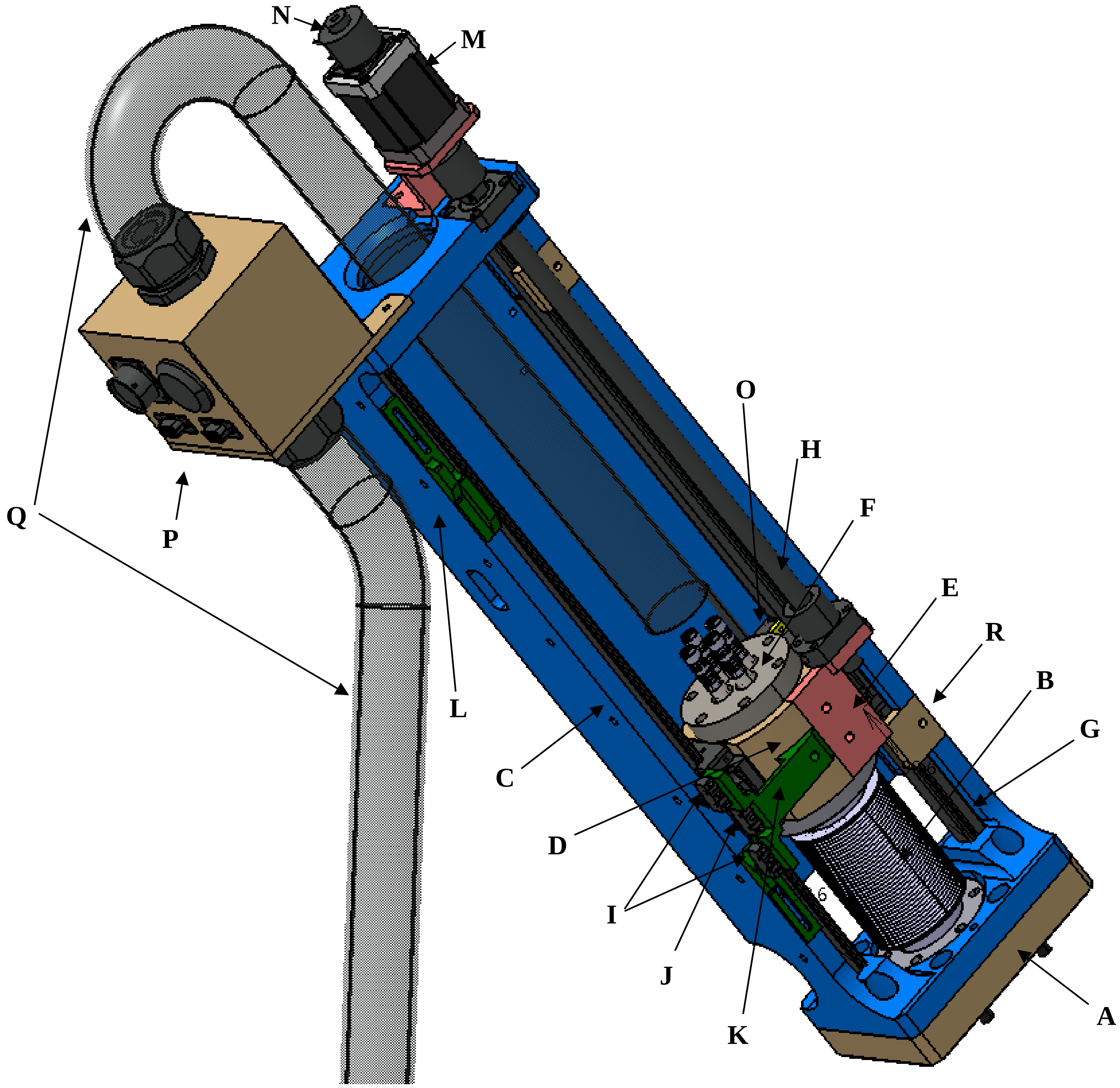

Figure 10: Actuator mechanical design

The actuator should have a total axial stroke of 240mm. Two limit switches should be placed in the travel limits to indicate the reaching to the final or initial position (I). An additional limit switch (J) should be placed in the beginning of the travel to have an indication of the wire scanner insertion. This last limit switch will be used by Machine Protection System purposes. The limit switches position and functionality is described in Annex IV. A pair of mechanical limits (R) should be used to protect the integrity of the instrument in case of a failure of the travel limit switches. The bellow (B) is fixed between the rectangular flange (A) and the shaft support (D). The movement of the shaft support is driven by two linear guides (G) placed one in front of the other.

A detailed view of the rectangular flange is shown on Figure 11. This piece has four different screw patterns. The first one (A) is to fix the Guides Support to the Rectangular Flange, the second one (B) is to fix the Rectangular Flange to the Vacuum Vessel, the third one (C) is to fix the Bellow to the Rectangular Flange and the last one (D) is to insert two precision pins to have a reproducibility in the actuator positioning. In the centre of the piece a **CF40 vacuum knife** should be machined in order to close vacuum between the Rectangular Flange and the Bellow. The dimension of the CF40 vacuum knife should be checked with the standard[1], the dimensions including in the 3D model can be considered as a guidance.

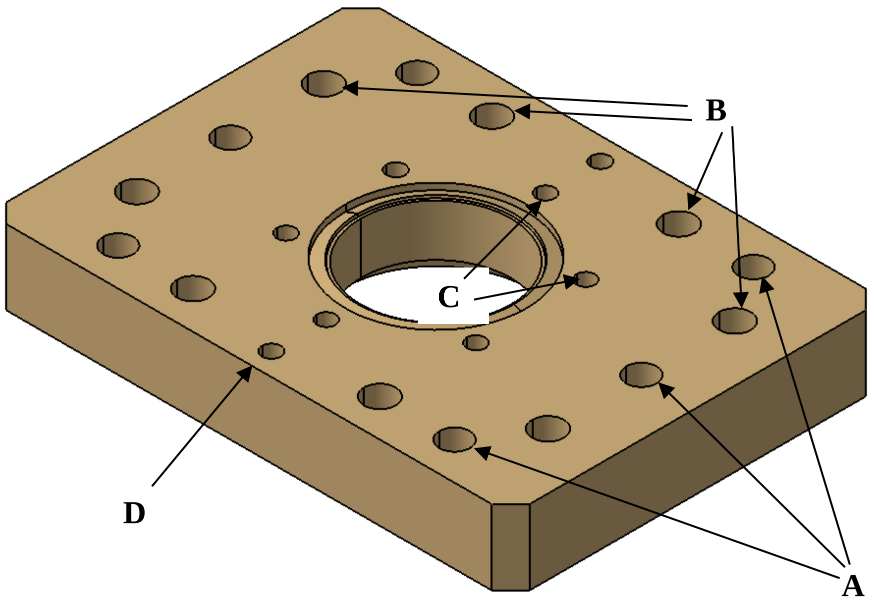

Figure 11: Rectangular Flange mechanical design

[1] ISO/TS 3669-2:2007(E)

A detailed view of the Guide Support is shown in Figure 12. The objective of this piece is to support the linear guides with rigidity and precision. To assure the proper assembly of the linear guides a surface (A) should be grinding during the fabrication to have a good mechanical precision reference to be used during the linear guides assembly. Two precision holes (B) should be machined in the bottom part of the piece to assure the repeatability during the assembly.

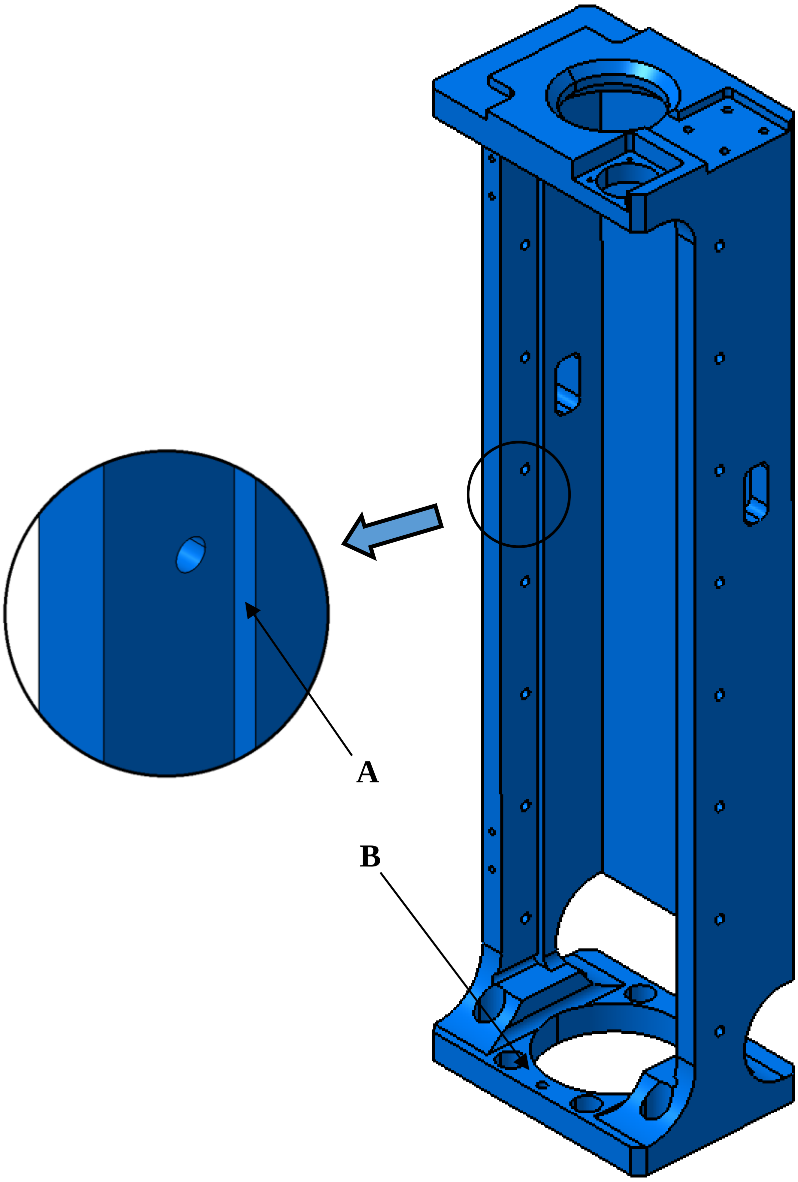

Figure 12: Guides Support mechanical design

A detailed view of the shaft support is shown in Figure 13. On both sides of the piece a pattern of four holes (A) should be mechanized to fix this piece to the linear guides. In the front side of the piece two patterns of one (B) and two (C) holes should be mechanized to fix the Limit Switches Support and the Spindle Support respectively. On the rear side, a mechanization should be done to place the encoder in position (D). Finally, on the top and bottom faces a **CF40 vacuum knife** should be machined to close vacuum between Shaft Support and Bellow in one side and between Shaft Support and Vacuum Feedthrough on the other side. The dimension of the CF40 vacuum knife should be checked with the standard[2], the dimensions including in the 3D model are a guidance.

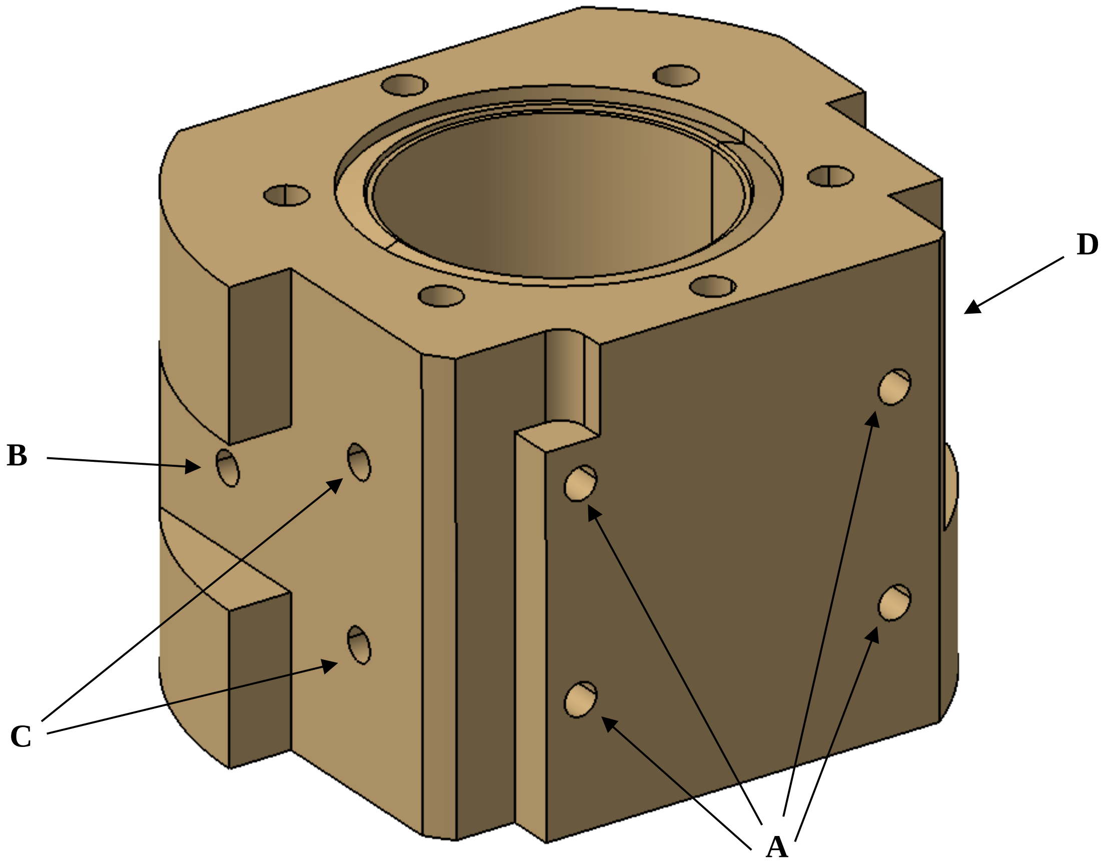

Figure 13:Shaft Support mechanical design

[2] ISO/TS 3669-2:2007(E)

2.3.3 Wires Alignment Tool

A picture of the Wires Alignment Tool is shown in Figure 14. The main functionality of this tool is to guarantee the positioning of the wires with precision enough to fulfil the Horizontal and Vertical Wires Angular Error specification described on 2.2 Specifications. The wires should be placed with an angle of 90 degrees between each other.

The main component of the are:

- A) Wires Alignment Tool Frame
- B) Alignment Rollers
- C) Tension Rollers
- D) Wire Holders
- E) Fork Clampers

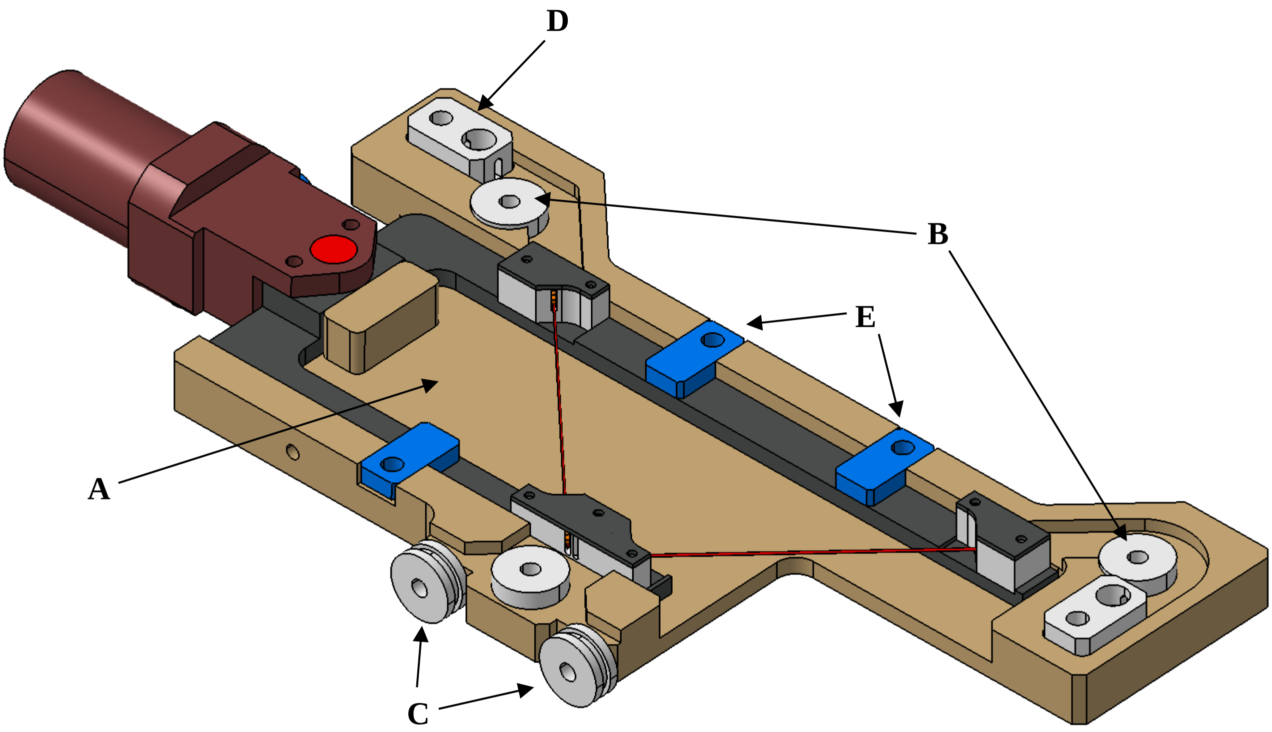

Figure 14: Wires Alignment Tool mechanical design

A detailed view of the Wires Alignment Tool Frame is shown in Figure 15. Two faces, horizontal (A) and vertical (B) should be machined with precision to be used like the referenced planes in the assemble between Fork and Wires Alignment Tool.

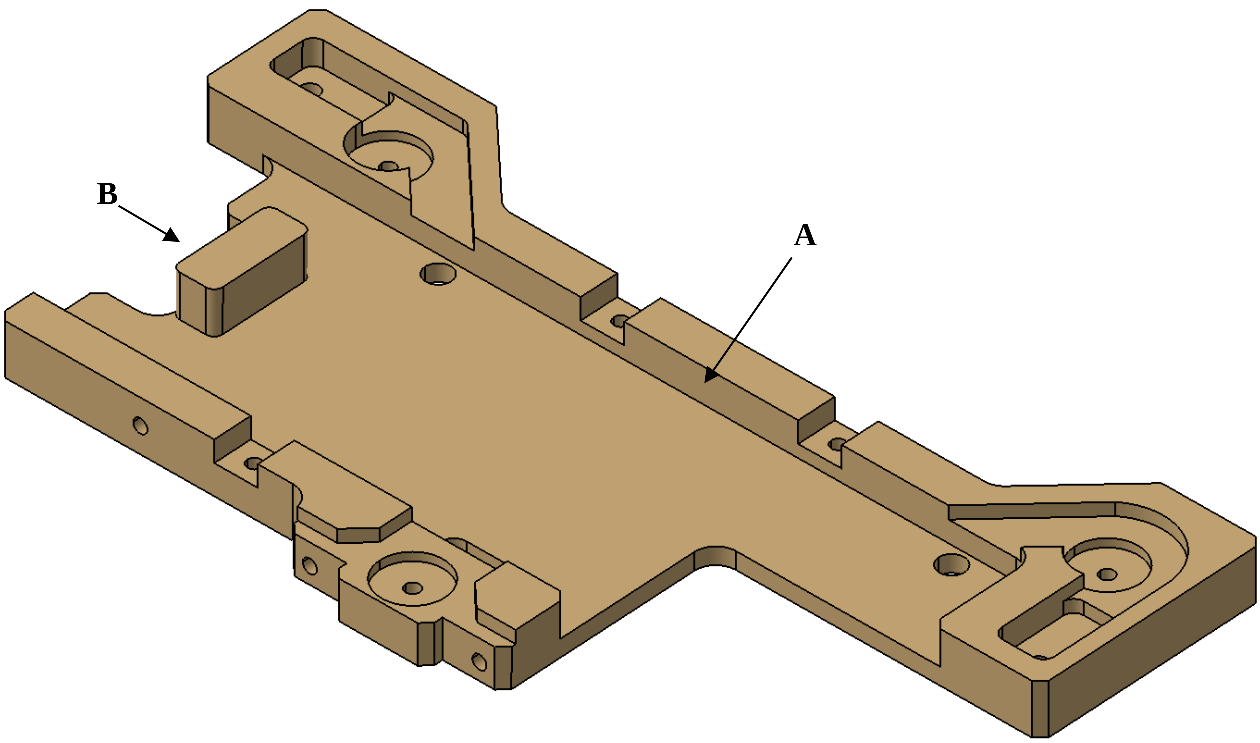

Figure 15: Wires Alignment Tool Frame mechanical design

2.4 Cabling

The cabling path between the fork connectors to the patch panel passing through the vacuum feedthrough is described in this section. All the commercial parts related with the cabling already selected are enumerated on Table 7.

The Figure 16 shows in red the proposal of the fork cabling path. A guide pieces (A), should be design by the contractor to guide the cables into a safe path. The cables should be inserted through a hole (B) into the shaft and connected to the vacuum feedthrough on the other side. The vacuum cables should be triaxial or coaxial type.

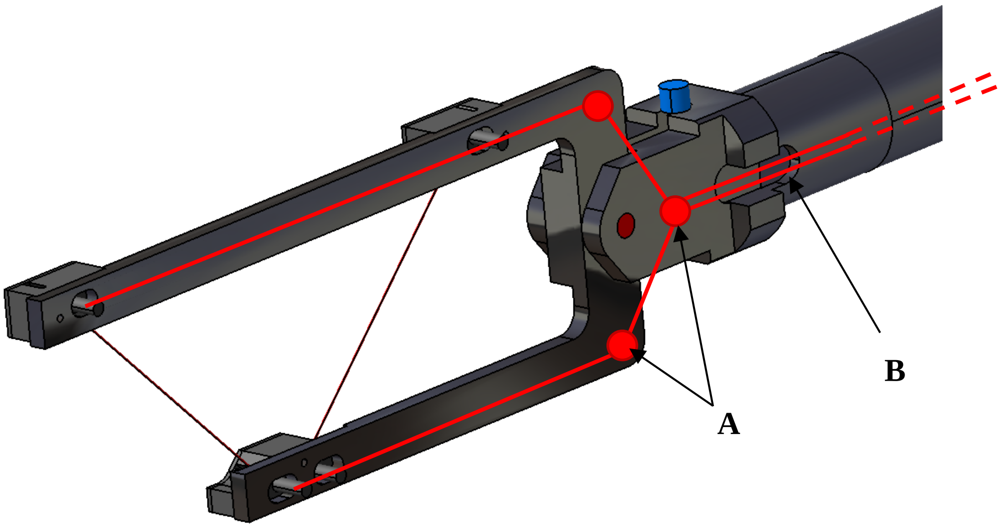

Figure 16: Fork cabling path.

A general view of the cabling is shown in Figure 17. The wires signal cables are represented in red and are connected from the fork copper pin connectors to the vacuum feedthrough (A) into the vacuum side and from the vacuum feedthrough (A) to the acquisition box (B) into the air side. The signal cables are placed through the patch panel (C) without any connection at this point. A total number of four channels are needed, one for each copper pin. Triaxial cables should be used in air side.

The carbon wires need to be polarized with 100V. Using triaxial cables the external conductor should be grounded, the middle one the 100V reference and the inner conductor the signal measured over this 100V level. With coaxial cables, only in vacuum side, the ground will be removed, using only the 100V reference and the inner signal conductor over this 100V level.

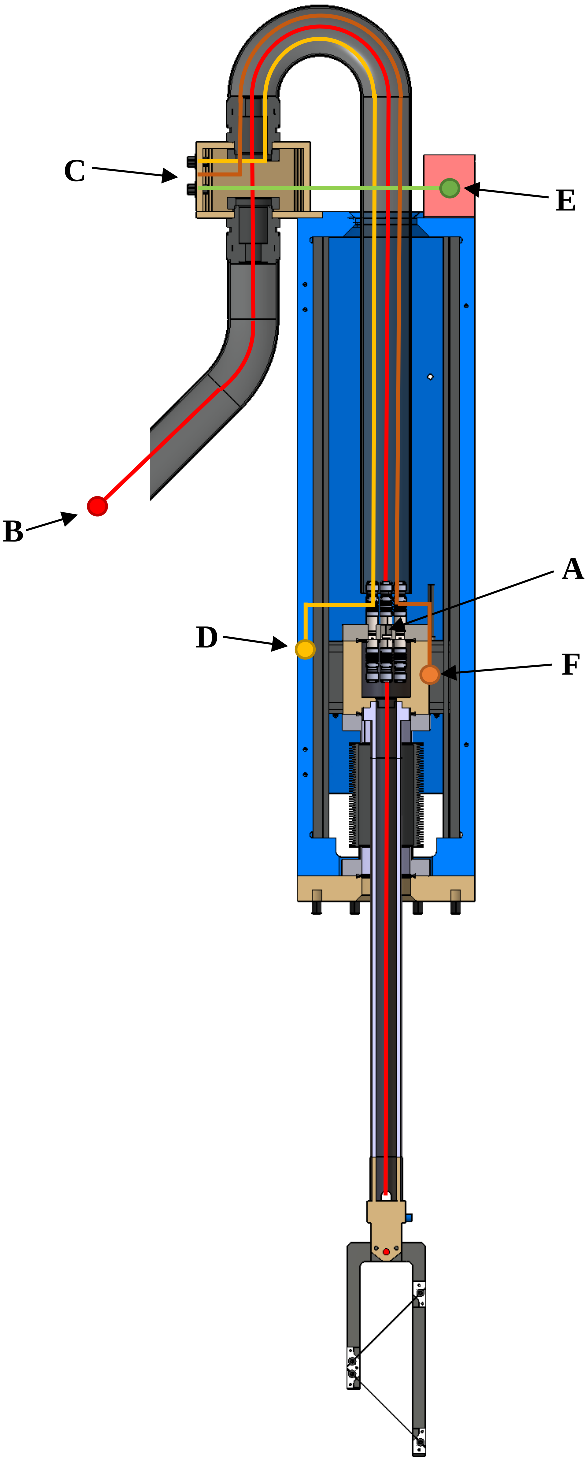

Figure 17: Cabling path general view

The limit switches cables are represented in yellow and are placed into the cables protector from the limit switches position (D) to the patch panel (C).

The motor and brakes cables are represented in green and are placed from the motor position (E) to the patch panel (C).

Finally, the encoder cable is represented in orange and is placed into the cables protector from the encoder position (F) to the patch panel (C).

The patch panel should be configured as indicated in Figure 18. A Souriau type connector should be used for the motor and brake connections (A). For the rest of the elements two DB9 connectors need to be used, one for the travel limit switches (B) and the other one for the encoder (D), and finally a LEMO connector (C) should be used for the MPS Limit Switch.

A connection should be placed on top and bottom sides of the patch panel (E) to fix the cables and cables protectors.

The contractor should be responsible of all the cabling and connectors based on the previous indications[3].

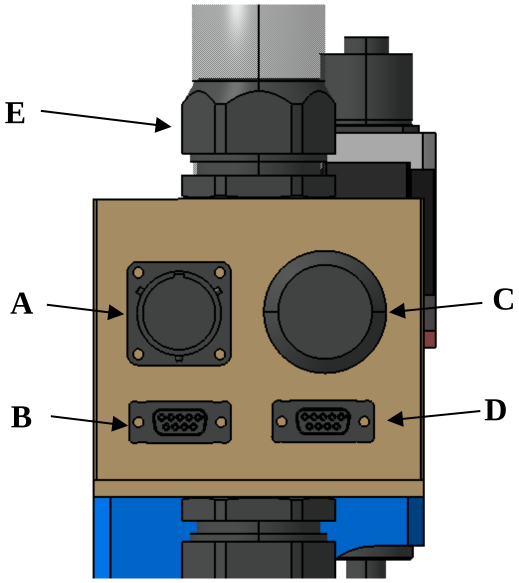

Figure 18: Patch panel connectors configuration

[3] As specified by the ESS-0064007 and ESS-0034035 documents.

2.5 Components to be supplied by ESS-Bilbao

ESS-Bilbao shall supply a collection of 3D files of all the pieces of Wire Scanner, Actuator and Alignment Tool. The list of 3D files is shown on Table 2, Table 3 and Table 4.

Table 2: Wire Scanner 3D files collection.

3D File Name	Description	Material	Units
MEBT-WS-1000-ESS	Wire Scanner + Actuator Assembly.		
MEBT-WS-1100-ESS	Wire Scanner Assembly.		
MEBT-WS-1101-ESS	Fork.	Stainless steel	1
MEBT-WS-1102-ESS	Fork alignment.	Stainless steel	1
MEBT-WS-1103-ESS	Shaft.	Stainless steel	1
MEBT-WS-1104-ESS	Shaft holding piece.	Stainless steel	1
MEBT-WS-1105-ESS	Fork alignment screw.	Stainless steel	1
MEBT-WS-1106-ESS	Precision alignment pin.	Stainless steel	1
MEBT-WS-1107-ESS	Alignment guide.	Stainless steel	1
MEBT-WS-1108-ESS	Signal pin.	Copper	4
MEBT-WS-1109-ESS	Wire clamper.	Copper	4
MEBT-WS-1110-ESS	Bottom Carbon wire holder.	Macor	1
MEBT-WS-1111-ESS	Bottom Carbon wire holder cover.	Aluminium	1
MEBT-WS-1112-ESS	Top-Right Carbon wire holder.	Macor	1
MEBT-WS-1113-ESS	Top-Right Carbon wire holder cover.	Aluminium	1
MEBT-WS-1114-ESS	Top-Left Carbon wire holder.	Macor	1
MEBT-WS-1115-ESS	Top-Left Carbon wire holder cover.	Aluminium	1

Table 3: Actuator 3D files collection.

3D File Name	Description	Material	Units
MEBT-WS-1200-ESS	Actuator Assembly		
MEBT-WS-1201-ESS	Guides Support.	TBD	1
MEBT-WS-1202-ESS	Rectangular Flange.	Stainless steel	1
MEBT-WS-1203-ESS	Shaft Support.	Stainless steel	1
MEBT-WS-1204-ESS	Spindle Support.	Stainless steel	1
MEBT-WS-1205-ESS	Limit Switches Support.	Aluminium	1
MEBT-WS-1206-ESS	Limit Switch trigger 1.	Aluminium	1
MEBT-WS-1207-ESS	Limit Switch trigger 2.	Aluminium	1
MEBT-WS-1208-ESS	Encoder Support.	Aluminium	1
MEBT-WS-1209-ESS	Motor Support.	Aluminium	1
MEBT-WS-1210-ESS	Raft Panel Box.	Aluminium	1
MEBT-WS-1211-ESS	Raft Panel Box Support.	Aluminium	1
MEBT-WS-1212-ESS	Mechanical Limit	Aluminium	2

Table 4: Wires Alignment Tool 3D files collection.

3D File Name	Description	Material	Units
MEBT-WS-1300-ESS	Wires Alignment Tool Assembly.		
MEBT-WS-1301-ESS	Wires Alignment Tool Frame.	Stainless steel	1
MEBT-WS-1302-ESS	Alignment Rollers.	TBD	3
MEBT-WS-1303-ESS	Tension Rollers.	TBD	2
MEBT-WS-1304-ESS	Wire Holders.	TBD	2
MEBT-WS-1305-ESS	Wire Clampers.	Copper	2
MEBT-WS-1306-ESS	Fork Clampers.	Aluminium	3

2.6 Blueprints

The contractor will be responsible of elaborate all the blueprints of every piece of the Wire Scanner and Actuator designs. The contractor will be also responsible of the choosing of all the tolerances to assure the requirements described on section 2.2 Specifications. The blueprints should be checked and approved by ESS-Bilbao prior to the fabrication.

2.7 Material

The Contractor must purchase all the materials for the fabrication of all the components of the three Wire Scanners, three Actuators and Alignment Tool, including the materials required in Table 2, Table 3 and Table 4. The materials must be verified according to internationally recognized standards (AISI).

2.8 Manufacturing

The Contractor must propose in a conceptual way the fabrication process to follow to ensure the compliance with the specifications described on section 2.2 Specifications.
The fabrication method must be compatible with 10-7 mbar vacuum applications[4]. To ease preparation for vacuum cleaning, the machining liquids must be free of silicones and halogens to avoid contamination of the material. The contractor must propose the type of cutting oil to be used and the characteristics of it, to ensure that the material is not contaminated.
The surfaces must be milled or turned. No surface of any of the vacuum component shall be terminated any type of mechanical abrasion.

Table 5: Elements under vacuum.

3D File Name	Description
MEBT-WS-1100-ESS	Wire Scanner Assembly.
MEBT-WS-1202-ESS	Rectangular Flange.
MEBT-WS-1203-ESS	Shaft Support (Inner faces).

[4] As specified by the ESS Vacuum Handbook Part 3.

The following materials are specifically prohibited for in-vacuum components[5]:

- Brass,
- Standard Hard Solder,
- All Plastics,
- Free cutting stainless steel,
- Silicon or sulphur based machining lubricants when machining any components (only water-soluble machining lubricants are permitted),
- Any material containing: Zinc, Cadmium, Phosphorus, Sodium, Selenium, Potassium or Magnesium.
- Soft Solder,
- Electrical Solder,
- ASTM type 303,
- All Glues, Greases,
- GE Varnish, Anodized surfaces or any mechanically polished components,

2.9 Cleaning

Prior to delivery to ESS-Bilbao, all the components must be cleaned in order to be ready for the assembly. All the surface of the pieces to be placed under vacuum listed in Table 5 should be provided free of contamination, grease, or other substances no ultra high vacuum compliance[6].

The Contractor shall establish and deliver together with the tender a detailed cleaning procedure appropriate to its manufacturing facilities. The procedure, including the properties of the cleaning products selected, will be submitted to ESS Bilbao for approval.

2.10 Storage, packaging and shipping

The contractor is responsible for storage, packaging and transportation to the ESS-Bilbao facilities all the components listed in Table 2, Table 3 and Table 4. The Contractor shall ensure that the equipment is stored in an area where the condition of the components is not altered[7].

The Contractor shall propose a packaging system to send the manufactured parts to the ESS Bilbao facilities.

The packaging must protect all the components against any types of hazards that may occur

5 As specified by the ESS Vacuum Handbook Part 1.
6 As specified by the ESS Vacuum Handbook Part 3.
7 As specified by the ESS Vacuum Handbook Part 3.

during transportation.

3 Verifications and tests

3.1 Verifications to be done by the contractor

All the pieces will be subjected to complete metrology campaign. All the tolerances less than 0.1mm of all the pieces directly related to fulfilling the specifications commented in section 2.2 Specificationsshould be documented as a part of the **Manufacturing and Quality Assurance** documentation. The Contractor shall submit its proposed metrology procedures for approval to ESS-Bilbao.

ESS-Bilbao reserves the right to be present, or be represented by an external organization of its choice, to follow all the tests carried out by the contractor or one of its subcontractors. The Contractor must notify at least 10 business days prior to the proposed date of any of such test.

The Contractor shall supply all tools, equipment and personnel necessary to perform all the tests required to ensure compliance with the specifications.

Verifications to be carried out by the contractor are specified in the following subsections.

3.1.1 Raw Material

The contractor shall include all the documentation of all the chosen material, including the mechanical properties as well as the chemical composition.

3.1.2 Metrology

The contractor shall deliver a **Manufacturing and Quality Assurance** document including all the measurements and test of the distance with tolerances under 0.1mm of all the pieces directly related to fulfilling the specifications commented in section 2.2 Specifications.

3.1.4 Leak Testing

Leak testing must be performed according to EN 1779 - A1 with a calibrated UHV leak detector connected to one of the CF vacuum ports, covered with a helium-filled plastic wrap for 10 minutes. The result should not give an overall leakage rate greater than 2.0 * 10-11 Pa * m3 / s (2.0 * 10-10 mbar * l / sec) at room temperature[8]. The Contractor shall submit its proposed leak detection equipment and procedures for approval to ESS-Bilbao.

3.2 Verifications to be carried out by ESS-Bilbao

ESS-Bilbao reserves the right to repeat all the tests listed in section 3.1 accepting the specifications. These acceptance tests will be carried out within a maximum of one month from the delivery at the ESS-Bilbao facility.

The Contractor will be informed of any part that does not meet the requirements. In this case and at its cost, the Contractor may send an inspector to verify the findings of ESS-Bilbao. The parts that prove to be unsatisfactory will be returned to the contractor for the repair or replacement according to a written program of mutual agreement.

[8] As specified by the ESS Vacuum Handbook Part 4.

4 Delivery

4.1 Provisional Delivery Calendar

Table 6: Delivery Calendar

Milestone	Delivery Term
Contract Formalization	T0
Delivery of Blueprints	T1 = T0 + 1 month
Acceptance of Blueprints	T2 = T1 + 1 month
Manufacture and delivery of WS1 and Verification Documents	T3 = T2 + 3 months
Acceptance of WS1	T4 = T3 + 1 month
Manufacture and delivery of WS2 and WS3 and Verification Doc.	T5 = T4 + 5 month
Acceptance of WS2 and WS3	T6 = T5 + 1 months
Total Duration of the Project	**12 Months**

4.2 Acceptance and guarantee

Acceptance will be given by ESS-Bilbao only after all the articles have been delivered in accordance with the conditions of the documentation, all the specified tests have been successfully completed and the complete records of the metrology, tests and other certificates have been supplied to ESS-Bilbao. The Contractor shall supply to ESS-Bilbao the complete documentation within a maximum of **five working days** before each shipment of equipment manufactured for ESS-Bilbao.

5 Other conditions

Compliance with the business obligations established by the Law on the Prevention of Occupational Risks, as well as the regulations and regulations that may be applicable in your case vr. Gratia (Technical Building Code, RD 314/2006 of 17 March, RD 1836/1999 Regulation on nuclear and radioactive facilities, RD 783/2001 Regulation on health protection against ionizing radiations, Regulations on Workplaces, etc.). The process of development of the work or activity, object of the specifications, shall be considered as many measures as are necessary to comply with the Green Public Contracting Plan of the General Administration of the State and its Public Agencies and the Social, Order PRE / 116/2008, of 21 January.

5.1 Responsibility for design, components and operation

The Contractor shall be responsible for the correct operation and functionality of all necessary components from delivery of material to the expiration of the warranty period, regardless of whether they have been chosen by the Contractor or suggested by ESS Bilbao. The approval of ESS Bilbao of the design and choice of components does not relieve the Contractor from its responsibilities in this regard.

5.2 Follow-up of work in progress

The Contractor shall assign a responsible person for the technical execution of the contract and its monitoring.
A one-page written report detailing the progress of the production situation will be sent to ESS Bilbao every two weeks until the end of the contract.

6 Technical Documentation

The Technical documentation will be presented in the form required in the Specific Administrative Clauses and signed by the legal representative of the company.
In the technical documentation envelope, in addition to the two copies requested, a copy of this documentation in electronic format will be included. The inclusion of such support does not exempt from the delivery of documentation as required by the Specific Administrative Clauses.

7 Contact

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Annex I: Commercial components recommended

Table 7: Commercial components recommended in 3D design

Name	Supplier	Item Reference	Units per WS
Linear Guides	NSK	N1S15	2
Skids	NSK	NAS15EMZ	2
Encoder	SIKO	MSK 1000	1
Encoder Connector	--	DB9 Type	1
Limit Switches	OMRON	SS-01GL2-E	3
Limit Switches Connector	--	DB9 Type	1
MPS Limit Switch Connector	LEMO	EGG.4K.312.CYM	1
Spindle	NSK	VSP1205N1D0500PP	1
Spindle support	NSK	WBK08-11	1
Stepper Motor	NANOTEC	ST4118D3004	1
Motor Connector	SOURIAU	Based on motor spec.	1
Break	NANOTEC	BKE-0.4-5.0	1
Bellow	VACOM	*Custom-made*	1
Feedthrough	ALLECTRA	243-TRIAX-C40-4	1
Triax Connectors	ALLECTRA	245-CON-TRIAX-HQ	12
Triaxial vacuum cables	ALLECTRA	310-PEEK50-TRIAX	0.5m x 4 ch
Triaxial air cables	ALLECTRA	310-PEEK50-TRIAX	2.5m x 4 ch

**The same or equivalent component should be used.*

Annex II: Motor axis torque calculations

All the calculation of torque has been done considering the actuator in vertical position as the worst-case scenario.

The torque calculation could be divided in two main components: the torque due to inertias during acceleration and the torque due to static forces. In this case, due to a low value of velocity and acceleration, the torque due to static forces will be the dominant factor of the equation so the calculation will be done without the consideration of inertias.

There are two static forces to be considered: the weight of the load and the atmospheric pressure over the vacuum flange. In the worst case, when the motor is pulling the load, the total force applied is the summation of the two.

Considering a total weight of the instrument to move inside the vacuum vessel of $m_L = 4Kg$ the force due to this mass could be calculated as:

$$F_L = m_L \cdot g = 39.2N$$

The force produce by the atmospheric pressure over the flange could be calculated as $F_P = \Delta P \cdot EA$, where ΔP is the pressure difference between the vacuum and atmospheric pressure (in N/m2 units) and EA is the Effective Area of the selected bellow (m2), in this case a CF40 Bellow.

Considering a pressure difference of $101325\ N/m^2$ and an effective area of the bellow of $0.00273m^2$ the force due to the atmospheric pressure over the vacuum flange is:

$$F_P = \Delta P \cdot EA = 276N$$

The total contribution of static forces is:

$$F_T = F_L + F_P = 315.82N$$

Considering a pitch of the spindle of $p = 5\ mm/rev$ the total torque applied by the motor is:

$$T_T = F_T \cdot \frac{p}{2\pi} = 0.251\,Nm$$

With this value of torque a commercial motor and a commercial break from NANOTEC have been selected. The reference of this motor and break can be consulting in Table 7.

The evolution of the torque applied by the motor with respect to the velocity of the instruments is shown in Figure 19.

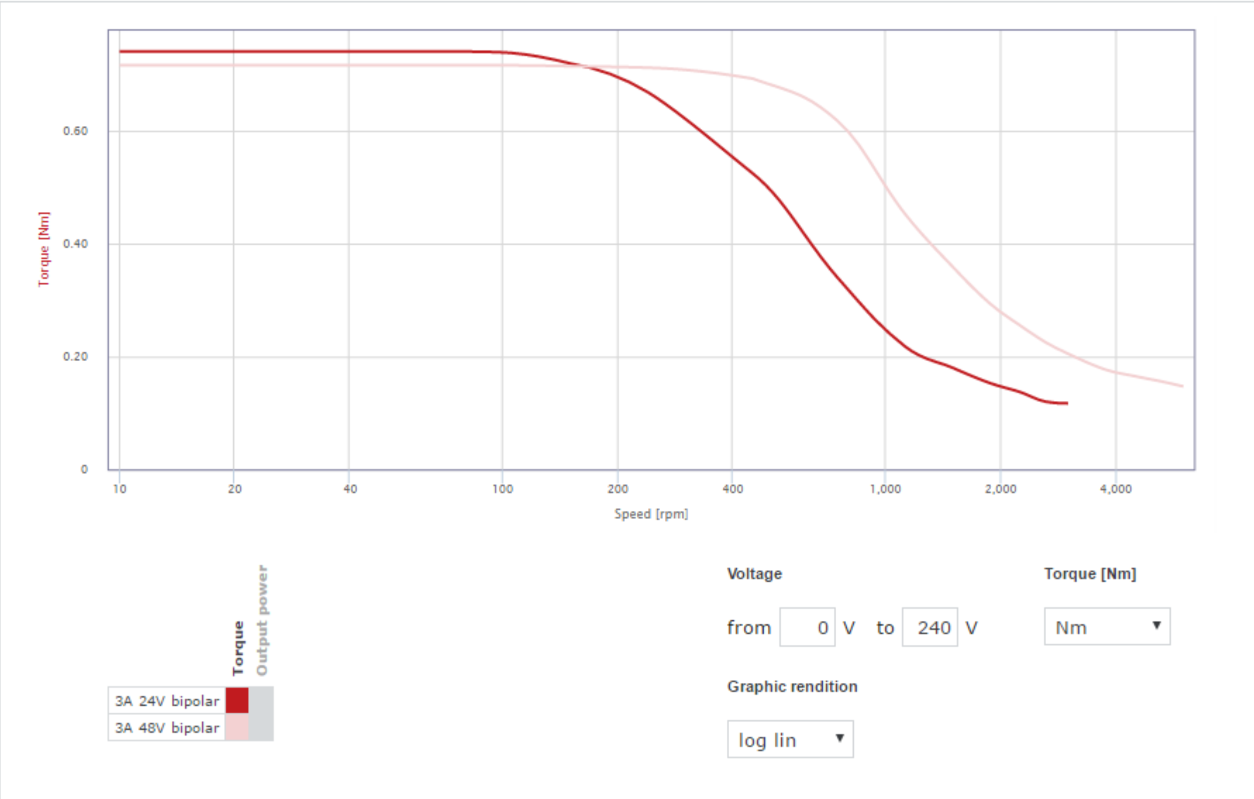

Figure 19: Torque/Velocity curves of motor ST4118D3004

Considering a spindle pitch of $p = 5\, {}^{mm}/_{rev}$ and an instrument linear velocity of $10\, {}^{mm}/_{s}$ the angular velocity of the motor axis is 120 rpm. This angular velocity is in the range of maximum torque of the curve.

The selected break has a holding torque of 0.4 Nm. Considering the calculated value of torque this value of holding torque is enough to maintain the instrument in position during a power failure.

Annex III: Linear guides stiffness considerations

One of the most important parameters of the linear guides is the stiffness, the declination of the instrument with respect to the pitching moment applied to the linear guide.

A simplified calculation has been done to validate the using of this model of linear guide in the particular case of the Wire Scanner actuator. Therefore, a single linear guide has been considered in this calculation to move the instrument inside the vacuum vessel.

The momentum applied to the linear guide by the instrument could be calculated as:

$$M = W \cdot D \cdot \sin\theta$$

where W is the total weight of the instrument, D the distance between the clamping face and the centre of inertia of the instrument and θ the angle between the vector W and the axis of movement of the instrument.

Considering a total weigh of 3.4 kg, a distance between the clamping face and the centre of inertia of 150 mm and an angle of 45º the momentum applied is:

$$M = 34 \cdot 0.15 \cdot \sin(45^{o}) = 3.6 Nm$$

The Figure 20 shows a graphic with the declination of the instrument with respect to the pitching moment applied to a N1S15 Linear Guide. Using the momentum calculated previously the instrument will have a declination of $1.4 \cdot 10^{-4} rad$.

Considering a total distance of the instrument of 580 mm, the total displacement of the wire scanner tip will be:

$$d = 580 \cdot tg(0.008) = 80 \mu m$$

With the consideration of using only one linear guide a total displacement of the wire scanner tip of $80 \mu m$ will appear. This value will be reduced in the real model with two linear guides placed one in front of the other.

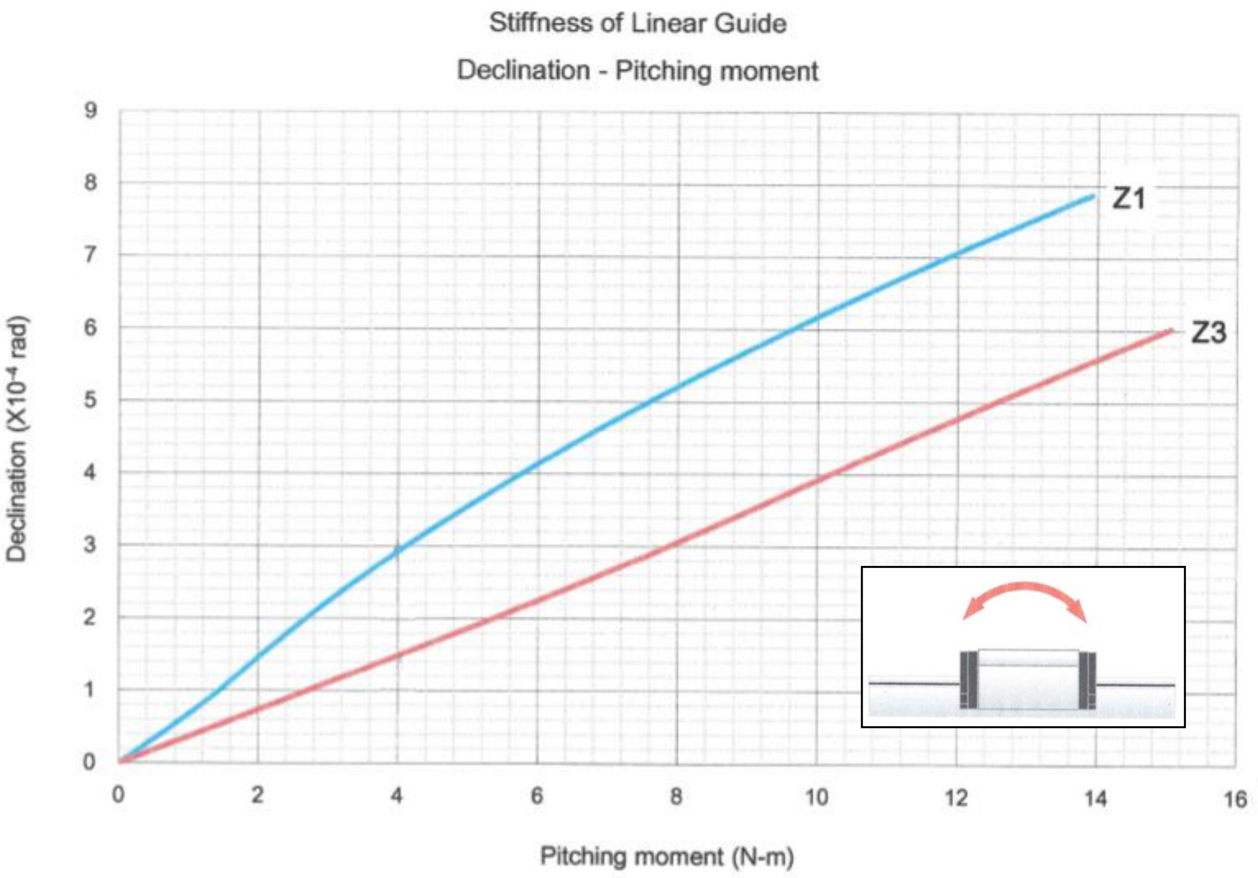

Figure 20: Stiffness of Linear Guide N1S15 from NSK

Annex IV: Limit Switches functionality

The limit switches position and functionality of the actuator are shown in Figure 21. Two limit switches should be used to have a reference of the wire scanner travel between the initial point to the final point. The total distance between this two limit switches should be 240 mm, which is the distance between the parking position and the final scanning position of the instrument. These limit switches should be close in the initial or final position and remain open during the rest of the travel.

An additional limit switch should be added for Machine Protection System purposes. This limit switch should be placed as close as possible of the initial WS travel limit switch. The MPS switch should be close when the wire scanner is in parking position and should remain open during the wire scanner travel.

Two mechanical limits should be placed to avoid collisions or bellow damages in case of a limit switch failure. The mechanical limits should be placed with a distance of 260 mm between each other and a distance of 10mm to the initial or final WS travel limit switches.

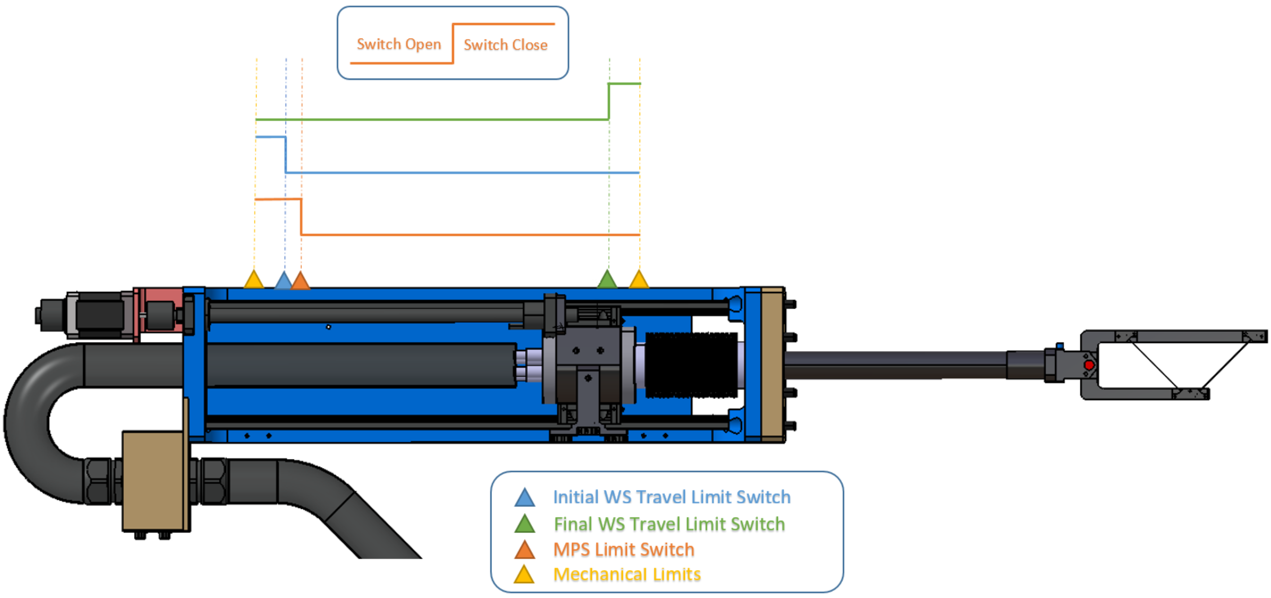

Figure 21: Switches position and functionality