VST Project

M1 SUPPORT SYSTEM

USE AND MAINTENANCE MANUAL

VST-MAN-TOM-22300-2128

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Issue	Date	Sections Affected	Reason/Remarks
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Applicable Documents (ADs)

id.	Document code	Title	Date	Issue
1	VST-SPE-OAC-22000-1311	Primary Mirror Support System Technical Specification	2008-01-17	1.5
2	VST-TRE-OAC-22300-2009	Primary Mirror System Design Description	2008-02-29	1.1
3	VST-TRE-OAC-22000-1305	Primary Mirror Active Optics Control System Hardware Electronics Design Report	2008-05-30	1.1
4	VST-MAN-OAC-24303-2121	M1 Actuators Control Board Description Manual	2009-02-03	1.0
5	VST-MAN-OAC-24300-2122	M1 AO PDB Electronic Board Description Manual	2009-02-09	1.0
6	VST-MAN-OAC-24303-2131	Motor Control Handset Description Manual	2009-02-11	1.0
7	VST-TRE-OAC-20000-1111	M1 Handling Integration of Primary Mirror in the Cell	2007-03-15	1.1

Reference Documents (RDs) – Design Descriptions

id.	Document code	Title	Date	Issue
1	VST-TRE-TOM-22303-2010	M1 Axial Force Actuator Design Description	2008-06-09	2.1
2	VST-TRE-TOM-22304-2011	M1 Axial Fixed Point Design Description	2008-07-16	3.1
3	VST-TRE-TOM-22300-2013	M1 Lateral Fixed Point Design Description	2008-06-09	3.1
4	VST-TER-TOM-22304-2012	M1 Lateral Support Design Description	2008-07-16	3.3
5	VST-TRE-TOM-22300-2092	Safety Devices Design Description	2008-12-21	1.4

Reference Documents (RDs) – Harness

id.	Document code	Title	Date	Issue
11	VST-TRE-TOM-22300-2105	M1 Harness Description	2009-01-21	2.2
12	VST-TOM-E-001-a	Block Diagram	2008-10-11	1.1
13	VST-TOM-E-001-b	Block Diagram	2008-10-11	1.1
14	VST-TOM-E-002	Power Cable Lay-Out	2008-10-11	1.1
15	VST-TOM-E-003	Power Supply Cable	2008-10-11	1.1
16	VST-TOM-E-004	Bus Cable Lay-Out	2008-10-11	1.1
17	VST-TOM-E-005	CAN Bus Cable	2008-10-11	1.1
18	VST-TOM-E-006	Power Supply Cable	2008-10-11	1.1
19	VST-TOM-E-007	CAN Bus Cable	2008-10-11	1.1
20	VST-TOM-E-008	Cable List	2008-10-11	1.1
21	VST-TOM-E-010	Sensing Cable	2008-10-06	1.1
22	VST-TOM-E-011	CAN Bus Cable	2008-10-06	1.0
23	VST-TOM-E-012	PDB Lateral Fixed Point Cable	2009-01-22	1.1
24	VST-TOM-E-013	PDB Absolute Transducer Cable	2009-01-22	1.1
25	VST-TOM-E-014	PDB Power Supply Cable	2009-01-20	1.0
26	VST-TOM-E-015	Axial Force Actuator, Internal Connections	2009-02-12	1.0
27	VST-TOM-E-016	Axial Fixed Point, Internal Connections	2009-02-12	1.0
28	VST-TOM-E-017	Axial Force Actuator with Potentiometer Interface, Internal Connections	2009-02-12	1.0

Reference Documents (RDs) – Assembly and Integration Procedures

id.	Document code	Title	Date	Issue
31	VST-PRO-TOM-22300-2090	Mirror Cell Integration Procedure	2008-09-11	1.2
32	VST-TRE-TOM-22303-2081	M1 Axial Force Actuator Assembly Procedure	2009-01-14	2.0
33	VST-TRE-TOM-22300-212	M1 Axial Fixed Point Assembly Procedure	2009-01-19	1.0
34	VST-TRE-TOM-22300-2124	M1 Lateral Fixed Point Assembly Procedure	2009-01-22	1.0
35	VST-TRE-TOM-22300-2125	M1 Lateral Support Assembly Procedure	2009-01-22	1.0
36	VST-TRE-TOM-22300-2129	M1 Safety Devices Assembly Procedure	2009-02-16	1.0

Reference Documents (RDs) – Assembly Drawings

id.	Document code	Title
51	OACN01.0101.000.0	Axial Force Actuator Assembly, 1st ring
52	OACN01.0102.000.0	Axial Force Actuator Assembly, 2nd ring
53	OACN01.0103.000.0	Axial Force Actuator Assembly, 3rd ring
54	OACN01.0104.000.0	Axial Force Actuator Assembly, 4th ring
55	OACN01.02.000.0	Axial Fixed Point, Assembly
56	OACN01.0301.000.0	Lateral Fixed Point (South-East and South-West), Assembly
57	OACN01.0302.000.0	Lateral Fixed Point (North), Assembly
58	OACN01.0401.000.0	Astatic Lever Nr.01 & Nr.13
59	OACN01.0402.000.0	Astatic Lever Nr.02 & Nr.14
60	OACN01.0403.000.0	Astatic Lever Nr.03
61	OACN01.0404.000.0	Astatic Lever Nr.04 & Nr.16
62	OACN01.0405.000.0	Astatic Lever Nr.05 & Nr.17
63	OACN01.0406.000.0	Astatic Lever Nr.06
64	OACN01.0410.000.0	Astatic Lever Nr.10
65	OACN01.0415.000.0	Astatic Lever Nr.15
66	OACN01.0418.000.0	Astatic Lever Nr.18
67	OACN01.0419.000.0	Astatic Lever Nr.07 & Nr.19
68	OACN01.0420.000.0	Astatic Lever Nr.08 & Nr.20
69	OACN01.0421.000.0	Astatic Lever Nr.09 & Nr.21
70	OACN01.0422.000.0	Astatic Lever Nr.22
71	OACN01.0423.000.0	Astatic Lever Nr.11 & Nr.23
72	OACN01.0424.000.0	Astatic Lever Nr.12 & Nr.24
73	OACN01.0501.000.0	Safety Device 0501 and 0515
74	OACN01.0508.000.0	Safety Device 0508
75	OACN01.0522.000.0	Safety Device 0522

76	OACN01.0503.000.0	Safety Device 0503, 0505, 0511, 0513, 0517, 0519, 0525, and 0527
77	OACN01.0509.000.0	Safety Device 0509
78	OACN01.0523.000.0	Safety Device 0523
79	OACN01.0507.000.0	Safety Device 0507 and 0521
80	OACN01.0516.000.0	Safety Device 0516
81	OACN01.0528.000.0	Safety Device 0528
82	OACN01.0602.000.0	Safety Device 0602
83	OACN01.0610.000.0	Safety Device 0610 and 0624
84	OACN01.0604.000.0	Safety Device 0604 and 0618
85	OACN01.0612.000.0	Safety Device 0612 and 0626
86	OACN01.0606.000.0	Safety Device 0606 and 0620

IMPORTANT

The use and maintenance operations described in the present manual shall not be carried out without having clear knowledge of the telescope as a whole system.

Before starting with any kind of operation related to the M1 Support System, it is mandatory that the present Instruction and Maintenance Manual has been completely read and understood.

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1 INTRODUCTION

1.1 Scope

The VST (VLT Survey Telescope) is an Alt-Az telescope designed by INAF-"Osservatorio Astronomico di Capodimonte" within a collaboration with ESO, responsible for the civil infrastructures. The telescope has a primary mirror of 2.6m diameter supported by a mirror cell and equipped with an active optics system.

The purpose of this document is to give all useful information and necessary instructions for the use and the maintenance of the Support System of the Main Mirror of the VST.

1.2 Warning

The use and maintenance operations described in the present manual won't be carried out before reading the use and maintenance manual of the telescope as a whole system, in full respect of the instructions therein.
Before starting with any kind of operation related to the M1 Support System, it is mandatory that the present Instruction and Maintenance Manual has been completely read and understood.
All actions carried out on the M1 Support system must be in accordance with the instructions given in the present manual.

1.3 General recommendations

Before proceeding with any of the use operations or maintenance interventions described in the present Instruction and Maintenance Manual, some general recommendations must be followed:

- the personnel required for the execution of the specific operation or intervention for maintenance has an adequate education, has received the necessary training and has sufficient experience in the field of mechanics, electric devices or electronics, depending on the task
- any use operation or maintenance intervention must be carried out in safety conditions, using the appropriate tools and wearing appropriate protections, according to the standard safety norms, as better specified in the use and maintenance manual of the VST telescope as a whole
- The present manual has been completely read and fully understood
- The documents reported as "reference documents" and namely the Design Descriptions, the Assembly Drawings, the Assembly Manuals and the Integration Procedures have been read and well understood, in the part concerning the required intervention
- The tools necessary to carry out the required use operation or maintenance intervention are available end ready to use.

1.4 Reference Documents

Together with the present manual, a set of documents must be available to the operator, where he can find useful information and all details he may need.
These documents have been declared as “reference documents” at the beginning of this manual.

Besides the official documents just above mentioned, the operator may need additional data sheets provided by the suppliers of some critical components, asin the list that follows.

Supplier	Device	Document
D.S. Europe	Load Cell model TS 50 kg	Use and installation instructions Calibration certificate
D.S. Europe	Load Cell model 546-QDT, 220kg	Use and installation instructions Calibration certificate
D.S. Europe	Load Cell model LT05-A5, 500kg	Additional notes Calibration certificate
Burster	LVDT Transducer model 8739	Data sheet Calibration certificate
Honeywell	Load Cell model 31, 250 lbs	Installation instructions Certificate of calibration
Honeywell	Load Cell model 31, 500 lbs	Installation instructions Certificate of calibration
Honeywell	Load Cell model 31, 1000 lbs	Installation instructions Certificate of calibration
Burster	Amplifier Module model 9243	Operation manual Test certificate
D.S. Europe	Load Cell model LT5, 3000kg	Instruction manual Calibration certificate
Del Mar Avionics	Hydra Set model C, Auxiliary Hoist Control	Operation and maintenance manual Certificate of conformance Calibration test report Test data sheet

Table 1 - Data Sheets, Instructions and Certificates

1.5 Safety

All operations described in the present manual, both use or maintenance related, must be carried out according to the general safety rules in force and following the instructions of the safety responsible, who must have clear knowledge of the telescope as a whole system.

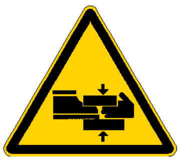
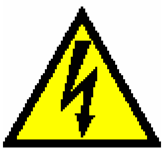
If the Mirror Cell is placed at or above 2m height, it is mandatory to set up a suitable staircase and a gangway as by the norms in force.
Beware of machine parts in motion and electrical connections, as well as parts at high voltage.
The operators must wear the appropriate safety equipment (helmet, protection shoes, gloves, glasses and so on), as by the norms in force and as best specified by the safety responsible, who must have clear knowledge of the telescope as a whole system.

In the present manual a set of symbols will be used, some of which are also reported on the Support System supplied. In the next table each symbol is described and commented.

SYMBOL	MEANING	COMMENT
 D ...	DANGER	It warns against any danger for the user health, including death.
 A ...	PAY ATTENTION	It highlights any warning or remark about key functions or useful information Pay attention to the text blocks that follow this symbol
 O ...	OBSERVE	The user is required to read a measurement, to check a warning signal, etc..
 I ...	INTERROGATION	The user is required to verify the correct position of a machine element, before proceeding with a specific command.
 L ...	LOOK UP IN THE MANUAL	It is necessary to look up in the Manual, before carrying out a specific operation.
 T ...	TUNING OR ADJUSTING	For specific working modes or in case of fault, it may be necessary to carry out either a mechanical adjusting operation or an electric tuning operation.

Table 2 – Symbols likely to be used in the manual

For ease of reference, a second set of symbols is also reported in the table below. These symbols may appear on the machine elements or in the environment where the Support system will be placed.

SYMBOL	DESCRIPTION
	GENERIC DANGER
	LOOK UP IN THE MANUAL
	FALL FROM HEIGHT
	FALLING OF MATERIAL
	DANGER OF CRUSHING UPPER OR LOWER LIMBS
	DANGER: MACHINE ELEMENTS AT POSSIBLY HIGH VOLTAGE
	PROTECTION HELMET MANDATORY

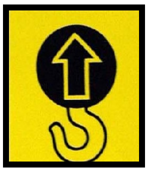
	PROTECTION SHOES MANDATORY
	ACCESS FORBIDDEN TO NON AUTHORISED PERSONNEL
	IT IS FORBIDDEN TO CLEAN, LUBRICATE, GREASE, REPAIR OR ADJUST BY HAND ANY MACHINE ELEMENT IN MOTION
	HOOKING POINT FOR LIFTING

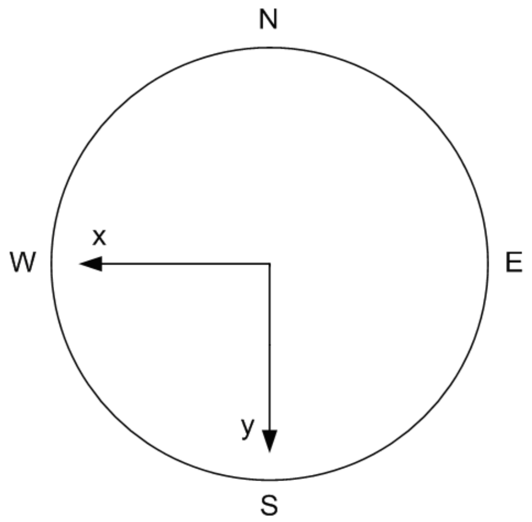
Table 3 – Symbols related to dangers, danger prevention and instructions

1.6 Definitions and Conventions

1.6.1 Coordinate System

If the telescope is horizontal (zenith angle = 90 deg) and the telescope is viewed from above, the primary mirror coordinate system can be defined as follows.

- The X axis is parallel to the altitude axis and pointing to the left
- The Y axis is perpendicular to the altitude axis and pointing downwards
- The Z axis (optical axis) follows the right hand rule and is directed from M1 to M2
- The origin of the reference system is the mirror vertex



The observer is looking from the secondary mirror to the surface of the primary mirror. The NSWE notations are referred to the situation where the telescope points to South (AZ=0°) and to Zenith (ALT=90°). The altitude axis is along X direction. The Z axis (optical axis) follows the right hand rule and is directed from M1 to M2.

1.6.2 Specific Terms

In this document several specific terms are used: these have been gathered in the table that follows.

AXIAL ACTUATORS (AA)	The 81 force controlled axial supports. They are used to support the weight along the z axis and to change the shape of the mirror.
AXIAL FIXED POINTS (AFP)	The 3 axial supports defining the Z position and orientation of the primary mirror around the x and y axes, and are 120° spaced. They are equipped with a motorized position control to adjust their height. They are purely passive during normal telescope operation.
LATERAL SUPPORTS (LS) OR ASTATIC LEVERS	The 24 astatic lever based lateral supports, purely passive.
LATERAL FIXED POINTS (LFP)	The 3 tangential fixed points defining the position of the primary mirror in the XY plane and the orientation around the z axis.
SAFETY DEVICES (SD)	The axial and lateral devices to prevent mirror damages in case of an earthquake.
ACTIVE STROKE	The internal stroke in the axial actuator in up direction of the piston obtained by the motor.
PASSIVE STROKE	The external stroke in the axial actuator in down direction by pushing down the sphere.

1.6.3 Abbreviations and Acronyms

Here follow a list of the abbreviations and acronyms that the reader may encounter while using the present manual.

AD	Applicable Document
AFA	Axial Force Actuator
AFPA	Axial Fixed Point Actuator
AL	Astatic Lever
ASD	Axial Safety Device
CCS	Central Control Software
CDT	Command Definition Table
CIT	Command Interpreter Table
DB	Database
DOF	Degree of freedom
ESO	European Southern Observatory
GUI	Graphical User Interface
HCU	Hexapod Control Unit
HW	Hardware
ICD	Interface Control Document
I/F	Interface
INAF	Istituto Nazionale di Astrofisica
LAN	Local Area Network
LCC	LCU Common Software
LCU	Local Control Unit
LFP	Lateral Fixed Point
LSD	Lateral Safety Device
M1	VST primary mirror
M1ACB	M1 Actuator Control Board
M2	VST secondary mirror
MLE	Maximum Likely Earthquake
MTBF	Mean Time Between Failure
OAC	Osservatorio Astronomico di Capodimonte
OBE	Operational Base Earthquake
SW	Software
TCS	Telescope Control Software
VLT	Very Large Telescope
VST	VLT Survey Telescope
VSTceN	VST Center at Naples
WS	Workstation

2 MIRROR CELL

2.1 Transportation

A copy of the present manual will be made available together with the wooden box containing the mirror cell. It will be placed inside a plastic envelope stuck on the front side wall of the box, so the operator may refer to it at any time.

A set of standardized images are used as warning reminders for safety reasons, both for the material being handled and for the operators.

All sub-systems of the M1 Support System have been integrated in the M1 Mirror Cell before delivery to I.N.A.F., so the following items have been transported together with and mounted on the Mirror Cell:
- nr. 81 Axial Force Actuators
- nr. 3 Axial Fixed Points
- nr. 24 Astatic Levers
- nr. 3 Lateral Fixed Points
- nr. 28 Safety Devices
- nr. 7 PDB Boxes
- nr. 1 CAN Bus Box
- nr. 1 Load Cell Box
- nr. 1 Dummy Mirror

The total weight of the Mirror Cell, including all above mentioned sub-systems, is about 12.000 Kg.

Before starting handling the Mirror Cell, verify that it has not been damaged at all, neither any of the above mentioned sub-systems. Carefully avoid any contact with them during the time the Mirror Cell is being lifted and handled.
The Mirror Cell must lay on wooden supports: pay attention that it is supported only through the structural parts.

2.2 Handling

The handling procedure is the exclusive responsibility of the user. Nevertheless, here follow some information about how to handle the mirror cell, together with support system and mirror dummy, because the interface to the handling device has also been designed and supplied by the manufacturer of the support system.
Four lifting plates (shown in the next picture) are fixed at the four corners of the Mirror Cell by means of eight M16 threaded rods with related nuts; the plates are foreseen for the insertion of four locking rings, each one having a load capacity of at least 10 ton. The technical documentation concerning the resistance calculations of the lifting plates is available on request.

Figure 1 - Lifting Plate with Locking Ring

The ropes or chains that will be used to lift the mirror cell must have a load capacity of at least 10 ton each. **The personnel involved in the handling of the Mirror Cell must be adequately prepared to this task.** Additional warning reminders are added on the surface of the lifting plate, as shown in the next figure:

Figure 2 - warning image for cell lifting

When supplied, each lifting plate will be already fixed onto the mirror cell with 8 M16 class 10.9 threaded rods, that is with 180Nm.
A mark will be traced on the nut and on the plate together, so to show any accidental nut release.

The Mirror Cell can be lifted horizontally by means of four ropes or chains with the angle between the ropes or the chains being less than 60°.

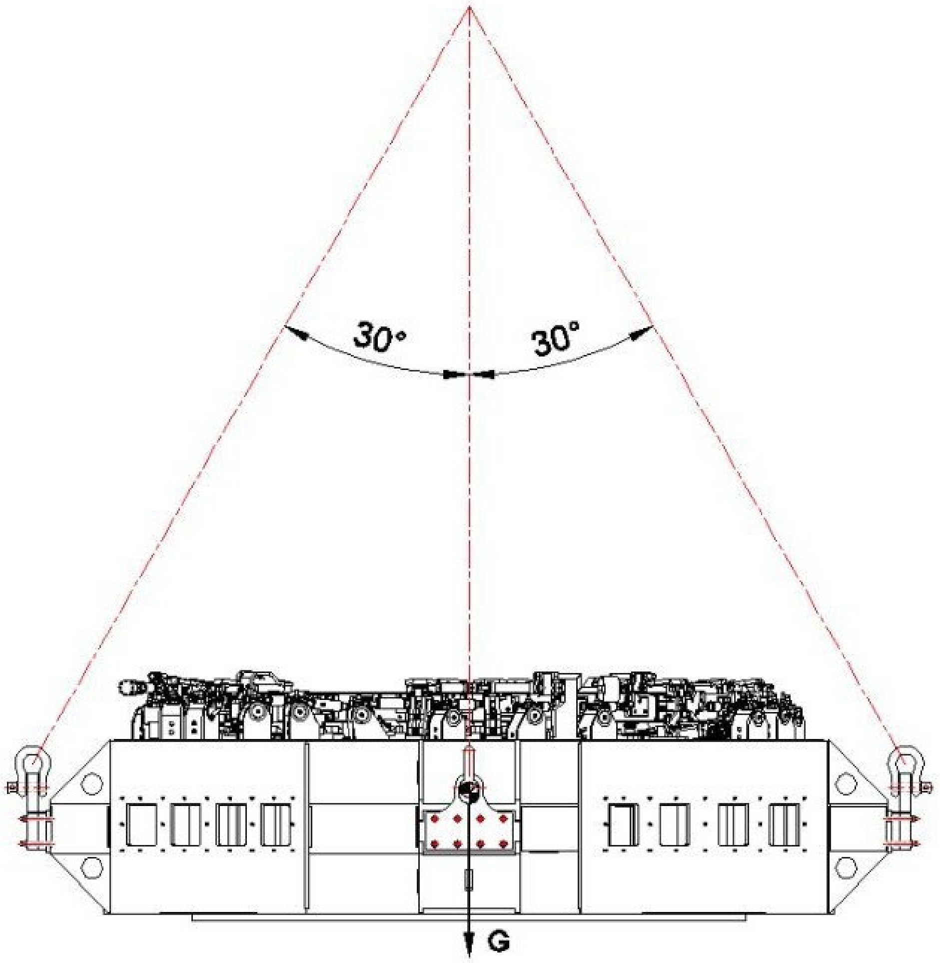


Figure 3 – lifting the cell in horizontal configuration

The Mirror Cell can also be lifted vertically by means of two ropes or chains with the maximum angle between the ropes or the chains being less than 45°.

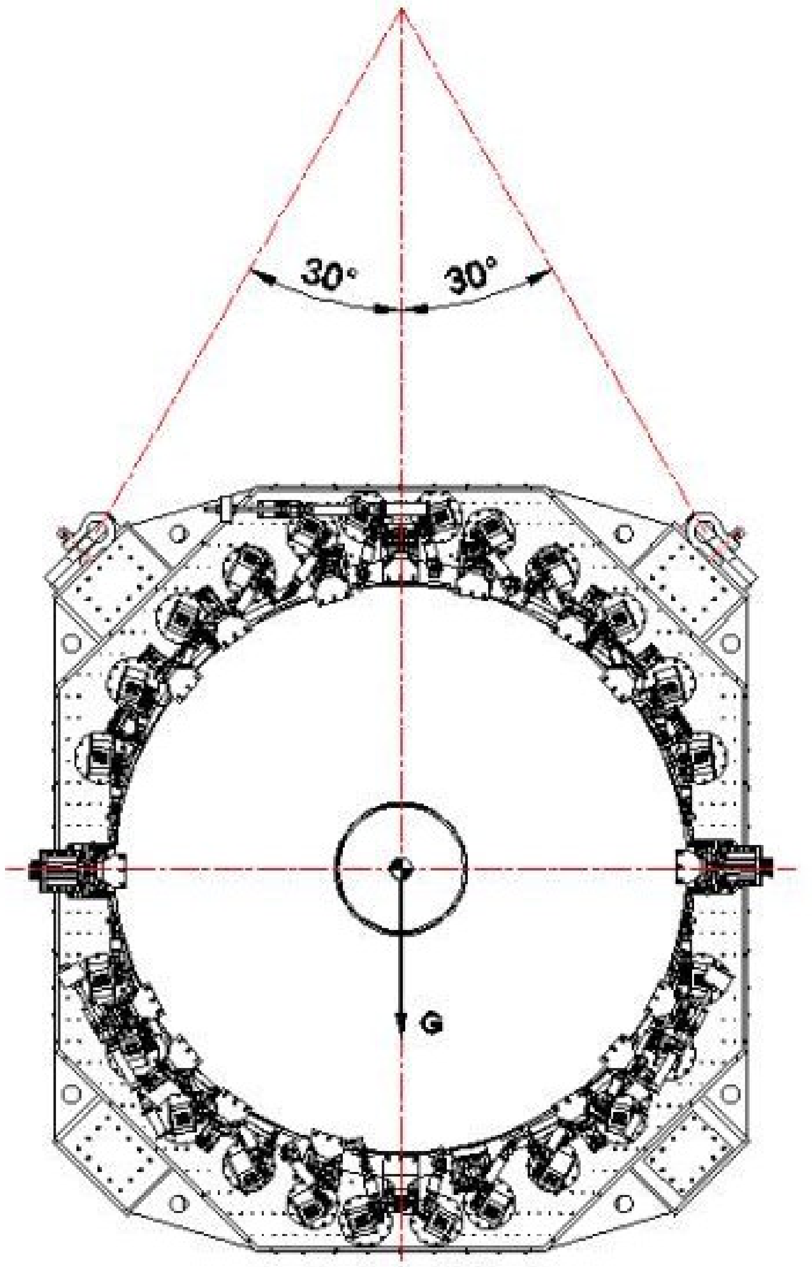


Figure 4 – lifting the cell in vertical configuration

2.3 Mirror Dummy Removal

WARNING

Do not touch the screws marked with either a yellow or a red dot: they can be released only for respectively ordinary and extra-ordinary maintenance reasons.

After the Mirror Cell has been mounted on the telescope structure, the Mirror Dummy shall be removed following the procedure later described in this manual, with the help of the Hydra Set and of the Handling Device (supplied by INAF). The Hydra-Set must be used for all mounting and removal operations of the Mirror or of the mirror Dummy on or from the Mirror Cell.

Figure 5 – hydra set for load monitoring when lifting the mirror

In order to read the applied loads, act on the switch located aside the display, but keep in mind that the reading accuracy is affected by the friction of the piston.
Pull the wire to act on the right lever: this lowers the Mirror at a speed proportional to the angle made by the lever.
Pull the wire to act on the left lever: this lifts the Mirror of about 0.1 mm for each time.
In rest conditions, when the Hydra-Set is off, the two levers must be up and locked by the appropriate locking piece.

The User Manual of the Hydra-Set is made available and is shown in the picture below to be easily identified by the operator.

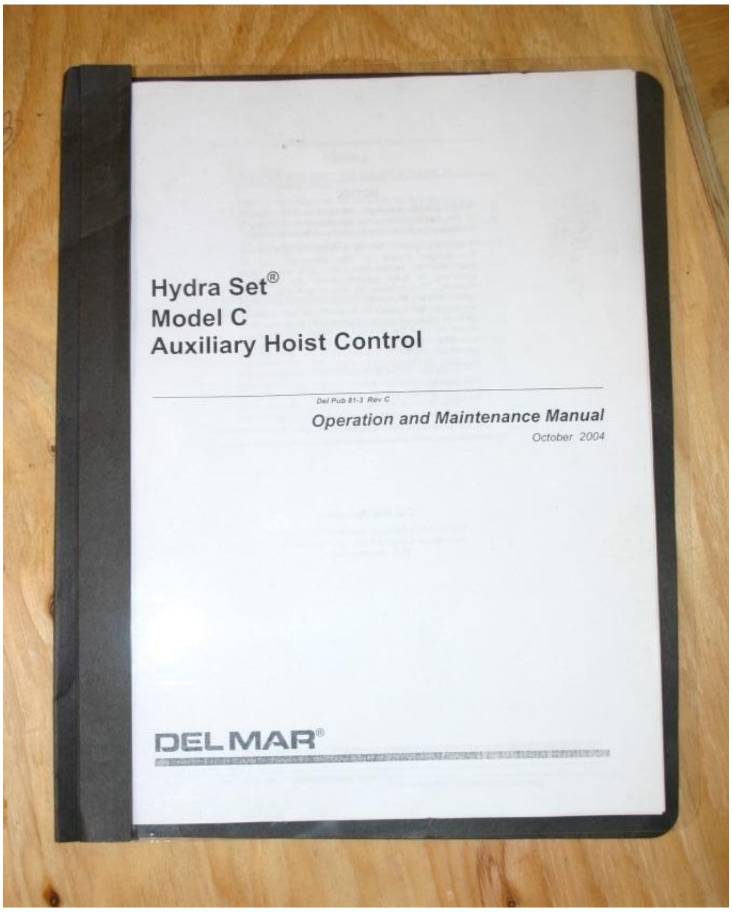


Figure 6 – User Manual of the Hydra-Set, Cover

3 MATERIAL, SPARES, EQUIPMENT, INSTRUMENTS AND TOOLS

In this section all spare parts and material are considered, as well as all tools for use operations and maintenance interventions. Besides being a “list”, this section helps to identify material and tools and further shows where to find them in the packing.

3.1 Material

Here below follows a short list of the material that has been made available for maintenance interventions, as below better detailed:
- nr. 3 Lubcon grease jars
- 5m power cable Sabix, 5x2.5mm2
- 30m supply cable Sabix, 8x0.75mm2
- 25m can bus, Belden 2x0.5mm2, shielded
- nr. 10 DB9 male connectors for the Axial Force Actuators and the Axial Fixed Points
- nr. 10 DB9 female connectors for the Axial Force Actuators and the Axial Fixed Points
- nr. 10 100 mA fuses for the Power Distribution Boxes

3.2 Spares

3.2.1 Spare Sub-Systems

The following spare sub-systems are available:
- nr.6 Axial Force Actuators:
  - one belongs to the first ring and has a blue cover,
  - three belong to either the second or the third ring and have red covers,
  - two belong to the fourth ring and have black covers;
- nr.1 Axial Fixed Point;
- nr.1 Lateral Fixed Point.

3.2.2 Spare Parts

The following spare parts are available:
- nr. 3 Load Cells for the Axial Force Actuators
- nr. 5 Motors for the Axial Force Actuators
- nr. 6 Pads for the Safety Devices
- nr. 10 Helical Springs for the Axial Force Actuators
- nr. 10 Spiral Springs for the Axial Force Actuators
- nr. 10 Flexible Plates for the Axial Force Actuators
- nr. 2 Sets of Bearings for the Astatic Levers (2 type NTN 6000 ZZ, 2 type NTN 6007 ZZ and 2 type NTN 6010 ZZ)
- nr. 2 Universal Joints for the Astatic Levers, as by drawing OACN01.0424.022.0

In case one or more spare parts have been used, it is recommended to restore the stock so to always have spare parts and material available.

The supplier of the parts or material can be found in the Assembly Drawings. Here follows just the reference data for each company.

supplier	reference and contact data
FAG	SCHAEFFLER ITALIA S.R.L. Strada Provinciale 229 Km 17, 28015 MOMO (NO) ITALY http://www.schaeffler.it, Tel. +39 0321929211, Fax +39 0321929300
SKF	SKF ITALIA Via A. Kuliscioff 37, 20152 Milano (MI) ITALY http://www.skf.com, e-mail: luca.baruffi@skf.com Tel. +39 0248327202, Fax. +39 024159563
Honeywell	BURSTER ITALIA S.R.L. Via Cesare Battisti 25, 24035 Curno (BG) ITALY www.burster.it, e-mail: burster@burster.it Tel: +39 035618120, Fax: +39 035618250 ref. Mr. Acquati
NTN	NTN-WALZLAGER (EUROPA) Via Maestri del Lavoro 3, 40138 Bologna www.ntn-europe.com, sales-it@ntn-europe.com Tel. +39 (0) 051 / 53 51 74, Fax +39 (0) 051 / 53 84 92
Burster	BURSTER ITALIA S.R.L. Via Cesare Battisti 25, 24035 Curno (BG) ITALY www.burster.it, e-mail: burster@burster.it Tel: +39035618120, Fax: +39035618250 ref: Mr. Acquati
Omnitrack	FITA S.R.L. Via Torricelli 12B, 37135 Verona (VR) ITALY www.fita.net, e-mail: info@fita.net Tel. +39 0458200955, Fax. +39 0458200953
INA	SCHAEFFLER ITALIA S.R.L. Strada Provinciale 229 Km 17, 28015 MOMO (NO) ITALY http://www.schaeffler.it Tel. +39 0321929211, Fax +39 0321929300
Portescap	DELTA LINE S.R.L. Via Ludovico il Moro 4/B, Palazzolo Pitagora MI3 City, 20080 Basiglio Milano ITALY www.deltaline-europe.com Tel: +39 0292276400, Fax: +39 0292276409 Ref: Mr. Simone Sacco, e-mail: simone@delta-line.it
DS Europe	DS EUROPE S.R.L. Via F.Russoli 6, 20143 Milano (MI) ITALY www.dseurope.com, e-mail: dseurope@dseurope.com Tel. +39 028910142, Fax: +39 0289124848 ref: Mr. Corbetta / Mr. Piardi
Bosch-Rexroth	BOSCH-REXROTH S.P.A. S.S. Padana Superiore 11 N°41, 20093 Cernusco sul Naviglio (MI) ITALY http://www.boschrexroth.it, e-mail: info@boschrexroth.it

	Tel: +39 02 92 365 1, Fax: +39 02 92 365 500
Télémécaniqe	SCHNEIDER ELECTRIC S.P.A. Via Circonvallazione Est 1, 24040 STEZZANO (BG) ITALY www.schneiderelectric.it Tel. +39 035 415 11 11, Fax: +39 035 415 28 66
Motovario	FITA S.R.L. Via Torricelli 12B, 37135 Verona (VR) ITALY www.fita.net, e-mail: info@fita.net Tel. +39 0458200955, Fax. +39 0458200953
Montesi	MONTESI PAOLO & C. S.n.c. Viale N.Baldini 51/53, 48010 Cotignola (RA) ITALY http://www.montesi.it Tel. 0545 40162, Fax. 0545 41621

Table 4 – Reference information to order commercial parts

3.3 Equipment

Here below is a list of the main tools and instruments made available with the shipping of the supply:

a) Manual Remote Control (axial support system)
b) Test Bench (static tests of the axial force actuators)
c) Reference Weights (axial force actuators: load cell verification)
d) Reference Load Cells (axial force actuators, safety devices, integrated cell)
e) Test Equipment (dynamic tests of the axial force actuators)
f) Lateral Support Calibration Box (+Chiave tagliata)
g) Spacers (calibration of the safety devices)

In the intent of making it easier for the operator, the different tools and instruments have been gathered in different boxes, as hereafter better detailed.

The **Calibration Box** is foreseen to carry out the calibration of the Lateral Supports (astatic levers). Besides power and conditioning electronics, it includes the four load cells necessary for the calibration of the astatic levers whose design does not include any load cell.

Figure 7 – Calibration Box with load cells and cables

Together with the calibration box, a **modified key** in included, which helps access the screws of the delrin spacer of the arm of the astatic levers. The modified key in is contained in a coffer, referred to as **coffer nr.1**.

The **Motor Control Handset** can be found in the wooden box of the axial support system, together with the spares of the axial force actuators and axial fixed points.

Figure 8 – Motor Control Handset (axial support system)

Special Spacers have been designed for the purpose of calibrating the Safety Devices. These are represented in the picture below and are also contained in a coffer nr.1.

[MISSING PICTURE: spacers being produced]

Figure 9 – Spacers for gap adjusting (safety devices)

The **Test Bench** used to test the static behaviour of the axial force actuators is also included in the shipping.

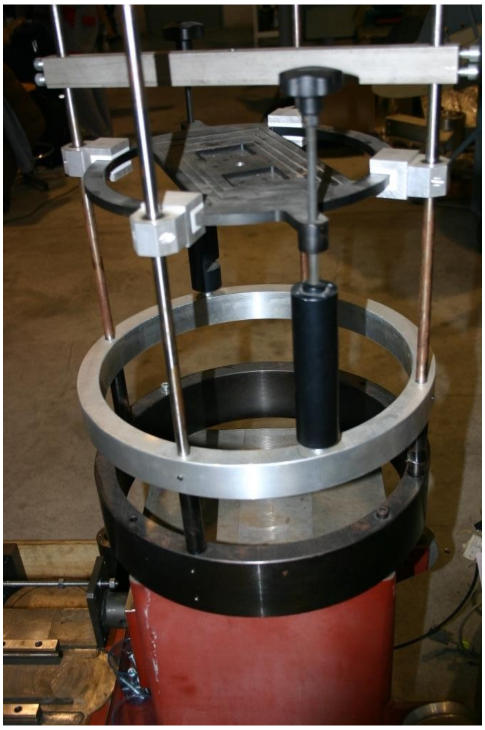


Figure 10 –Test Bench for the static tests (T1 and T3) of the axial force actuators

Together is the **Test Equipment** used to verify the dynamic performance of the axial force actuators: hard steel plates, screws and pipe segments, as you can see in the figure below, that also shows how to use these parts.

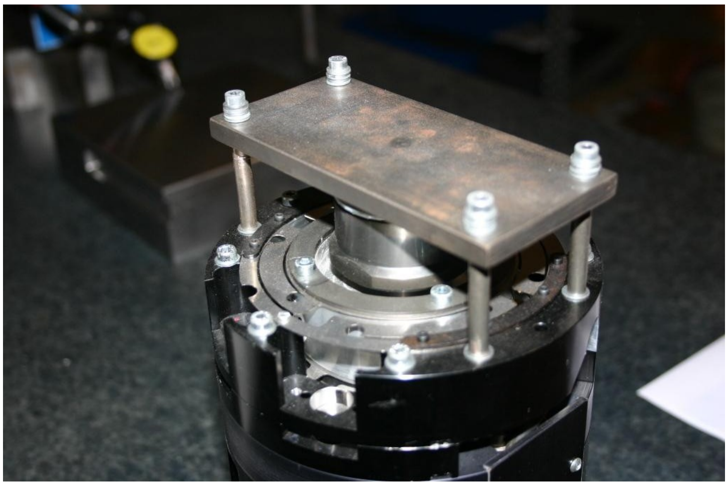


Figure 11 –Test Equipment for the dynamic test (T2) of the axial force actuators

The **Reference Weights** are also shipped together: they had been mostly used to load the axial force actuators, but also to verify the good reading of the reference load cells before calibrating the astatic levers.

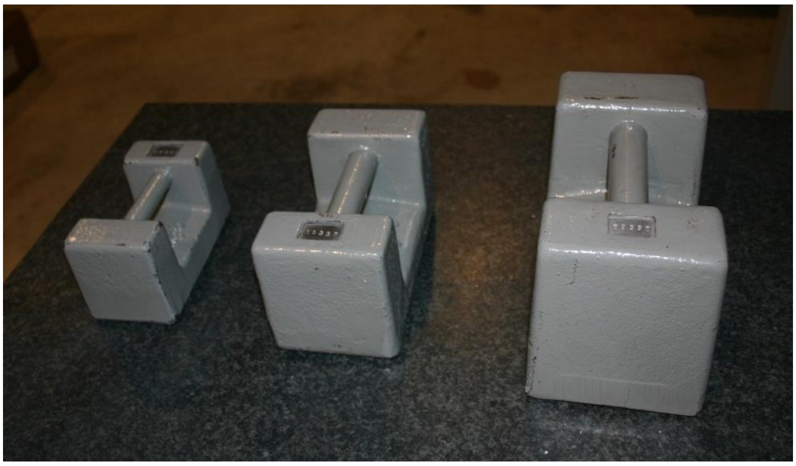


Figure 12 – 5Kg, 10Kg and 20Kg reference weights

The load cells used in the course of the different tests of the M1 Support system are of course sent together:
- high accuracy, 50kg full scale Load Cell, used to test the static behaviour of the axial force actuators below 400N
- 220kg full scale Load Cell, used to test the static behaviour of the axial force actuators in critical conditions
- 3000kg full scale Load Cell, used to test both the safety devices and the movement allowed to the mirror dummy inside the mirror cell

Figure 13 –high accuracy, 50kg full scale Load Cell

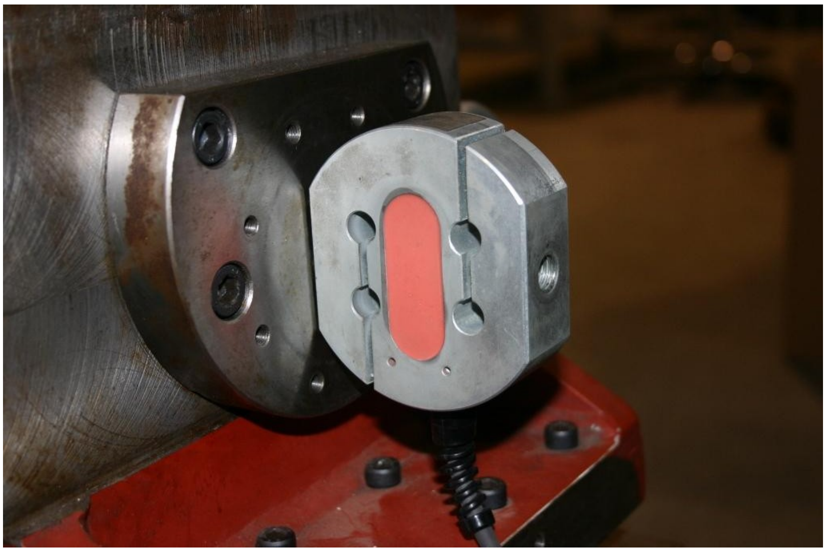


Figure 14 – 220kg full scale Load Cell

Figure 15 – 3000kg full scale Load Cell

3.4 Instruments and Tools

In order to carry out the use operations and the maintenance interventions, the necessary tools and instrumentation must be made available. In the case of some specific operations or interventions, special tools are required that are not available on the market. It is both the case of commercial tools that have been slightly modified for the sake of accessibility or the case of a special design to help a specific purpose.
Because electronics is part of the design, also basic electrical instrumentation must be made available. Besides this, specific electronics is foreseen for specific purposes.

3.4.1 General Purpose Tools and Instruments

General purpose tools and electric instruments are not included in the shipping, but are equally necessary to carry out the use operations and maintenance interventions later described in this manual. It is recommended to provide the following:
- digital multimeter
- power supplies for Load Cells
- feeler gauges
- gauges endowed with magnetic base
- nr. sets of keys for hexagonal seats
- nr. 2 sets of fork keys

3.4.2 Special Tools and Instruments

In the course of the integration of the axial force actuators in the mirror cell a special tool was developed to make the operation easier. It is the matter of **Support Rods** with a shaped end that fits in the bottom seat of the axial force actuators. Two extension rods were produced and are available, with different lengths, so to accommodate different mounting situations.
The extension rods are contained in a coffer, referred to as coffer nr.2.

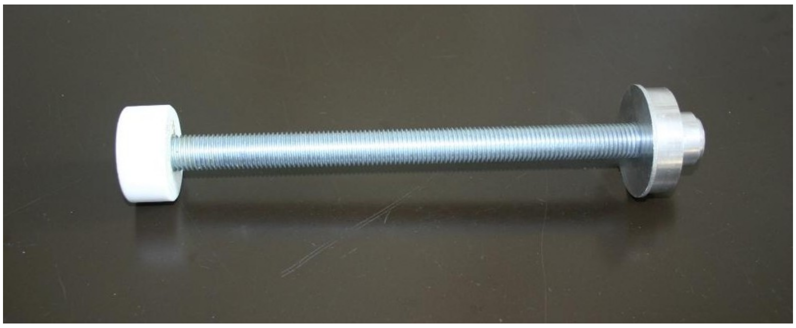


Figure 16 – Support Rod for the axial force actuators and axial fixed points

The operation of mounting and demounting the Safety Devices needs for a set of tools, some of which are obtained by simple adaptation of commercial tools. In coffer nr. 2are also nr. **3 sets of the following keys**:

- L-shaped M8 allen spanner
- modified M8 allen spanner
- T-haped M8 allen spanner

Safety devices nr. 0501 and 0515 are out of reach to the operator to adjust and fix the position of the pads, therefore two special tools have been developed.
Because the radial position adjustment system is based on a commercial reducer, a **Shaft Extension** has been designed having a shaft-like end with key matching the motor reducer.
An additional **Key Extension** has been foreseen with a “screw-driver” interface in order to turn screws and nuts of safety devices 0501 and 0515 and then tighten the nuts.

Figure 17 – Shaft Extension (bottom) and Key Extension (top) for safety devices 0501 and 0515

The Shaft Extension and the Key Extension for safety devices 0501 and 0515 are also contained in coffer nr.2

4 SUPPORT SYSTEM DESCRIPTION

The entire Primary Mirror Support System consists of the following sub-systems:

- nr. 81 Axial Force Actuators
- nr. 3 Axial Fixed Points
- nr. 24 Astatic Levers
- nr. 3 Lateral Fixed Points
- nr. 28 Safey Devices
- Harness

Each mechanical sub-system is applied onto the cell at the appropriate seat machined in the mirror cell, as described in the following sub-sections.

4.1 AXIAL FORCE ACTUATORS

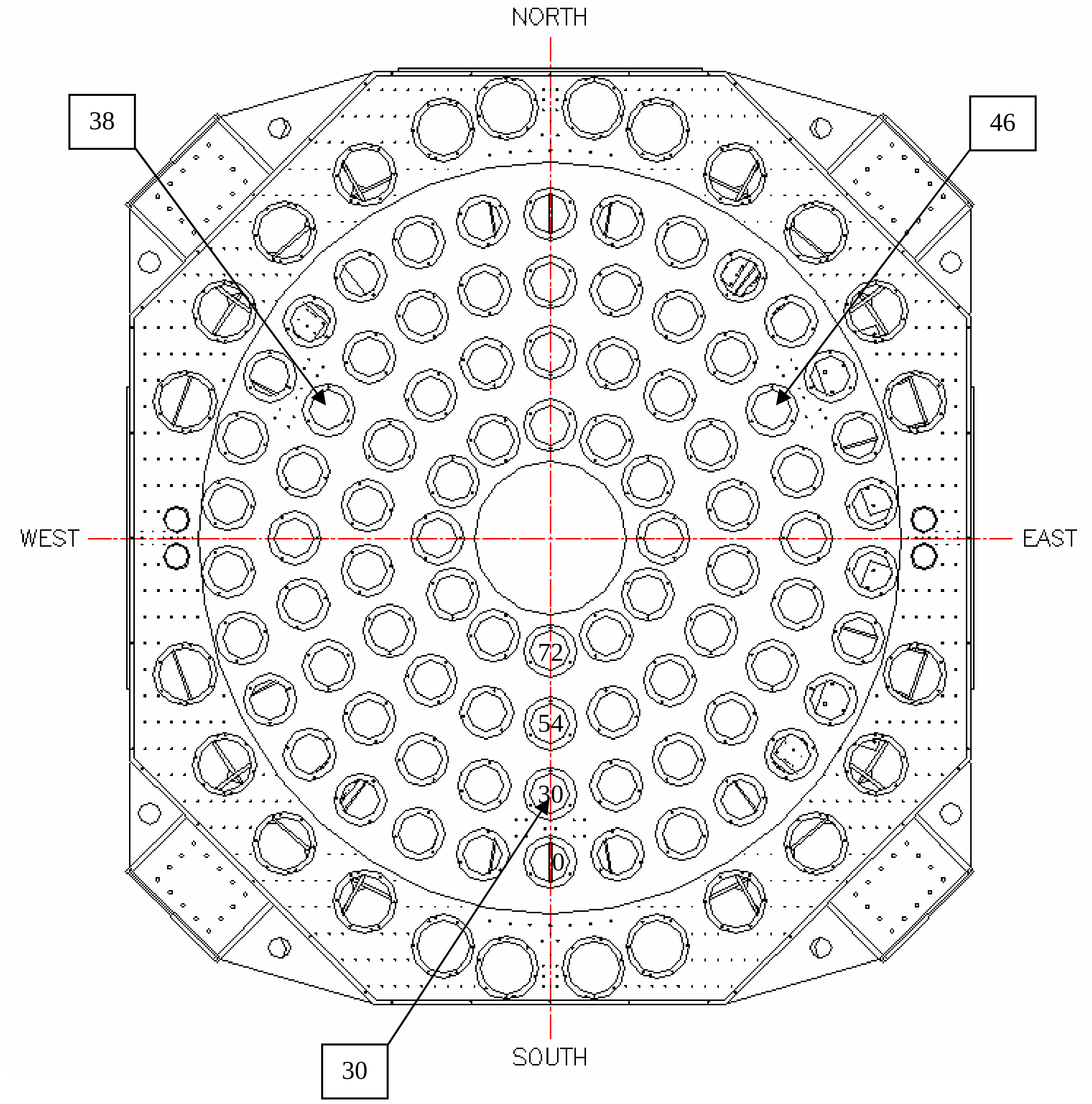


Figure 18 – Axial Force Actuators and Axial Fixed Points: arrangement, top view

The 81 axial force actuators are applied at the related 81 seats obtained in the central aera of the mirror cell by machining. As shown in the figure, the seats are divided in four rings: the innermost ring is referred to as ring nr. 1 and has 12 seats, next outwards is ring nr. 2 with 18 seats; then comes ring nr.3 that has 24 seats and eventually the outward ring with 30 seats, referred to as ring nr.4. Every seat is identified by a number as follows:

- ring nr.1: seats from 72 through 83 numbered in clockwise direction
- ring nr.2: seats from 54 through 71 numbered in clockwise direction
- ring nr.3: seats from 30 through 53 numbered in clockwise direction
- ring nr.4: seats from 0 through 29 numbered in clockwise direction

The axial force actuators that belong to ring nr.1 are different from those of rings nrs 2, 3 and 4; further the axial force actuators that belong to rings nrs 2 and 3 are different from those of ring nr. 4. Every single actuator is identified by a label with an identification code, that is structured as follows:

- from OACN01.**0101**.0**72**.0 through OACN01.**0101**.0**83**.0 for the axial force actuators of ring nr.1
- from OACN01.**0102**.0**54**.0 through OACN01.**0102**.0**71**.0 for the axial force actuators of ring nr.2
- from OACN01.**0103**.0**31**.0 through OACN01.**0103**.0**37**.0, from OACN01.**0103**.0**39**.0 through OACN01.**0103**.0**45**.0 and from OACN01.**0103**.0**47**.0through OACN01.**0102**.0**53**.0 for the axial force actuators of ring nr.3
- numbers OACN01.**0103**.0**30**.0, OACN01.**0103**.0**38**.0 and OACN01.**0103**.0**46**.0 refer to the three axial fixed points and also belong to ring nr.3
- from OACN01.**0104**.0**00**.0 through OACN01.**0104**.0**29**.0 for the axial force actuators of ring nr. 4

WARNING

It is not possible to mount an Axial Force Actuator of ring nr.1 in either ring 2, 3 or 4.
Accordingly, it is not possible to mount an Axial Force Actuator of ring nr.2 or nr.3 in either rings nr.1 or nr.4.
Again, it is not possible to mount an Axial Force Actuator of ring nr.4 in any of rings nr.1, 2 or 3.

In order to quickly identify the ring an axial force actuator belongs to, the bottom cover of each axial force actuator has been painted with different colours, namely:

BLUE PAINT COVER: axial force actuators to be mounted on ring nr.1

RED PAINT COVER: axial force actuators to be mounted on ring nr.2 and nr.3

BLACK PAINT COVER: axial force actuators to be mounted on ring nr.4

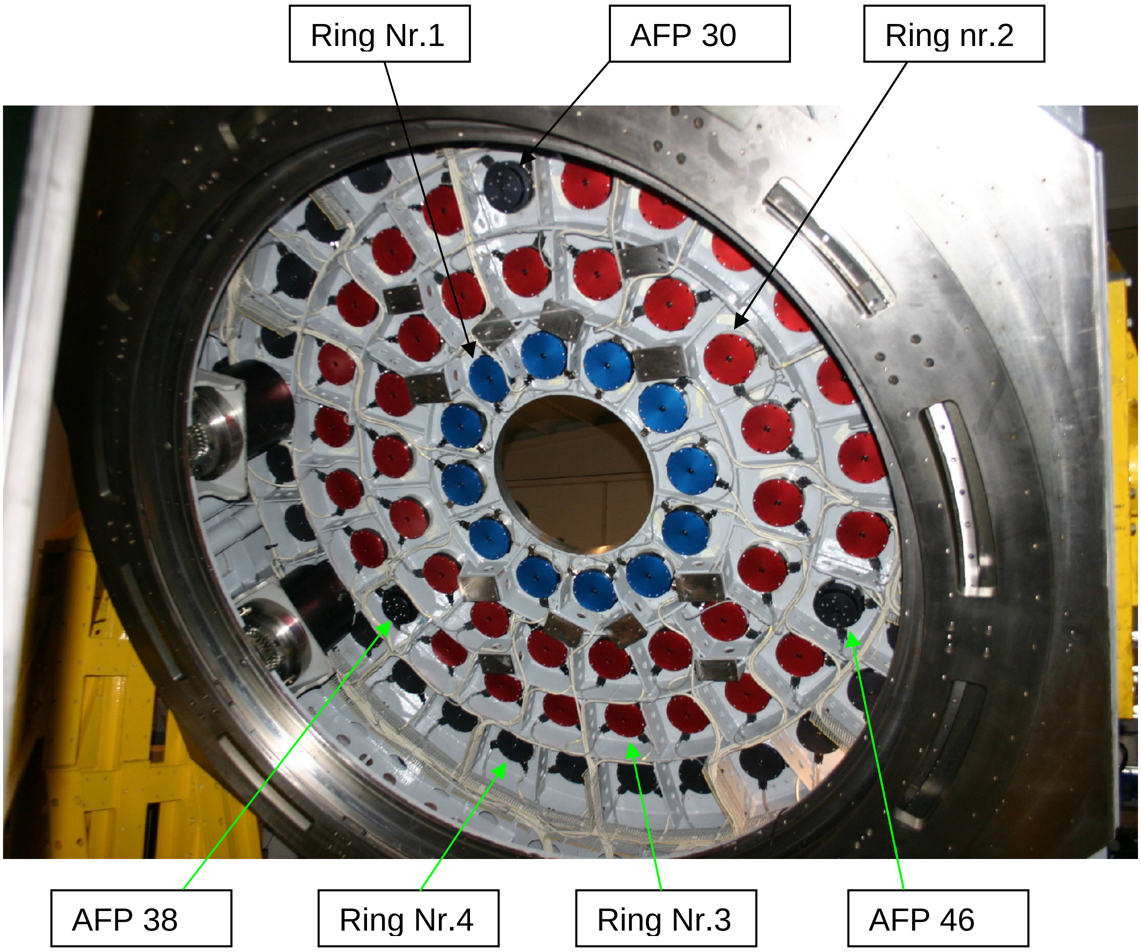


Figure 19 – Axial Force Actuators and Axial Fixed Points (AFP) position

For ease of reference, the cross section views of the three different types of axial force actuator are reported in the next pages: the total height of each type is shown so to ease the identification.

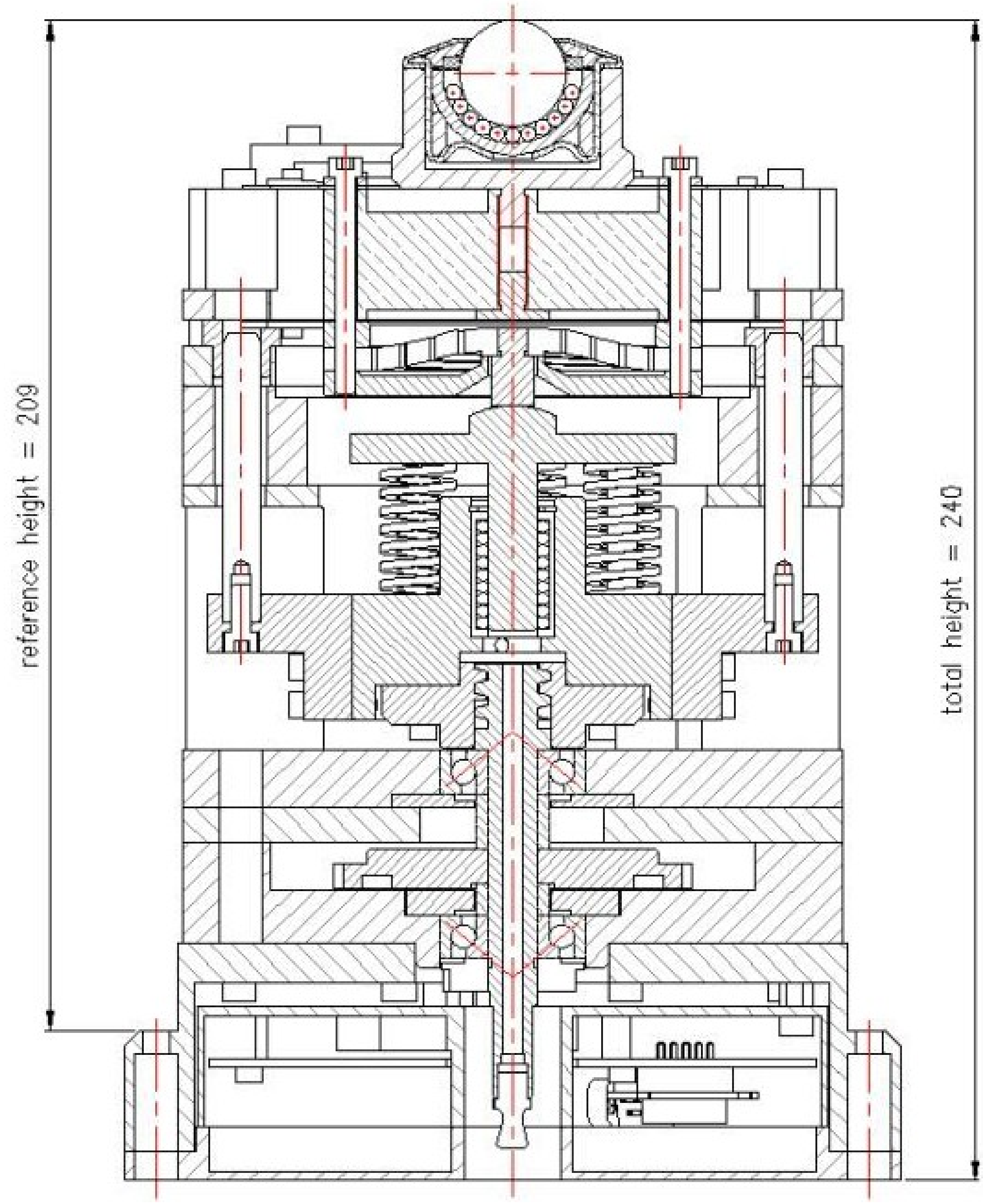


Figure 20 – Axial Force Actuator to be mounted on ring nr.1, cross section view

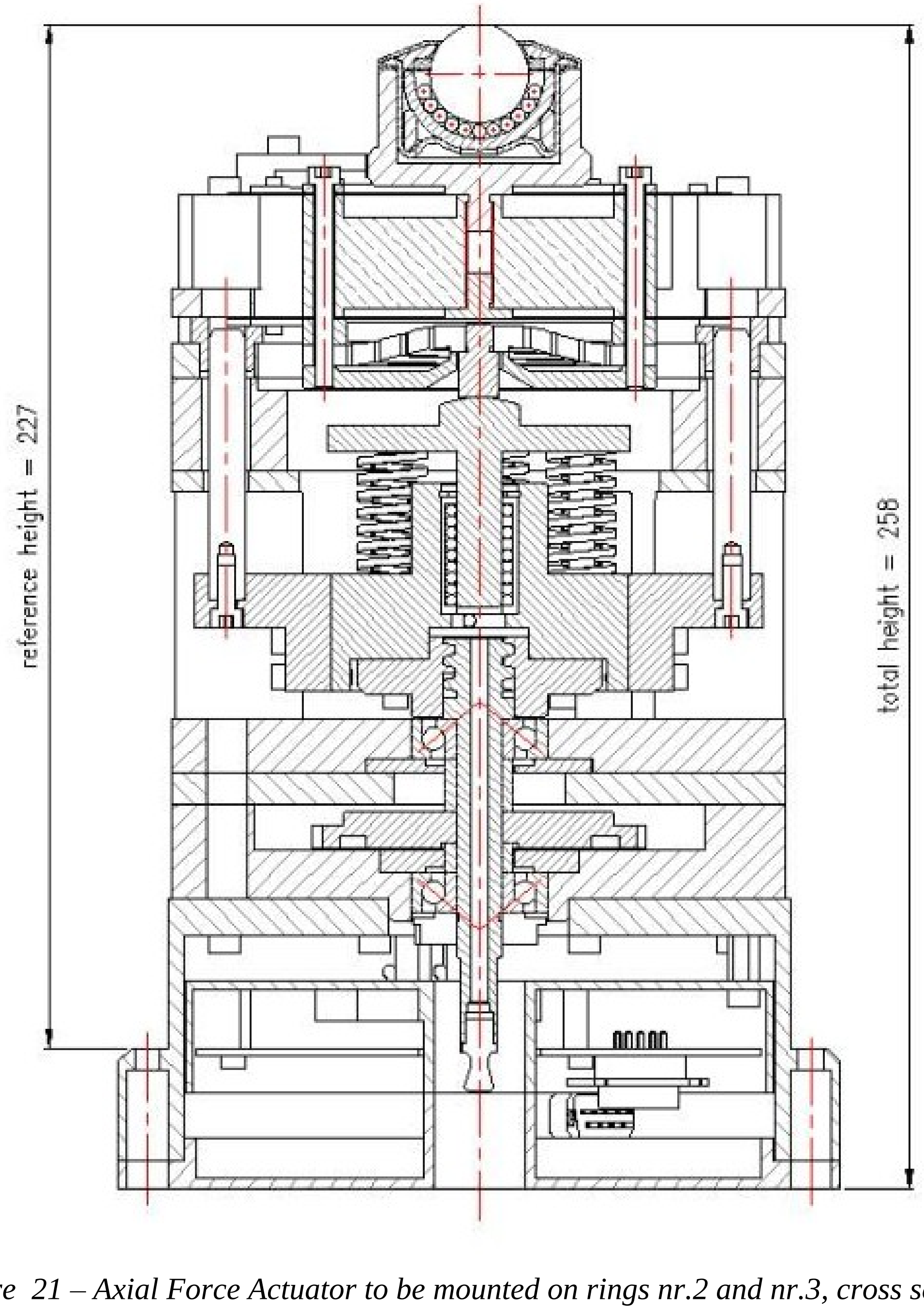


Figure 21 – Axial Force Actuator to be mounted on rings nr.2 and nr.3, cross section view

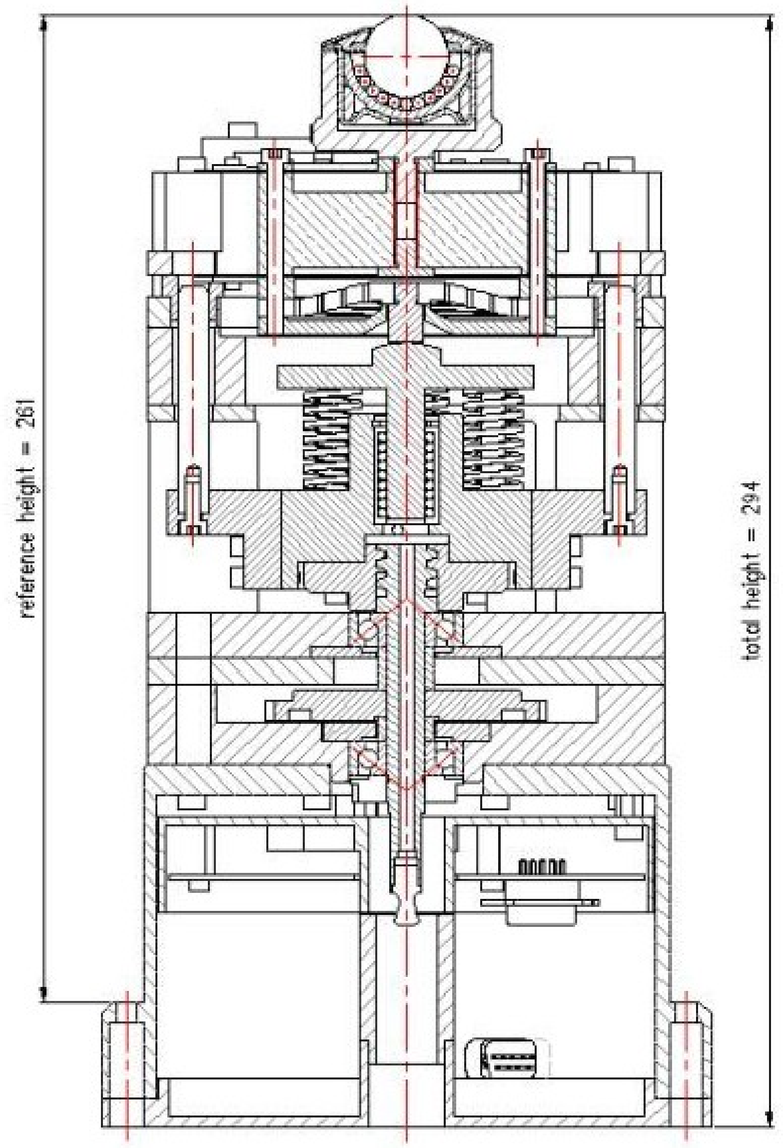


Figure 22 – Axial Force Actuator to be mounted on ring nr.4, cross section view

An interface flange is placed inside each seat, with the purpose of supporting the axial force actuators as well as the axial fixed points. The interface flanges are marked on the top with the same number as the seat they are in.
The height of each single flange has been adjusted, therefore it is not possible to move it to a different seat or to replace it with a different one.

WARNING

The Axial Force Actuators can be mounted and removed in both cases, when the mirror is integrated in the cell and when the mirror is removed.
In case the mirror is integrated in the cell, it is allowed to remove just one axial force actuator. So, before removing a second actuator, it is mandatory that the previous one has been restored in the mirror cell.
In case the mirror is not integrated, it is no problem to remove no matter how many actuators, but they must be mounted back in the mirror cell before the next mirror integration.

4.1.1 How to Mount the Axial Force Actuators

A special tool, referred to as **Support Rod**, has been realised to make it easier to mount the axial force actuators in their seat in the mirror cell: it helps keeping the actuator centered in the seat. It is available in two units of different lengths, to bets accommodate the operator position. Anyway the operation must be carried out by **two mechanical technicians** together.

The actuators must be mounted onto the mirror cell from the bottom side, preferably with an altitude rotation of 90° (cell pointing to zenith), as this gives no extra difficulties to the operators. Follow these steps to mount an actuator:

a) verify that the axial force actuator is completely assembled (don't forget to check the two brackets at the top of the actuator) and that the actuator height corresponds to colour of the bottom cover and it is within tolerance
b) place and center the body of the actuator inside the hole of the flange
c) turn the body of the actuator, taking the electrical connectors as reference
d) plug and fix with the appropriate screws the two electrical connectors (of the cell harness) to the base of the actuator
e) choose either support rod and push the actuator up to make the interface surface of the actuator touch the bottom surface of the interface flange
f) in case the mirror is integrated, the Axial Force Actuator should be in contact with the flange without exerting any force (this proves that the actuator has the right height);
g) otherwise, in case the mirror is not integrated, verify the actuator height by inspection, using the actuator next by as reference
h) while the one technician holds the actuator in contact with the interface flange, the other one fits the M5 screws and locks the actuator on the interface flange (four screws are necessary)

The same procedure holds for the Axial Fixed Points

WARNING

pay attention and mount the axial force actuators on the right ring

4.1.2 How to Remove the Axial Force Actuators

The same **Support Rods**, as in the previous sub-section, are to be used for the purpose of removing the axial force actuators from the mirror cell.
As for the integration, **two mechanical technicians** must be employed to remove the actuators.

The actuators must be removed from the bottom side of the mirror cell, keeping the cell horizontal, that is at an altitude angle of 90°, as follows:

a) as the one operator holds the actuator in contact with the interface flange, the second one will release the M5 screws so to free the actuator from the interface flange
b) lower down the actuator, out of the interface flange
c) release the screws that fix the electrical connectors and unplug them from the base of the actuator

The same procedure holds for the Axial Fixed Points

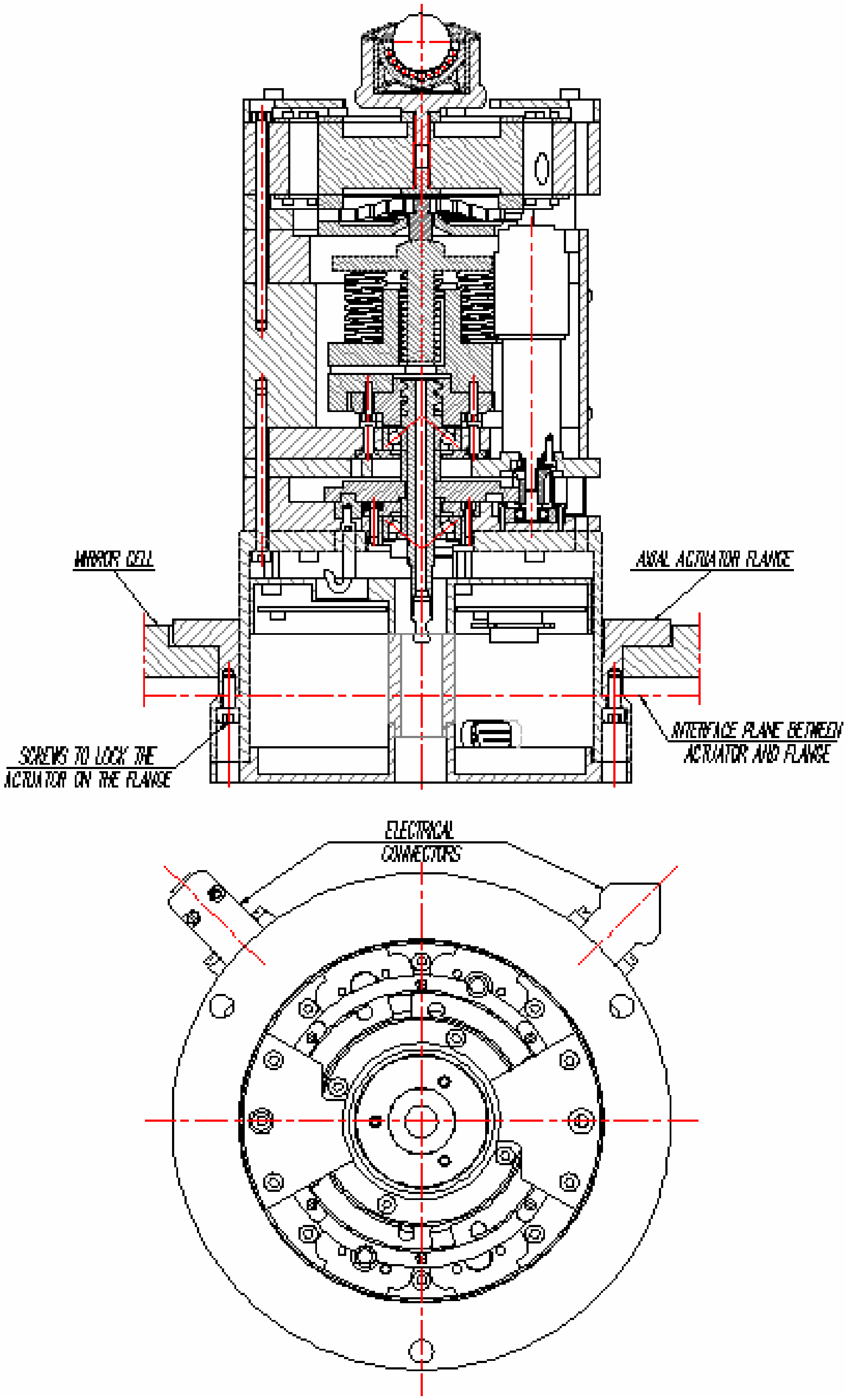


Figure 23 – Axial Force Actuator, cross section view and top view

Figure 24 – Axial Force Actuator held with the Support Rod

4.1.3 How to Verify the Height of the Axial Force Actuators

The axial force actuators have a given height by design and have been realised within the required tolerance. The type of actuator is quickly identified by the color of the bottom cover; this can be easily checked with the overall height, as shown in the pictures before.
In this section, it is not the matter of the overall actuator height, but we refer to the height difference:
- from the reference plane that couples with the interface flange
- to the top of the sphere

So, the height of the three different types of axial force actuators are give in the table that follows.

ring	**height [mm]**
1	209.00 ± 0.15
2	226.50 ± 0.15
3	226.50 + 0.20
4	261.00 ± 0.20

Table 5 – axial force actuators (and axial fixed points), reference height table

In case any part of an axial force actuator or axial fixed point is removed and assembled back, then the height should be checked with the help of Johnson blocks and a gauge.

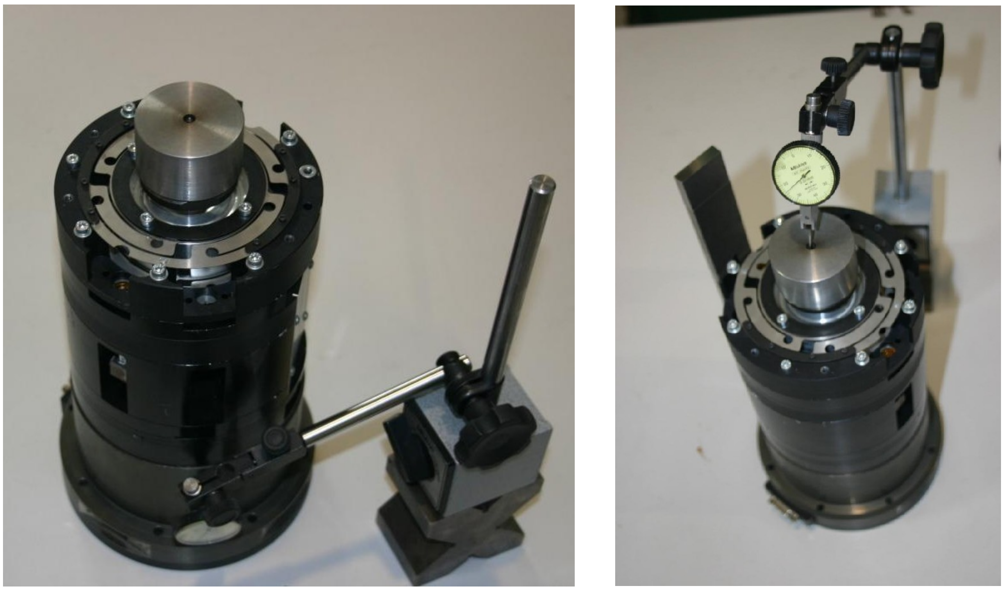


Figure 25 – Measuring the Height of the Axial Force Actuators with respect to the reference plane, by differentiation

Once the axial force actuator or axial fixed point has been placed back onto the mirror cell, the height of the top of the sphere should be measured again, but this time from the references available at the top of the mirror cell:

- in case of intervention on one single actuator, it is possible to quickly check whether the height is correct by simply measuring the height of the tops of the spheres of the actuators in the neighbourhood, but belonging to the same ring;
- in case of intervention on any actuator of the 1st, 3rd or 4th ring, it is possible to measure the height with reference made to the average height of any three actuators of the 2nd ring;
- in case of intervention on any actuator of the 2nd ring (but this holds as well for actuators of the 1st, 3rd and 4th ring), the height must be referred to the plane defined by three reference points, taken on the surface of the cell at the interface with any three astatic levers spaced 120° around the z axis

The theoretical height of the Axial Force Actuators are reported in the table below:

ring	from the cell interface with the astatic levers	from any three actuators of ring nr.2
1	-5.3 $\pm$ 0.15	-16.9 $\pm$ 0.15
2	11.6 $\pm$ 0.15	0 $\pm$ 0.15
3	35.5 $\pm$ 0.15	23.9 $\pm$ 0.15
4	65.6 $\pm$ 0.15	54.0 $\pm$ 0.15

Table 6 – axial force actuators (and axial fixed points), functional height table

4.1.4 Disassembly of an Axial Force Actuator

In case of any intervention that requires to open and disassemble an axial force actuator, more information is necessary, which can be easily found in the Design Description (VST-TRE-TOM-22303-2010, 2.1), in the Assembly Procedure (VST-TRE-TOM-22303-2081, 2.0) or derived from the Drawing (OACN01.01.000.0).

4.2 AXIAL FIXED POINTS

The Axial Fixed Point can be mounted onto the mirror cell or removed from it no matter whether the mirror is integrated in the cell or not.
In the case of mirror integrated in the cell, it is allowed to remove just one axial fixed point at a time. This means that you have to restore the one axial fixed point back onto the mirror cell before removing the next one.
If the mirror is not integrated in the cell, all three axial fixed points can be removed, but they must be all placed back before integrating back the mirror in the cell.
The 3 axial fixed points are mounted, as shown in the figures that follow, in three seats that belong to the ring nr.3, namely at seats nrs. 30; 38 and 46.
The axial fixed points are interchangeable, even though each one is identified by a code, as follows:

OACN01.**02**.0**30**.0: axial fixed point placed at position nr.30, in ring nr.3

OACN01.**02**.0**38**.0: axial fixed point placed at position nr.38, in ring nr.3

OACN01.**02**.0**46**.0: axial fixed point placed at position nr.46, in ring nr.3

The bottom cover of all axial fixed points is painted black, so they can be recognised from the bottom of the mirror cell thanks to their

BLACK PAINT COVER.

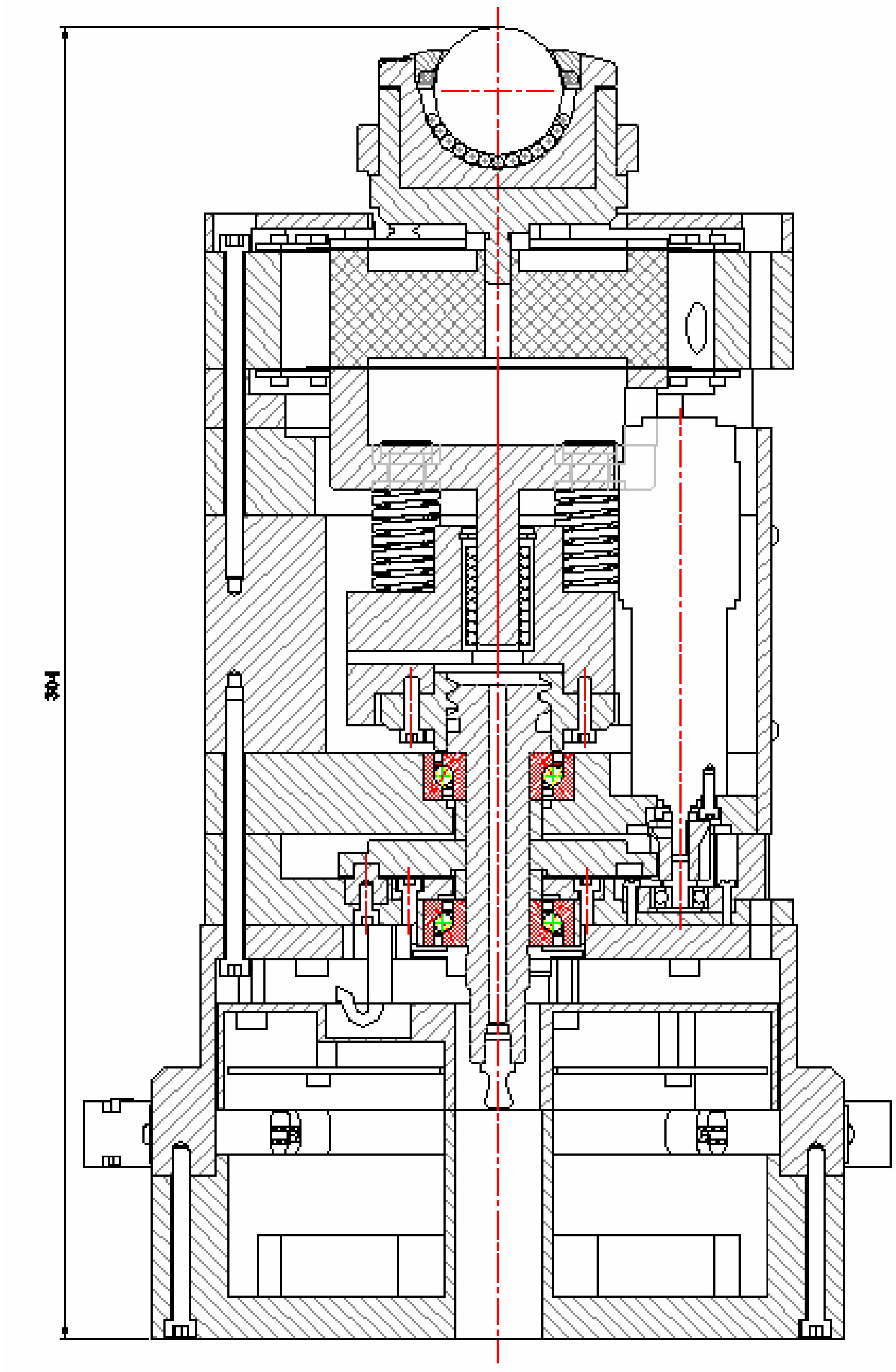


Figure 26 – Axial Fixed Point, cross section view

4.2.1 How to Mount an Axial Fixed Point

The same **Support Rods** are used as for the axial force actuators and **two mechanical technicians** are necessary for the mounting operation.

Just like the axial force actuators, the axial fixed points must be mounted onto the mirror cell from the bottom side, preferably with an altitude rotation of 90° (cell pointing to zenith). The procedure how to mount them onto the mirror cell is very similar to that of the axial force actuators, as hereafter detailed:

a) verify that the axial fixed point is completely assembled (don't forget to check the two brackets at the top) and that the height is within tolerance
b) place and center the body of the axial fixed point inside the hole of the flange
c) turn the body of the axial fixed point, taking the electrical connectors as reference
d) plug and fix with the appropriate screws the two electrical connectors (of the cell harness) to the base of the axial fixed point
e) choose either support rod and push the axial fixed point up to make the interface surface of the axial fixed point touch the bottom surface of the interface flange
f) while the one technician holds the axial fixed point in contact with the interface flange, the other one fits the M5 screws and locks the actuator on the interface flange (four screws are necessary)

4.2.2 How to Verify the Height of an Axial Fixed Point

The axial fixed points have a given height by design and have been realised within the required tolerance. In this section, height is referred to as the height difference of the top of the sphere from the reference plane that couples with the interface flange. This is 241.00 +/- 0.20 [mm].

In case any part of an axial force actuator or axial fixed point is removed and assembled back, then the height should be checked with the help of Johnson blocks and a gauge, just like shown in the case of the axial force actuators.

4.2.3 How to Remove an Axial Fixed Point

Just like the mounting operation, either **Support Rod** must be used by **two mechanical technicians** for the removal operation of an axial fixed point.
Once again, the axial fixed points must be removed from the bottom of the mirror cell when the azimuth angle is 90° (cell pointing to zenith). Proceed as follows:

a) as the one operator holds the axial fixed point in contact with the interface flange, the second one will release the M5 screws so to free the axial fixed point from the interface flange
b) lower down the axial fixed point, out of the interface flange
c) release the screws that fix the electrical connectors and unplug them from the base of the axial fixed point

4.2.4 Disassembly of an Axial Fixed Point

In case of any intervention that requires to open and disassemble an axial fixed point, more information is necessary, which can be easily found in the Design Description (VST-TRE-TOM-22304-2011, 3.1), in the Assembly Procedure (VST-TRE-TOM-22300-2123, 1.0) or derived from the Drawing (OACN01.02.000.0).

4.3 LATERAL FIXED POINTS

As shown in the figure below, the three Lateral Fixed Points are mounted onto the top side of the mirror cell with three supports and are applied to the lateral surface of the mirror, along the tangent direction, through three lateral special invar pads.
They are all identified by code, as follows:

OACN01.**03**.0**01**.0: Lateral Fixed Point to be mounted at the North position

OACN01.**03**.0**02**.0: Lateral Fixed Point to be mounted at the South-West position

OACN01.**03**.0**03**.0: Lateral Fixed Point to be mounted at the South-East position

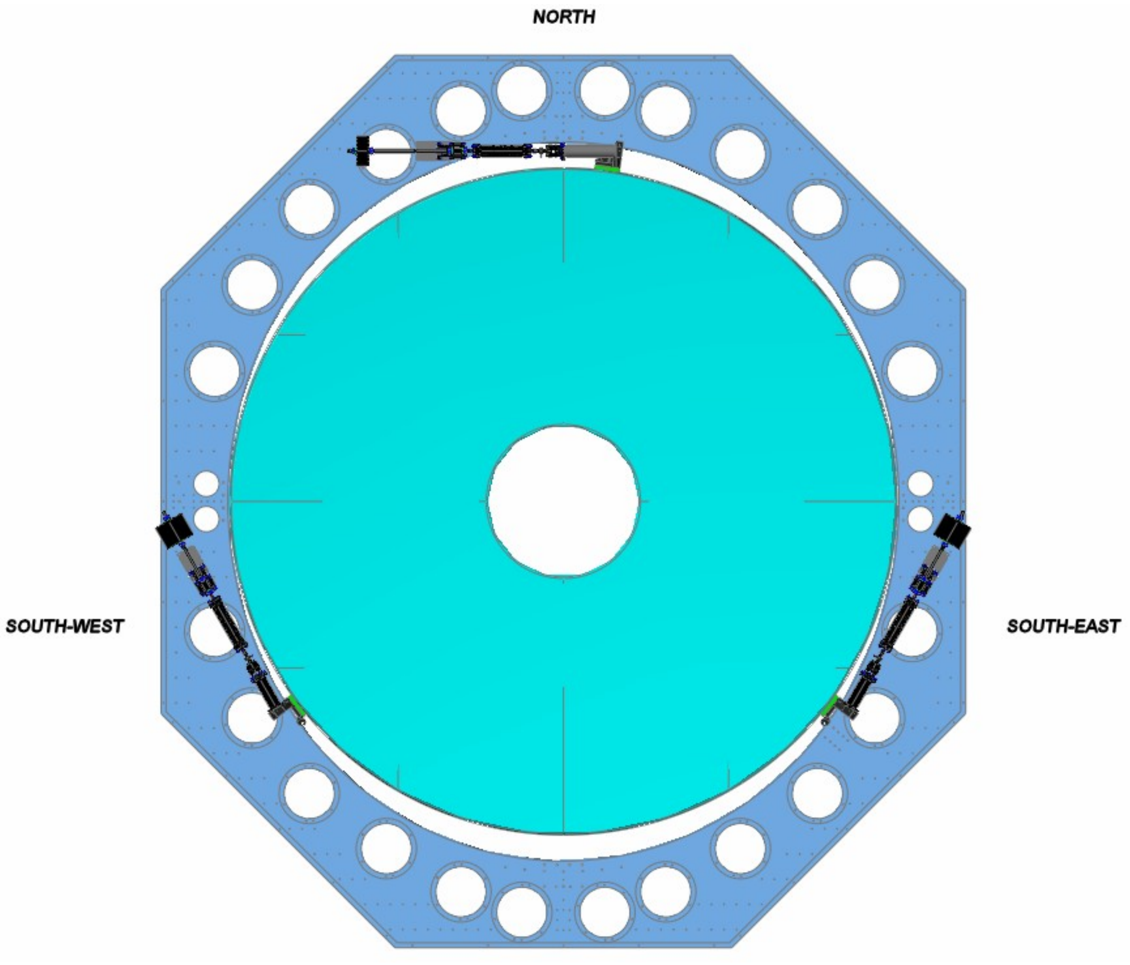


Figure 27 –Lateral Fixed Points, positions

The Lateral Fixed Points foreseen for the South-West and South-East positions are interchangeable, while the Lateral Fixed Point at North is different, so it cannot replace any of the first two and vice-versa.

The purpose of the three Lateral Fixed Points is to constrain the position of the mirror along the X-Y axes and around the Z axis, as well as to allow repositioning the mirror in the mirror cell during the integration phase. This is the reason why the Lateral Fixed Points must be fixed to the cell before integrating the mirror.

The three Lateral Fixed Points must be the first sub-systems to be connected to the mirror during the integration phase; in the same way, they must be the last sub-systems to be removed from the mirror when removing the mirror from the cell.

4.3.1 How to Mount the Lateral Fixed Points

Within this scope, two different situations are to be considered:
a) the mirror is integrated in the mirror cell
b) the mirror is removed from the mirror cell

In both cases, two mechanical technicians together must carry out the operation.

The Lateral Fixed Point must first be fixed onto the column support (which is already fixed on the mirror cell) and then it gets either:
- fixed to the mirror, when this is integrated in the telescope
- or it is beard by the appropriate fork support (which is already fixed on the mirror cell) if the mirror is removed from the cell

The altitude rotation angle must be 90° (cell pointing to zenith).

Proceed with the following steps when the mirror has already been integrated in the cell:

a) fix the support of the lateral fixed point onto the top side of the mirror cell
b) place the lateral fixed point and verify that the counterweight is oriented as shown in the figure below
c) while the one operator holds the lateral fixed point in contact with the column support (that is fixed on the mirror cell), the second one can fix the flange of the flexible joint with M6 screws to the column support
d) as the same operator bears the lateral fixed point, the second one fits a spacer between lateral fixed point (invar tube side) and the mirror pad
e) fix the lateral fixed point together with the spacer to the mirror pad with M6 screws

BEWARE NOT TO TOUCH THE HEADLESS SCREWS IN THE MIRROR PAD

f) fit and screw the connector of the load cell

WARNING

The flange of the invar tube won't be in contact with the flat surface of the lateral special pad, but will couple with the theoretical plane given by the four headless screws fixed in the pad itself.
THESE FOUR HEADLESS SCREWS MUST BE UNSCREWED FOR NO REASON. ONLY QUALIFIED PERSONNEL CAN DO IT, IN ORDER TO ADJUST THE MIRROR OPTICAL AXIS.

Proceed with the following steps if the mirror has been removed from the cell:

a) verify that the counterweight is oriented as shown in the picture below
b) while the one operator holds the lateral fixed point in contact with the column support (that is fixed onto the mirror cell), the second one can fix the flange of the flexible joint to the column support with M6 screws
c) let the fork support (already mounted onto the mirror cell) bear the lateral fixed point
d) fit and screw the electrical connector of the load cell

This same procedure must be followed when integrating the mirror in the cell, so to gave the three lateral fixed point ready to be connected to the three special lateral invar pads of the mirror.

4.3.2 How to Remove the Lateral Fixed Points

The removal operation of a lateral fixed point must be carried out by two **mechanical technicians**. In case the mirror is integrated in the cell, the lateral fixed point must be removed from the mirror as first and only then from the column support (which is fixed onto the mirror cell).
In any case, the altitude rotation angle must be 90°, that is the cell points to zenith.

Proceed with the following steps when the mirror has already been integrated in the cell:

a) release the electrical connector of the load cell
b) while the one operator holds the lateral fixed point, the second one can release the M6 screws that fix the flange of the flexible joint to the invar extension;
c) as the first operator keeps holding the lateral fixed point, the second one releases the M6 screws that fix it to the column support and removes the lateral fixed point from the mirror cell.

Remark that the invar extension is still mounted on the mirror at the end of this operation.

4.3.3 Disassembly of a Lateral Fixed Point

In case of any intervention that requires to open and disassemble a lateral fixed point, more information is necessary, which can be easily found in the Design Description (VST-TRE-TOM-22300-2013, 3.1), in the Assembly Procedure (VST-TRE-TOM-22300-2124, 1.0) or derived from the Drawings (OACN01.0301.000.0 and OACN01.0302.000.0).

4.3.4 How to Adjust the Lateral Fixed Points

Positioning the Mirror in relation to the axis of the De-Rotator can be achieved by changing the length of one or more Lateral Fixed Points by turning the four headless screws in the special mirror pad:
a) remove the 8 screws that fix the flange of the invar extension to the mirror pad;

b) then drive the 4 headless screws to move the theoretical plane to the right position;.
c) only then, fix the invar extension back to the mirror pad with the 8 screws just removed;
d) verify whether the required position has been reached.

Remark that this is an iterative procedure, so it is likely that more than one positioning is necessary.

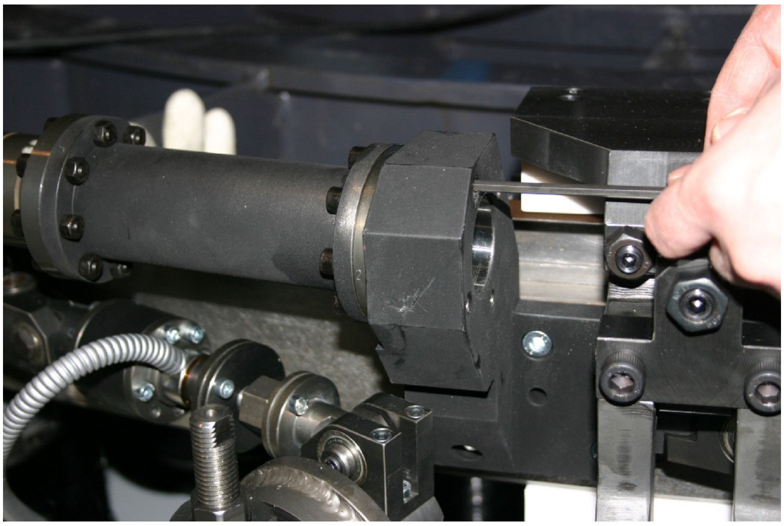


Figure 28 – Lateral Fixed Point, adjusting the length

After completion of the adjusting operation (length) of the three lateral fixed points, it is mandatory to verify the gap of the flexible joints: both flexible plates at both sides of all lateral fixed points. For each flexible plate, the gap is given by two head-less screws (locked by the related counter-screws) and is less than the available room: it should be around 0.5mm.

Figure 29 – Lateral Fixed Points, verifying the gap of the four flexible plates

4.4 ASTATIC LEVERS

The 24 Lateral supports, also referred to as Astatic Levers (AL), are located at the top side of the mirror cell, as shown in the next picture. They are connected to the lateral surface of the mirror through 24 lateral invar pads; they are fixed on the mirror cell through their own supports, mounted in the 24 seats worked on the top side of the mirror cell. Each astatic lever has an identification number, structured as follows:

from OACN01.**0401** to OACN01.**0424**, increasing counter-clockwise, starting from the West position, as highlighted in the following picture.

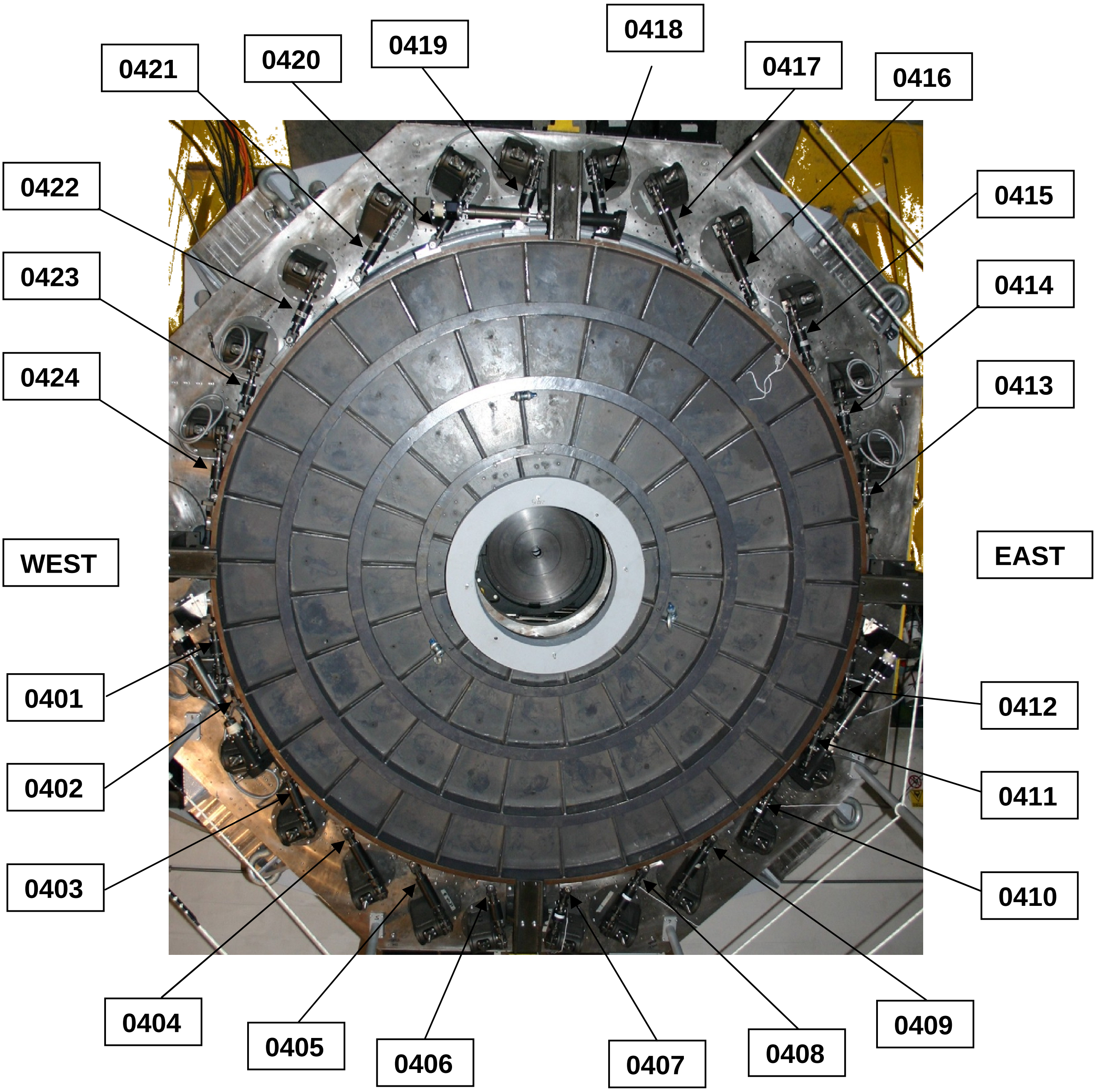


Figure 30 – Lateral Supports (astatic levers), positions

The purpose of the 24 astatic levers is to counter-balance the mirror weight component along the Y direction, that shows when the telescope rotates around altitude axis. To obtain this, it is necessary to have already applied the 24 astatic lever supports in their seats on the mirror cell. Astatic levers nr.1, 2, 11, 12, 13, 14, 23 and 24 have a special device at the end of the arm, that will be connected to a removable lateral invar pad. These pads are always fixed onto the invar pads glued on mirror lateral surface and **cannot be demounted** from the mirror. All others have the removable lateral invar pad directly jointed to the end of the arm and **cannot be disconnected** from the arm, unless in case of damage. These pads have to be fixed on invar pads glued on mirror lateral surface during the mirror integration.
Astatic levers nr. 3, 10 and 18 are connected on special invar pads, the same that are used by the three lateral fixed points; this is why these lateral supports will be the first ones to be connected to the mirror during integration.
All astatic lever supports are already mounted on the mirror cell and cannot be demounted, unless in case of damage (e.g. counterweight or bearings that support the shaft). The only way to remove the supports of astatic levers nr. 1, 2, 3, 10, 11, 12, 13, 14, 15, 22, 23 and 24 is to first remove the mirror from the cell for accessibility reasons; as for the supports of the other astatic levers, it is possible to remove the support without removing the mirror.
The arms of all astatic levers can be installed or removed without removing the mirror.

4.4.1 How to Remove an Astatic Lever

In case of removal of an astatic lever, refer to the identification number because two different procedures are foreseen, as hereafter described.

4.4.1.1 Removing the Supports of Astatic Levers nr. 1, 2 ,3, 4, 9, 10, 11, 12, 13, 14, 15, 16, 21, 22, 23 and 24

As mentioned before, in order to remove the supports of these levers, it is necessary to remove the mirror and operate from the area occupied by the axial force actuators. Otherwise, accessibility from outside the mirror cell wouldn't be enough
Within the group of astatic levers discussed in this paragraph, it is necessary to proceed in two different ways, depending on the shape of the counterweight.

- astatic levers nr. 1, 3, 10, 12, 13, 15, 22 and 24:

a) verify any possible interference between the support and the safety devices: if it is the case, it is first necessary to remove all safety devices that cause interference;
b) remove the fork (see picture) from the shaft (see picture) and then remove the arm from the support;
c) remove the M8 screws that fix the support to the mirror cell;
d) lift the support so to see the counterweight, then hold it concentric with the hole axis while lifting it and do so until the counterweight has come out of the hole enough to allow the support to rotate in direction internal to the mirror cell.
e) remove the support of the astatic lever from the mirror cell.

- astatic levers nr. 2, 4, 9, 11, 14, 16, 21 and 23:

a) verify any possible interference between the support and the safety devices: if it is the case, it is first necessary to remove all safety devices that cause interference;
b) remove the fork (see picture) from shaft (see picture) and then remove the arm from the support;
c) remove the M8 screws that fix the support to the mirror cell;
d) measure and record the height of the tip of the bar (see picture) with respect to the top surface of the mirror cell;
e) release the two headless screws (see picture) just the necessary to unlock, along the radial direction, the bar that supports the counterweight
f) Unscrew the locking bar nut
g) release the special nut (see picture) to unlock the regulation shaft (see picture)
h) release the regulation shaft: in this way the bar will move down until the counterweight leans in a plate inside the mirror cell. When the counterweight has been leaned unscrew completely from the bar the regulation shaft.
i) Lift the support until it comes out from its mirror cell centring and then rotate the support towards the center of the mirror cell, so to allow taking the support out from the bar. Keep on taking the support out until it has completely come out from the bar.
j) Now it is possible to remove the support of the astatic lever from the mirror cell.

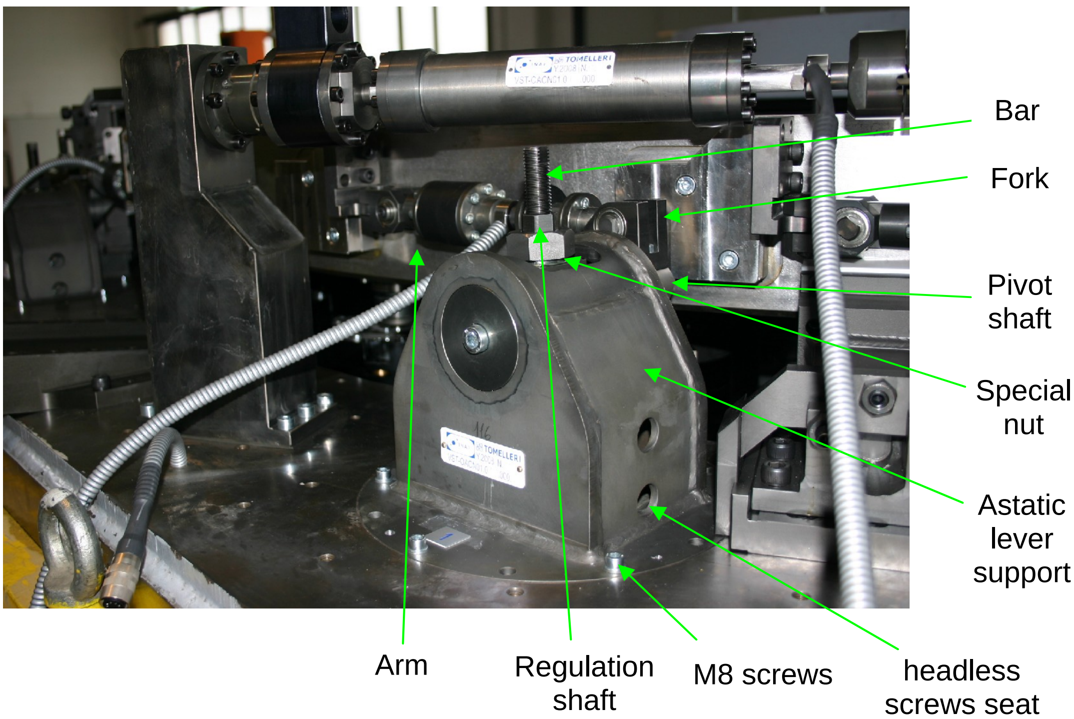


Figure 31 –Astatic Lever Support, type removable with mirror removed

4.4.1.2 Demounting the support of astatic levers 5,6,7,8,17,18,19 and 20

To remove the supports of these astatic levers, as said before, it is not necessary to remove the mirror because it is possible to have adequate accessibility from the outside of the mirror cell.

a) verify any possible interference between the safety devices and the support to remove. If there are any, it is first necessary to remove all safety devices that cause interference.
b) unscrew the five M5 screws that fix the arm fork to the pivot shaft in order to remove the arm from the support
c) unscrew the M8 screws that fix the support to the mirror cell
d) lift the support to see the counterweight, hold it concentric with the hole axis and keep on lifting it until the counterweight has come out enough so to allow the rotation of the support towards the center of the mirror cell. Keep on taking the support out until the counterweight has completely come out of the holes.
e) now it is possible to remove the support of the astatic lever from the mirror cell.

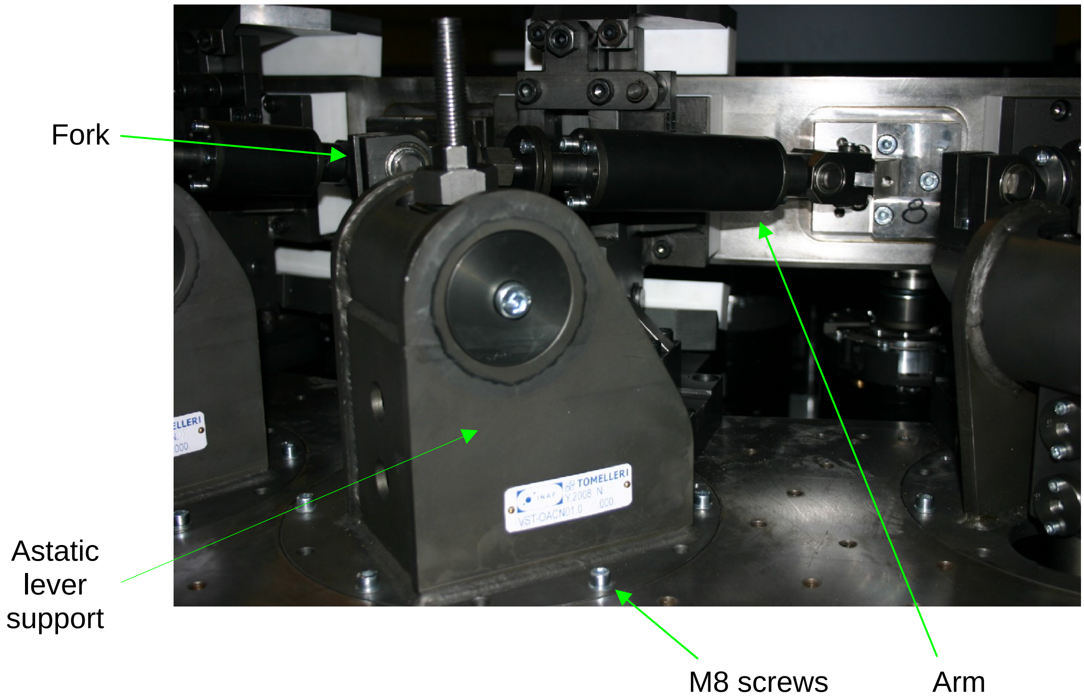


Figure 32 –Astatic Lever Support, type removable with mirror installed

4.4.2 How to Mount an Astatic Lever

To proceed with mounting the support of an astatic lever, it is necessary to verify the code because, depending on this one, two different procedures are foreseen to bre followed.

4.4.2.1 How to Mount the suppots of astatic levers 1, 2, 3, 4, 9, 10, 11, 12, 13, 14, 15, 16, 21, 22, 23 and 24

Inorder to mo mount the support of any of these astatic levers, it is necessary to have demounted the mirror because it is not possible to have the adequate accessibility from the outside of the mirror cell, conversely accessibility is assured if working from the area where the axial actuators are.
It is necessary to discern among the astatic levers of this group because the shape of the counterweight obliges to proceed in two different ways:

- astatic levers number 1, 3, 10, 12, 13, 15, 22 and 24

a) rotate the support of the astatic lever towards the center of the mirror cell, so to be able to insert the counterweight into the hole of the seat, in which the support has to be mounted. Let the counterweight move down in the hole and, when the encumbrance of the centrepiece allows it, straighten up the support so to centre it in its own seat.
b) rotate the support around the vertical axis so to position it with the right orientation, just like the arm must be repositioned.
c) screw in the M8 screws that fix the support to the mirror cell
d) position the arm fork on the pivot shaft and fix it with the five M5 screws
e) now it is possible to reposition the safety devices that have been removed to allow the removal of the support of the astatic lever.

- astatic levers number 2, 4, 9, 11, 14, 16, 21 and 23

a) rotate the support of the astatic lever towards the center of the mirror cell, so to be able to insert it in the counterweight bar that was previously inserted in the seat hole of the support. Pay attention that the bar has a lateral plane that has to be oriented along the direction of the two headless screws. Let the support move down along the bar and, when the encumbrance of the centrepiece allows it, straighten up the support to centre it in its own seat.
b) while the counterweight is being leaned inside the mirror cell, screw in the regulation shaft to the bar until it gets in contact with the pivot shaft of the support of the astatic lever. From this moment on, the bar and relative counterweight will start to move up. Continue to screw in the regulation shaft until the top of the bar will come up to the measure that has been noted before the removal.
c) screw in the two headless screws to radially lock the bar that supports the counterweight
d) screw in the special nut so to lock the regulation shaft
e) screw in the nut of the locking bar
f) screw in the six M8 screws to fix the support to the mirror cell

g) position the arm fork on the pivot shaft and fix it on with the five M5 screws
h) now it is possible to reposition the safety devices that have been removed to allow the removal of the supports of the astatic lever.

4.4.2.2 How to Mount the suppots of astatic levers 5, 6, 7, 8, 17, 18, 19 and 20

The supports of these astatic levers can be mounted from the outside of the mirror cell because there is adequate accessibility.

a) rotate the support of the astatic lever outwards of the mirror cell, so to be able to insert the counterweight into the hole of the seat, in which the support has to be mounted. Let the counterweight move down in the hole and, when the encumbrance of the centrepiece allows it, straighten up the support to centre it in its own seat.
b) rotate the support around the vertical axis so to position it in the right orientation, along which the arm must be repositioned.
c) screw in the six M8 screws that fix the support to the mirror cell
d) position the arm fork on the pivot shaft and fix it with the five M5 screws
e) now it is possible to reposition the safety devices that have been removed to allow the removal of the support of the astatic lever.

4.4.3 Lateral Support Assembly Procedure

To have further information see document VST-TRE-TOM-22300-2125

4.5 SAFETY DEVICES

The 28 safety devices (SD) are applied, as shown in fig.19, onto the top side of the mirror cell. They are applied on the top surface of the mirror cell.

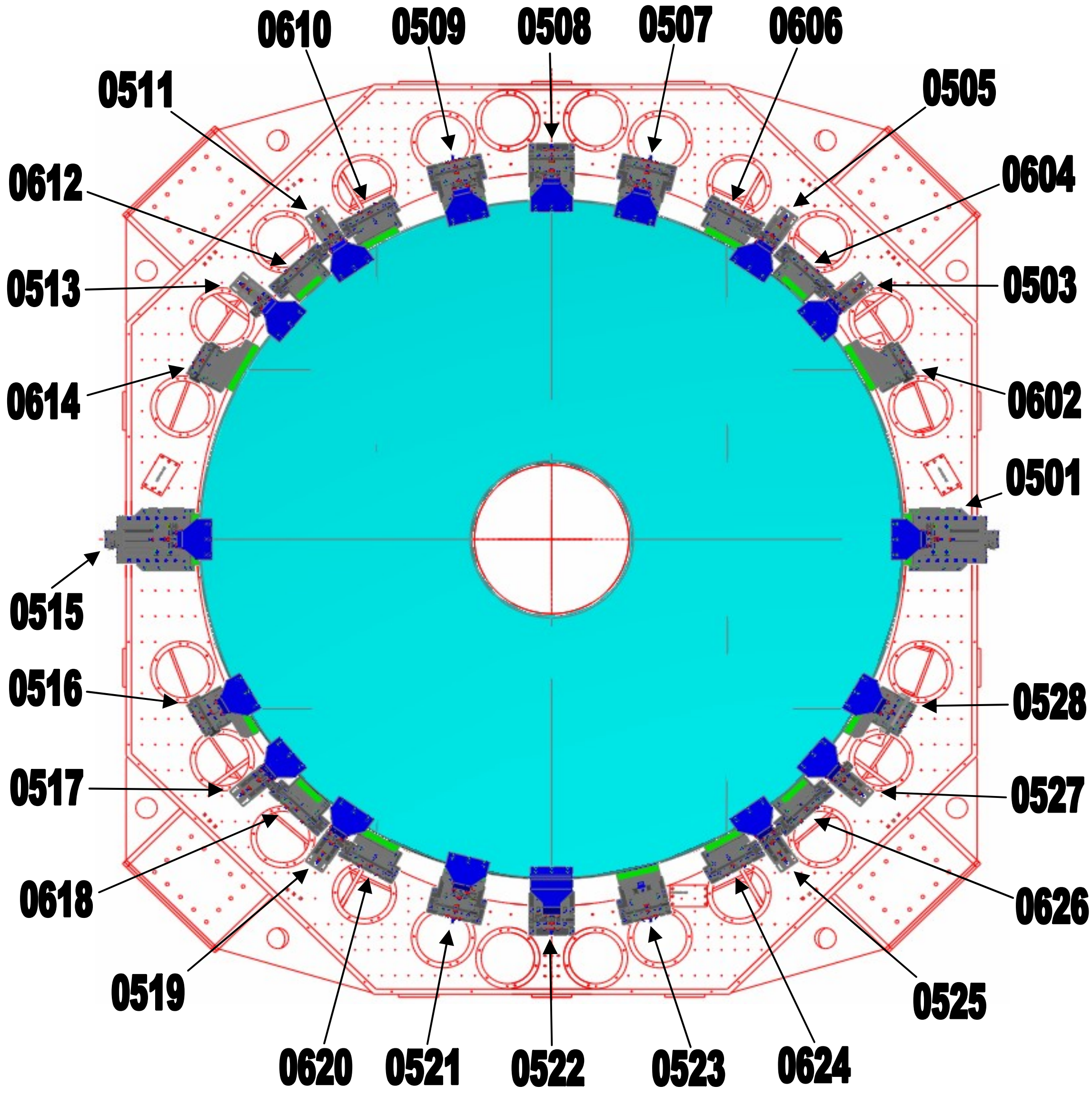


Figure 33 – Safety Devices, positions

4.5.1 Safety Devices Identification

The safety devices are divided in two groups:
- axial & radial safety devices
- just radial safety devices

The first group is identified by the first two numbers of the code being equal to 05; the second one is identified by the first two numbers of the code being equal to 06.
The numbering that defines all safety devices starts from the east point of the mirror cell and increases proceeding in anticlockwise direction.

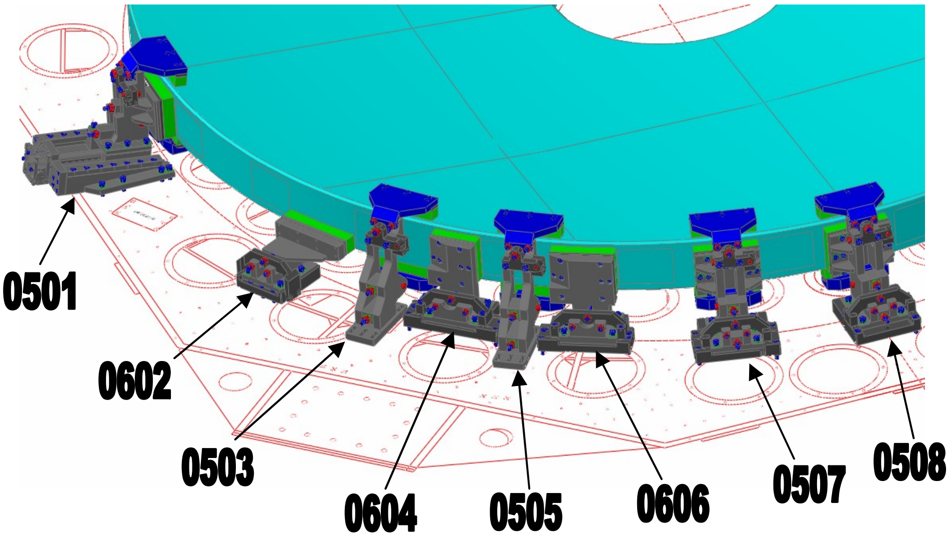


Figure 34 – Safety Devices, North-East section: positions

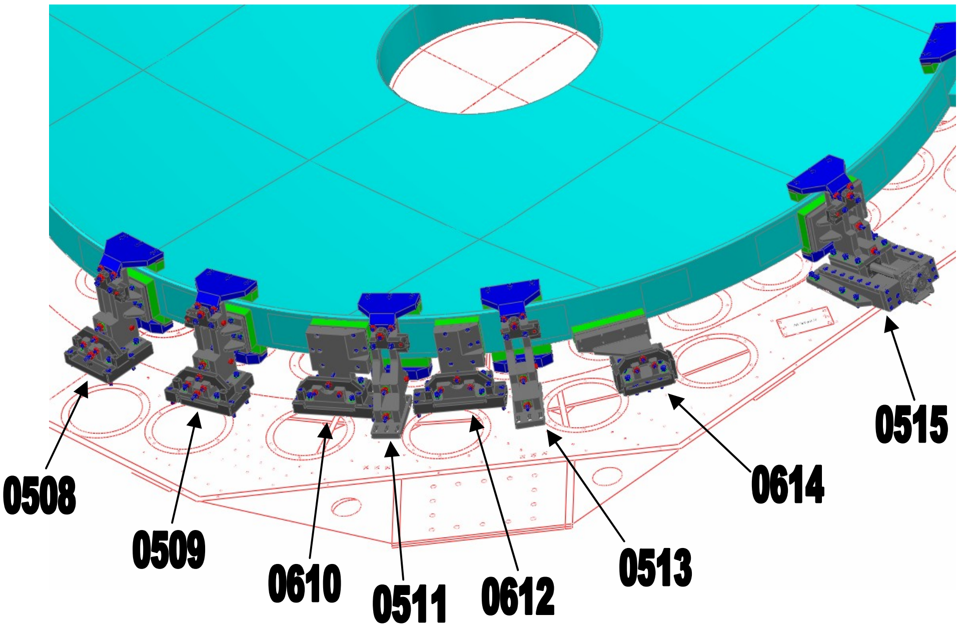


Figure 35 – Safety Devices, North-West section: positions

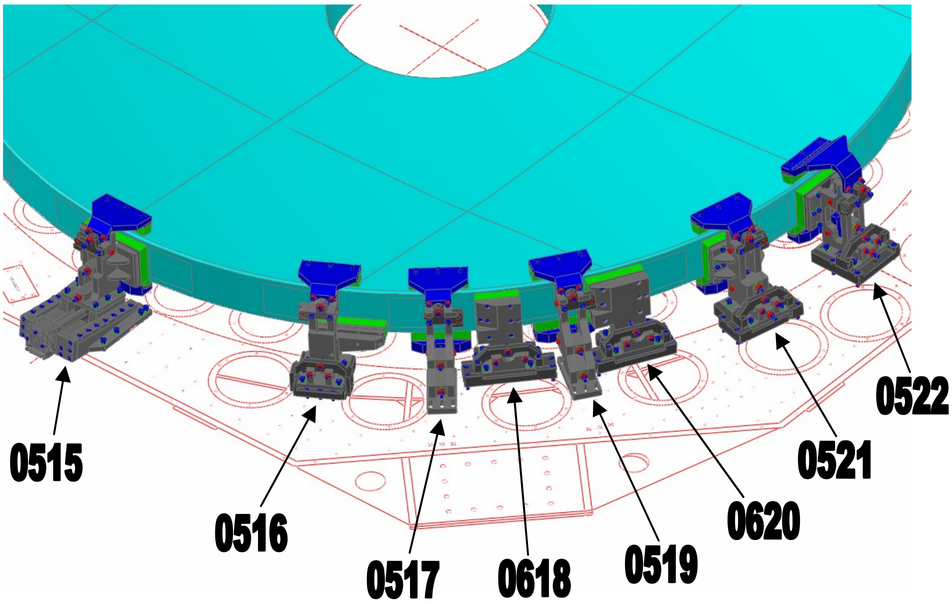


Figure 36 – Safety Devices, South-West section: positions

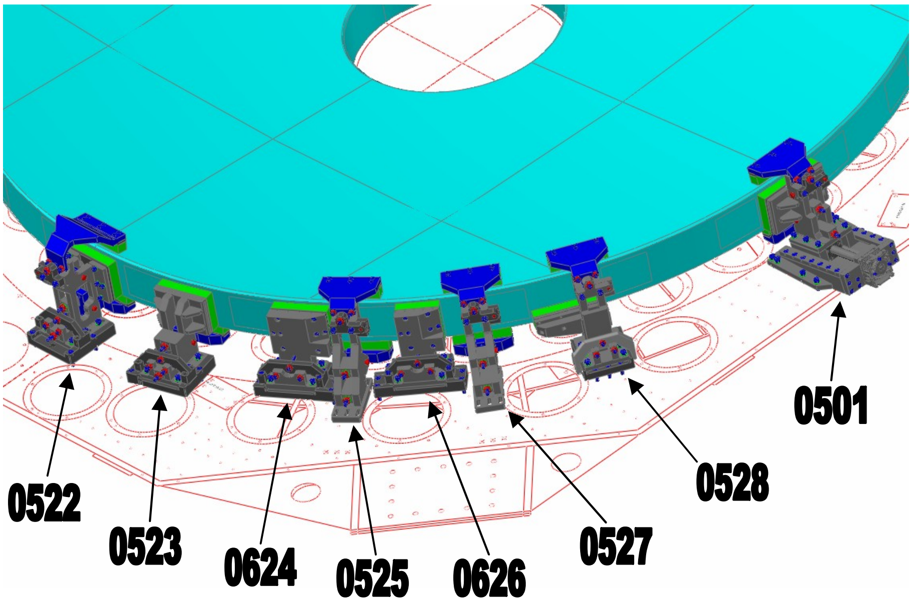


Figure 37 – Safety Devices, South-East section: positions

In the following list, for each code, are reported all letters T, B and L, that indicate the presence of the safety pads in the position Top, Bottom and Lateral; then, for each one, the elastomer pad surface foreseen (mm):

0501	T-B-L (160x30;160x30;200x115)	0515	T-B-L (160x30;160x30;200x115)
0602	L (200x40)	0516	T-L (160x30;200x40)
0503	T-B (160x30;160x30)	0517	T-B (160x30;160x30)
0604	L (120x115)	0618	L (120x115)
0505	T-B (160x30;160x30)	0519	T-B (160x30;160x30)
0606	L (160x115)	0620	L (160x115)
0507	T-B-L (160x30;160x30;160x115)	0521	T-B-L (160x30;160x30;160x115)
0508	T-B-L (160x30;160x30;160x115)	0522	T-B-L (160x30;160x30;160x115)
0509	T-B-L (160x30;160x30;160x115)	0523	B-L (160x30;160x115)
0610	L (160x115)	0624	L (160x115)
0511	T-B (160x30;160x30)	0525	T-B (160x30;160x30)
0612	L (120x115)	0626	L (120x115)
0513	T-B (160x30;160x30)	0527	T-B (160x30;160x30)
0614	L (200x40)	0528	T-L (160x30;200x40)

Table 7 – Safety Devices, pads size

According to this disposition, safety devices 0505; 0606; 0511; 0612; 0519; 0620; 0624; 0525 are located at the four arms of the handling supports and therefore they must be removed during mirror integration. Conversely safety devices 0501 and 0515, that are located in correspondence of the other two arms and that for accessibility problems cannot be demounted, can be drawn back using their own slide.

4.5.2 Integration of the safety devices

To mount all safety devices on the mirror cell, it is necessary to fix the different bases, that every type of the safety device has, on their own threaded holes. It must be taken into account that safety devices “only T-B” have the main structure directly fixed to the mirror cell (fig. 24), while the other types (fig.25), have their own base fixed to the mirror cell, on which base the main structure slides.

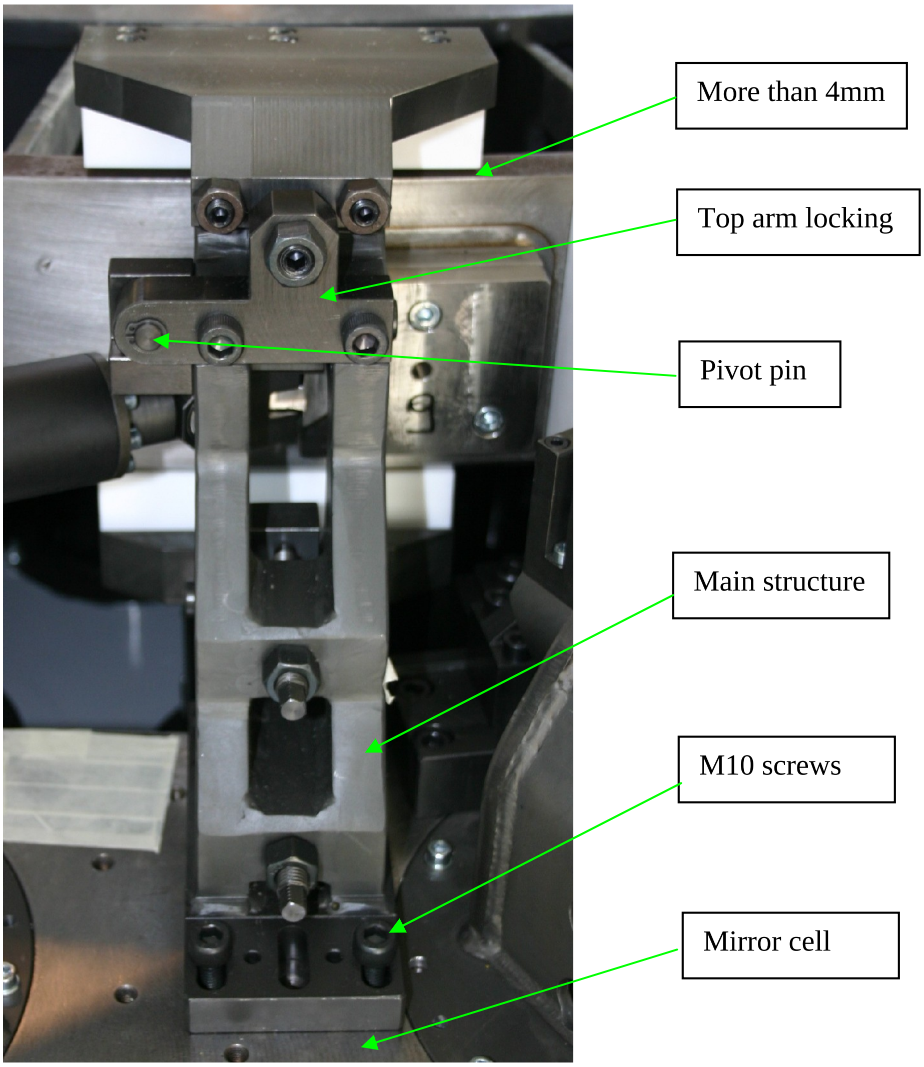


Figure 38 – Safety Devices, type T-B

To assemble safety devices type T-B:

a) position the main structure by their own threaded holes done on the upper surface of the mirror cell
b) slide the main structure along the slots until the distance, in the radial direction, between the external corners of the top pad and the lateral surface of the dummy, is more than 4mm

c) fix the main structure with the six M10 screws, tighten them with a torque of about 70 Nm
d) verify that the rotation around the pivot pin of the top arm locking, allow the opening of the top arm
e) verify that the rotation of the top arm is free from any encumbrance.
f) verify accessibility to adjust backlash and lock the forward position toward the mirror.

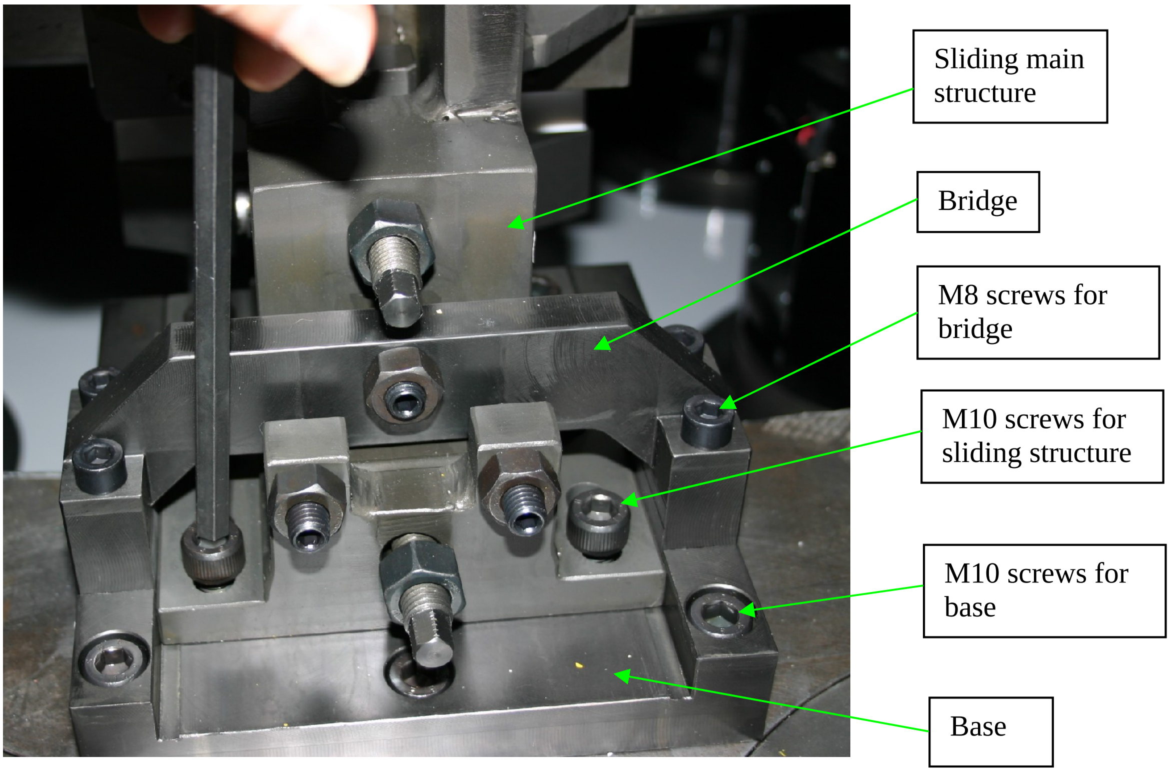


Figure 39 – Safety Devices, type T-B-L, or just L

To assemble the safety devices type T-B-L or only L:

a) position the base with their own threaded holes done on the upper surface of the mirror cell and fix it with the M10 screws foreseen, tighten them with a torque of about 70 Nm
b) insert the sliding structure on the base
c) insert the bridge in the seats foreseen on the base and fix it with the four M8 screws
d) slide the main structure along the base until the distance, in the radial direction, between the radial pad and the lateral surface of the dummy is about 1mm
e) verify that the rotation around the pivot pin of the top arm locking, allow the opening of the top arm
f) verify that the rotation of the top arm is free from any encumbrance
g) verify accessibility to adjust backlash and lock the forward position toward the mirror
h) fix the sliding structure on the base with the six M10 screws. The final tightening torque will be given during the radial adjusting operation as shown in chapter 3.3.4.

4.5.3 Integration of the safety devices 0501 and 0515

a) Position the base with their own threaded holes obtained on the upper surface of the mirror cell and fix it with the M10 screws foreseen, tighten them with a torque of about 70 Nm
b) slide the main structure along the base acting on the angular gearbox with a special tool (shaft elongation) until the distance, in the radial direction, between the radial pad and the lateral surface of the dummy is about 1mm
c) verify and take note what the best accessibility is to adjust the gaps between the three pads and the dummy.

Figure 40 – Safety Devices 0501 and 0515, position adjusting with the Shaft Extension

Figure 41 – Safety Devices 0501 and 0515, top arm adjusting with the Key Extension

4.6 ABSOLUTE TRANSDUCERS

To measure the dummy or the mirror position during the integration phase, five position transducers are applied to the Mirror Cell, three along the axial direction and two along the radial direction.
The three axial transducers are positioned close to the three axial fixed points in the room available between the third and the fourth ring, where the axial force actuators are assembled. The two radial transducers are so positioned, one at South-Eastern and one at South-Western sector of the mirror cell, on the plane where the safety devices are applied, making an angle with the North-South axis of ± 45°.
Their electrical connectors have to be connected with their own electrical cables that come out of the holes obtained on the top plane of the mirror cell.

Figure 42 – Axial Absolute Transducer: integrated

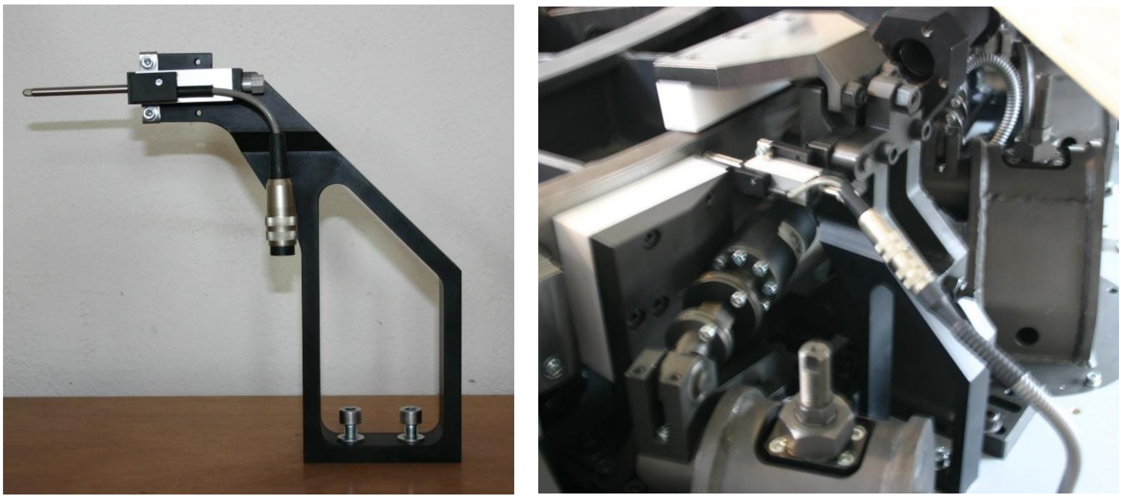


Figure 43 – Radial Absolute Transducer: apart and integrated

5 OPERATIONAL CONDITIONS AND PERFORMANCE OF THE SUPPORT SYSTEM

Environment, operational and survival conditions:

- Telescope operating range …………………........................ 0° C to 15°C
- Functional temperature range ……………………………… - 10°C to 30°C
- Dust environment in enclosure …………………………….. Class 30000
- Maximum humidity ……………………………………….. 95% RH

Earthquake:

- Moderate earthquake Negligible system damage
- OBE Minor system damage (repair time < 3 weeks)
- MLE Major system damage (repair time > 3 weeks)

Here below follow the performances given by the Axial Force Actuators:

from	Refer. spec.	to be verified/measured/calculated	Expected value	Measured value
ver. mat.	R14	**Fma**: maximum force against the mirror	< 1500 N	***1150 N***
ver. mat.	R22	**Ssa**: passive stroke	3.2 mm	***3.2 mm***
ver. mat.	R51	**Ka**: axial stiffness	> 9000 N/mm	***12.000 N/mm***
ver. mat.	R53	**Pa**: preload	580 - 700 N	***700 N***

Table 8 – Axial Force Actuators, main parameters

Here below follow the performances given by the Axial Fixed Points:

from	Refer. spec.	to be verified/measured/calculated	Expected value	Measured value
ver. mat.	R14	**Fma**: maximum force against the mirror	< 1500 N	***1150 N***
ver. mat.	R22	**Ssa**: passive stroke	3.2 mm	***3.2 mm***
ver. mat.	R51	**Ka**: axial stiffness	> 9000 N/mm	***12.000 N/mm***
ver. mat.	R53	**Pa**: preload	580 - 700 N	***700 N***

Table 9 – Axial Fixed Points, main parameters

Here below follow the performances given by the Lateral Fixed Points:

from	ref.spec.	to be verified/measured/calculated	expected value	measured value
ver. mat.	R9	**Ssl**: passive stroke, measured along the push-direction	5 mm	***5.10 mm***
ver. mat.	R9	**Ssl**: passive stroke, measured along the pull-direction	5 mm	***5.40 mm***
ver. mat.	R9	**Ssl**: passive stroke, along any lateral direction	5 mm	***>5 mm***
ver. mat.	R9	**Fml**: maximum axial force, measured along the push-direction	< 1300 N	***1200-1250***
ver. mat.	R9	**Fml**: maximum axial force, measured along the pull-direction	< 1300 N	***1100-1150***
ver. mat.	R60	**Kl**: axial stiffness, measured along the push-direction	> 20000 N/mm	***27000 N/mm***
ver. mat.	R60	**Kl**: axial stiffness, measured along the pull-direction	> 20000 N/mm	***25000 N/mm***
ver. mat.	R61	**Pl**: preload, measured along the push-direction	600 – 800 N	***650***
ver. mat.	R61	**Pl**: preload, measured along the pull-direction	600 – 800 N	***620***

Table 10 – Lateral Fixed Points, main parameters

6 DUMMY MIRROR INTEGRATION

6.1 First Integration of the Mirror Dummy in the Mirror Cell

All subsystems that performed the mirror support and safety, have been already calibrated on the dummy mirror dimensions that are very similar to those of the real mirror, so it is not necessary to check all the positioning that the axial actuators, axial fixed points, astatic levers and safety devices have with respect to the dummy mirror.
The first dummy integration starts with the dummy already integrated into the mirror cell. Indeed, according with INAF, the supply foresees the dummy being laid on the axial force actuators and on the axial fixed points, with the astatic levers already applied to their lateral pads and with both axial and radial safety devices locking the dummy in this position.
After unpacking and before starting with the operations that allow to remove and mount the dummy into the mirror cell, it is necessary to verify that:

- all the subsystems have been correctly assembled
- any visible damage is present
- all astatic levers have been correctly applied to the lateral pads of the dummy
- all Teflon pads of safety devices (axial and radial) are in contact with the dummy

6.2 Removing the Mirror Dummy

6.2.1 Before Lifting the Mirror Dummy

Before proceeding with the dummy mirror removal from the mirror cell, it is necessary to check or to do or to verify the following items step by step:

v.1	The mirror cell must be at an elevation angle equal to 90°±0.05° (to do this is possible to use a spirit level with precision 0.02 mm/m leaned on the top plane of the mirror cell)

v.2	The three lateral fixed points have to be disconnected from the dummy

a) one person has to sustain the lateral fixed point until the second one unscrews the eight M6 screws that connect the mirror flexible joint to the invar extension
b) move outwards the unlocked end of the lateral fixed point and insert it over its own support
c) lock the lateral fixed point in this position

v.3	Lateral removable invar pads 4, 5, 6, 7, 8, 9, 15, 16, 17, 19, 20, 21 and 22 included special invar pads 3, 10 and 18 have to be disconnected from the dummy

a) starting from astatic lever nr.03 and proceeding counter-clockwise, one person has to sustain the arm on whose end is a removable invar pad until the second one unscrews the three M8 screws that connect the removable pad to that fixed to the dummy lateral surface

b) once disconnected, it is necessary to insert their own locking spring in the provided seat to constrain the arm against the safety device structure and to remain sufficiently far from the dummy

v.4	Lateral special devices 1, 12, 13 and 24 have to be disconnected from the dummy.

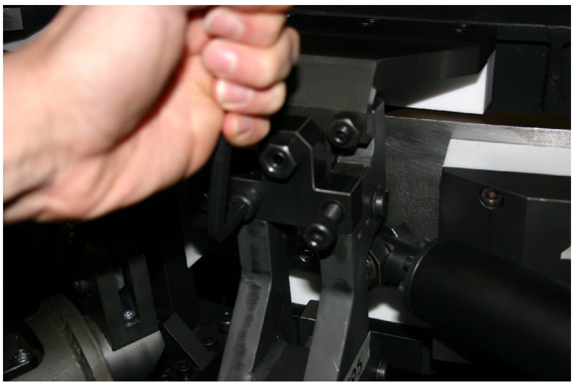
a) starting from astatic lever nr.01 and proceeding counter-clockwise, a first person has to unscrew the two M8 screws that locked the special device to the non removable lateral invar pad.
b) until a second person brings the upper part of the counterweight bar and pulls it externally, the first one verifies that the special device has come out of the two alignment pins and, turning the arm outwards, has to pose it on its own support.
c) once posed, it is necessary to insert their own locking spring in the provided seat to constrain the arm to remain sufficiently far from the dummy

v.5	Lateral special devices 2, 11, 14 and 23 have to be disconnected from the dummy.

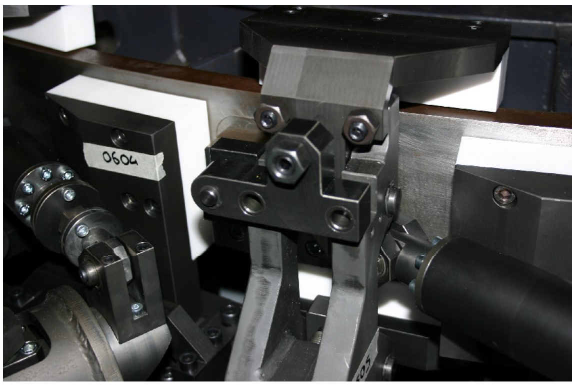
a) starting from astatic lever number 02 and proceeding counter-clockwise, the first person has to unscrew the two M8 screws that locked the special device on the non removable lateral invar pad.
b) until the second person brings the upper part of the counterweight bar and pulls it outwards, the first one verifies that the special device has come out of the two alignment pins and, turning the arm outwards, inserts their own locking spring in the provided seat to constrain the arm to remain sufficiently far from the dummy

v.6	All the top arms of safety devices have to be open (except safety 1 and 15)

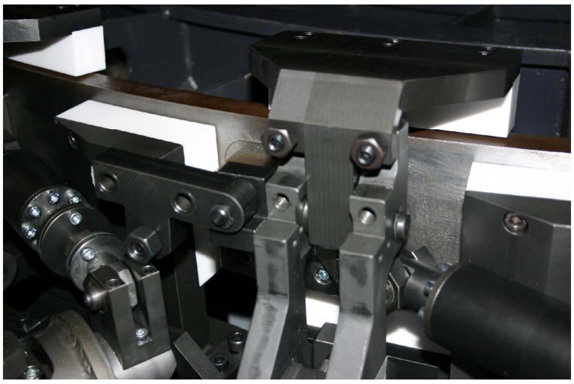
a) unscrew the two M10 upper screws
b) slide externally the top locking plate along the pivot pin
c) rotate the locking plate around the pivot pin
d) open the top arm



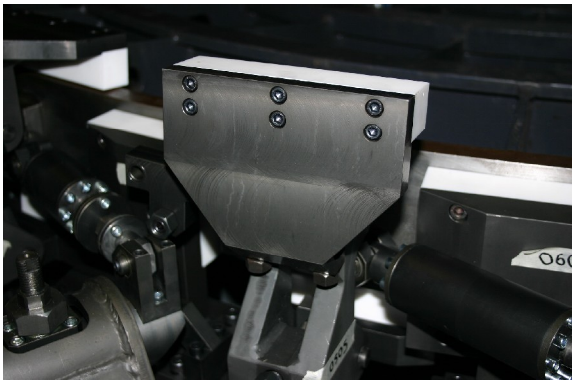
a



b



c



d

Figure 44 – Safety Devices, steps to open the Top Arm

v.7	No bottom arm of safety devices has to be moved

v.8	Demount completely, from the mirror cell, axial safety devices nr. 0505, 0511, 0519 and 0525, and, limited t the sliding structure from the base, radial safety devices nr.0606, 0610, 0620 and 0624, because they have interference with the arms of the handling device

As for the axial safety devices:

a) unscrew the six M10 screws that lock the safety structure to the mirror cell
b) now it is possible to remove the axial safety device

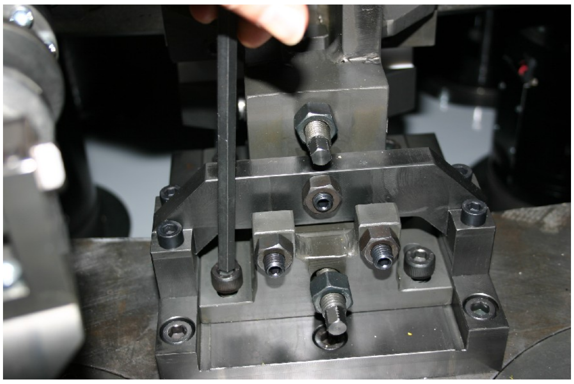
As for the radial safety devices:

a) unscrew the four M8 screws that lock the bridge and remove the bridge from the base
b) unscrew the six M10 screws that lock the safety structure to the base
c) now it is possible to remove the radial safety device

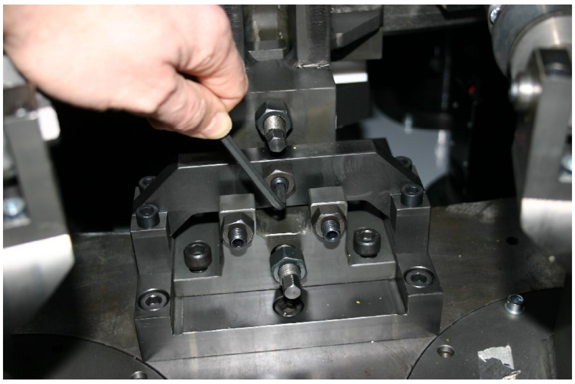
v.9	Position the crane with the Hydra Set, on which the mirror handling device has been hooked, over the mirror cell and proceed with all the operations needed to hook the dummy mirror

v.10	All radial safety devices have to be moved back of 8mm referred to the lateral surface of the dummy mirror

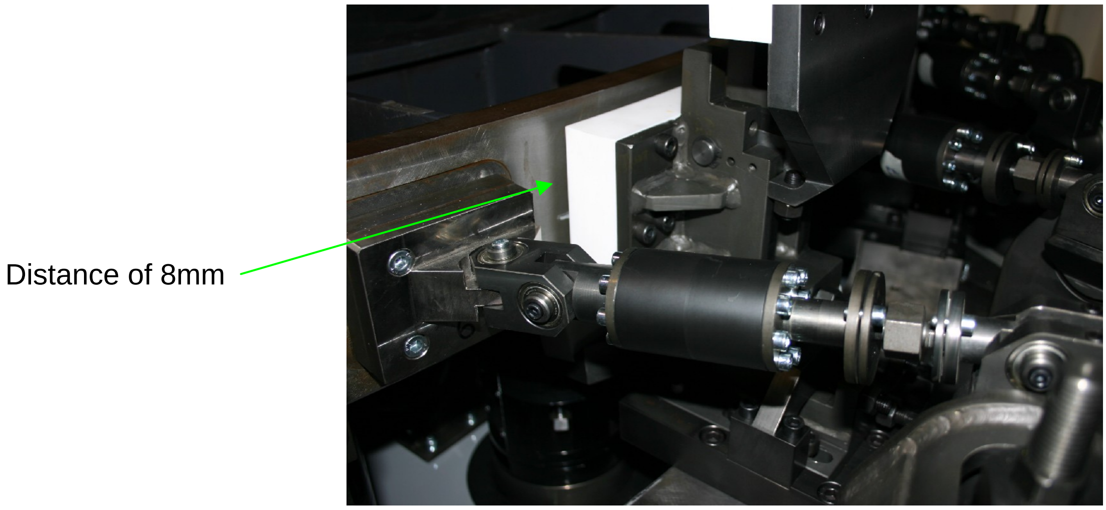
a) unscrew the six M10 screws that lock the sliding structure to the base
b) unscrew the headless screw 8mm
c) move back the sliding structure by hand until it stops against the headless screw
d) screw the six M10 screws to lock the sliding structure



a



b



c/d

Figure 45 – Safety Devices, moving back away from the mirror

v.11	Special safety devices 1 and 15 have to be moved back to their mechanical end of stroke, without opening the top arms

Inserting the appropriate special elongation device in the lateral hole of the angular gearbox, it is sufficient to rotate it until the slide that supports all lateral and axial safety devices, reach the external end of stroke.

v.12	Verify that all three axial and two lateral positioning transducers are read by the LCU

v.13	Verify that the load cells of all axial actuators are read by the LCU

6.2.2 Lifting the Mirror Dummy

Now it is possible to proceed with lifting the dummy mirror from the mirror cell:

a) use the remote control UP of the Hydra Set to start lifting the dummy
b) read the load cell display of the Hydra Set to know how the weight is that the handling device is charging and compare this value with that read from the LCU, pay attention that the load cells of the axial actuators have to measure similar decreasing of the load. If this condition is not verified, it means that the dummy is not correctly balanced by the handling device, so it is necessary to lower the dummy and proceed with a more accurate adjustment.
c) when the load cells of the axial actuators are equally discharged, it is possible to continue with the lifting operation with the remote control UP until the total load on the axial actuators is zero. If the hook crane is not correctly aligned with the dummy center of gravity, it may happen that the dummy undergoes a lateral translation: it is necessary therefore to center the hook so to have the dummy equally spaced between all pads of the lateral safety devices. At this point the dummy is suspended from the hook of the crane and centered in the mirror cell so it is necessary to read the value given by the two lateral position transducers and the three axial position transducers. These values are those that will have to be reached first of all, during the following dummy mirror integration.

6.3 First Integration of the Dummy in the Mirror Cell

6.3.1 Starting check

Before proceeding with the dummy mirror integration into the mirror cell, it is necessary to check and verify the following items step by step:

FIRST DUMMY MIRROR INTEGRATION MIRROR CELL CHECK LIST	
v.1	Verify that the mirror cell is at an altitude angle of 90°±0.05° (to do this it is possible to use a level with accuracy 0.02 mm/m leaned on the top plane of the mirror cell)
v.2	Visual control of all heights of the Axial Force Actuators spheres, considering the possibility that someone might have mounted an axial force actuator in the wrong position
v.3	Verify that all top arms of the Safety Devices are open, while the Safety Devices 1 and 15 shall be in the rear position
v.4	Verify that all radial safety devices are in the rear position (external with respect to the mirror cell axis) at their mechanical end of stroke, equal to 8 mm back
v.5	Verify that the special safety devices 1 and 15 are moved in the rear position (external with respect to the mirror cell axis) at their mechanical end of stroke (100 mm back)
v.6	Verify that all invar pads are locked with the spring to their own hook fixed on the top plane of the mirror cell
v.7	Verify that the cardanic joint of the arm of the astatic levers 1, 12, 13 and 24 lay on their own supports and that the interface with invar pads are locked with the spring to their own hook fixed on the top plane of the

	mirror cell
v.8	verify that the interface with invar pad of the arm of astatic levers 2, 11, 14 and 23 are locked with the spring to their own hook fixed on the top plane of the mirror cell
v.9	verify that the three lateral fixed points lay on their own supports
v.10	verify that the load cells of both Axial Force Actuators and Axial Fixed Points are read by the LCU
v.11	verify that the load cells of the Lateral Fixed Points are read by the LCU
v.12	verify that all Axial Force Actuators are at the lower end of stroke
v.13	verify that the axial position of the three axial fixed points are read by the LCU
v.14	verify that the lateral absolute transducers are locked in the rear position and the position of all absolute transducers is read by the LCU

All subsystems that performed the mirror support and safety, are already calibrated on the dummy mirror dimensions that are very similar to those of the real mirror, so it is not necessary to check all the positioning that the axial actuators, axial fixed points, astatic levers and safety devices, have with respect to the dummy mirror.

FIRST DUMMY MIRROR INTEGRATION DUMMY MIRROR CHECK LIST	
v.15	verify that the mirror handling device has been adjusted to lift the dummy mirror
v.16	verify that the dummy mirror, suspended from the mirror handling device, lays in a horizontal plane (to do this it is possible to use an air level with precision 0.02 mm/m, leaned on one axial pad, and verify the planarity in both perpendicular directions within $\pm$ 2 mm on the diameter)
v.17	verify that the removable invar pads 1, 2, 11, 12, 14, 14, 23 and 24 are fixed on lateral pad of the dummy mirror
v.18	verify that the lower Hydra Set is connected to the handling device and that the two remote control devices are unlocked and sufficiently stretched out to allow all necessary maneuvers

6.3.2 Lowering the Mirror Dummy down in the Mirror Cell

1. Move the three axial fixed points up to 0,4 mm over the lower end of stroke position
2. lift the dummy 500 mm over its final height in the mirror cell
3. horizontally move the dummy until it is about on top of its final position in the mirror cell
4. verify that the dummy orientation, around the z axis, is correct
5. lower the dummy down to 100 mm over any possible contact point with the safety devices of the support system
6. horizontally move the dummy until it is about on top of its final position in the mirror cell

7. lower the dummy down to 10 mm over any possible contact point with the safety devices of the support system
8. horizontally move the dummy until it is about on top of its final position in the mirror cell
9. horizontally move the dummy in the two directions until it has backlash between 5 mm and 15 mm in relation to the lateral safety devices
10. lower the dummy until the bottom of the dummy is 5 mm over the same height as the top of the lateral safety devices of the support system
11. horizontally move the dummy in the two directions until it has backlash between 5 mm and 11 mm in relation to the lateral safety devices
12. slowly lower the dummy until it touches the three axial absolute transducers that are about 20 mm over the final position
13. rotate the dummy around the z-axis in order to reach its final orientation within 5mm tangential distance between the pads of the dummy and the pads of the astatic levers or the pads of the lateral fixed points
14. disengage the lateral absolute transducers in order to read the lateral position of the dummy
15. monitor the force of the axial force actuators and of the axial fixed points
16. lower the dummy with the crane step by step verifying its height by means of the absolute transducers until it is about 4 mm over its final position
17. mount the lateral pads of the three lateral fixed points inside the appropriate pins and fix the pads with the screws, verifying with a plate that they are parallel to the pads of the dummy within 0.2 mm; now it is possible to proceed with mounting the three lateral fixed points following the instructions in the dedicated section.

Now the dummy mirror is mechanically assembled and it is possible to verify whether also all electronics works properly. It is necessary to connect the electrical cables to the connectors of the Lateral Fixed Points to the electrical boxes and then connect the LCU. It must be checked whether all electrical devices (M1ACBs of the axial force actuators and of the axial fixed points; load cells of the lateral fixed points; axial and radial position transducers) work properly.

18. verify that the dummy is in its theoretical final position within $\pm$ 1mm, by measuring equal distances of the lateral pads in relation to two couples of symmetrical tapered holes M8 on the mirror cell
19. radially move the four main safety devices until they have 1mm gap from the lateral cylindrical surface of the dummy
20. lock the position of the four safety devices
21. lower the dummy with the Hydra Set step by step continuously verifying the load on the three Axial Fixed Points until the load read is between 200 N e 400 N each one
22. set to zero the height read from the three axial absolute transducers
23. set to zero the distance read from the lateral absolute transducers
24. verify that the load on the Axial Force Actuators is still the initial value close to zero; in this case it is necessary to take note of the actuator number and later verify its height in relation to the axial fixed points, and correct it
25. adjust the position of all lateral safety devices with 1mm gap
26. lower the dummy down slowly with the Hydra Set, verifying that the load on the Axial Force Actuators is less than 300 N and that the load on the Axial Fixed Points

is less than 900 N; verify that the displacement read from the axial absolute transducers is less than 1mm below the zero setting position

27. disengage the handling from the dummy and lift it
28. verify the force on all Axial Force Actuators and take note of possible errors
29. evaluate the theoretical mean force on the axial force actuators when the force on the three axial fixed points is about 300 N, taking into account the measured weight with the Hydra-Set
30. switch on the Axial Force Actuators, set the above mentioned theoretical mean force and read the remaining loads on the three Axial Fixed Points
31. if necessary, change the force setting according to the value of the force on the three axial fixed points, spreading the correction among the 81 actuators
32. verify that the dummy is at the reference height for all three absolute transducers
33. fix the arms of all astatic levers on the related lateral dummy mirror pads, starting at the same time from astatic lever 01 and 13, moving counter-clockwise and following the procedure described in the related section

6.3.3 Centering the Dummy Mirror in the Mirror Cell

Proceed with adjusting the length of the lateral fixed points following the instructions of the related section.

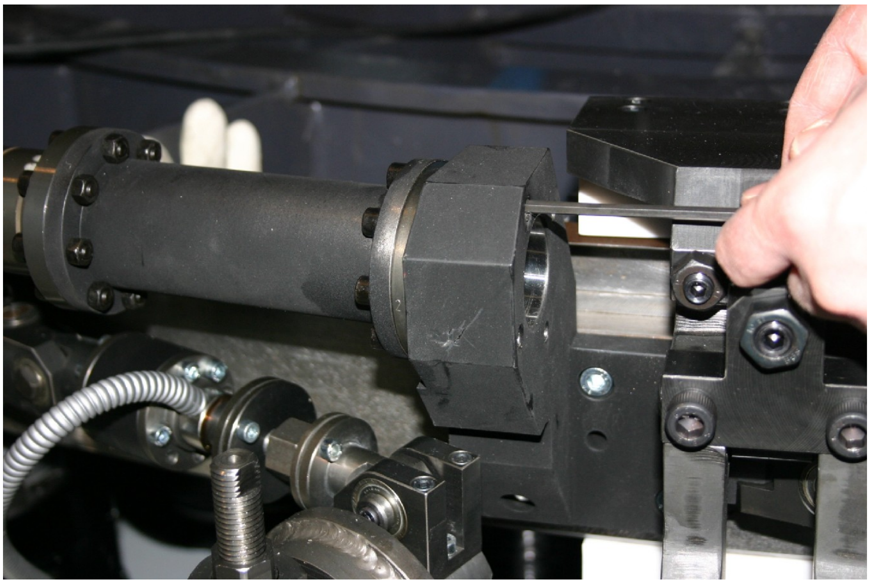
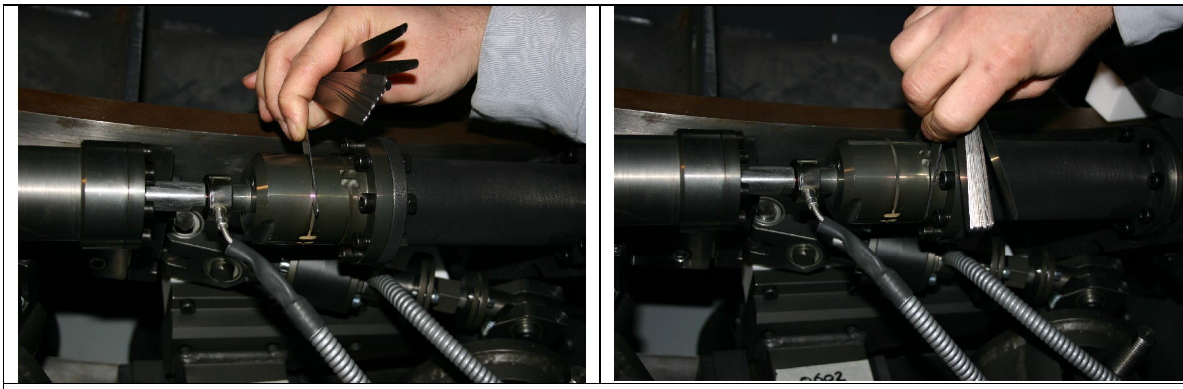
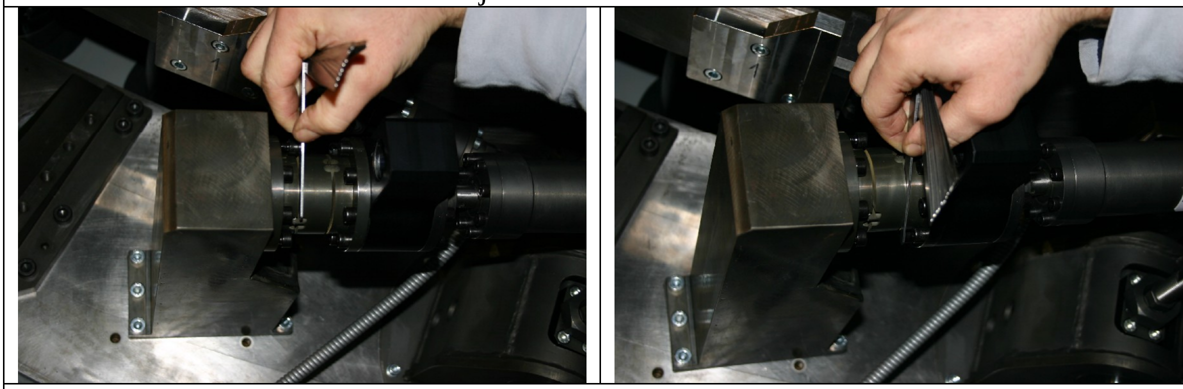


Figure 46 – Lateral Fixed Points, length adjusting

To check whether the three lateral fixed points have been assembled correctly, it is necessary to use a spacer 0.4mm thick and verify whether this passes completely through the eight cuts obtained in the two flexible joints (see pictures).



Flexible joint mounted on the mirror



Flexible joint mounted on support device fixed on the mirror cell

Figure 47 – Lateral Fixed Points, verifying the gap of the flexible plates (cardanic joints)

6.3.4 Adjusting the Arm Length of the Astatic Levers

When the mirror cell lays in horizontal position, the load that the three lateral fixed points have to read must be less than 20N. If this does not happen, it means that the arms of the astatic levers have not been correctly adjusted, the counterweights act against the dummy mirror and cause a certain load that is not desired. In this case it is necessary to recalibrate the length of the arms, repositioning the counterweight axis along the vertical direction.
The arms of the astatic levers connected to the dummy mirror are of two types:

a) arms with integrated load cell
b) arms without integrated load cell

In both cases it is necessary to use the Calibration Box, where are the load cell amplifiers (see next pictures) and one voltmeter able to read every load on each load cell.
The calibration of the length of all arms is divided into four steps, each corresponding to the verification of six arms at a time; this is so because it is necessary to replace the four Delrin pads, in the arms without load cell, with four external load cells (see figure 51, "removable load cells") by which it is thus possible to evaluate the load along the arms;

conversely, in the other two arms, the load cells are already integrated and they can be directly connected to the load cell electrical box.

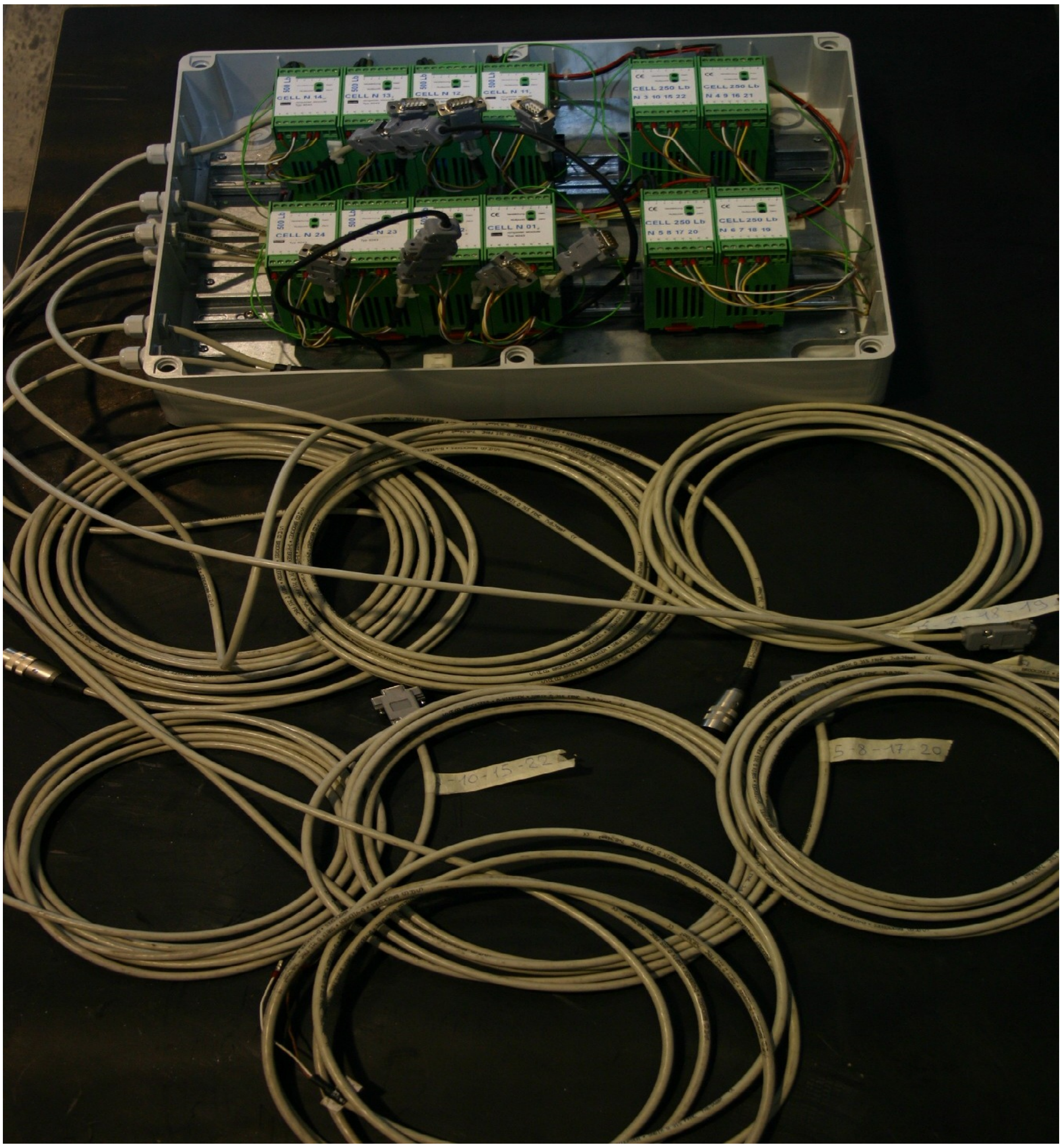


Figure 48 – Lateral Supports, Load Cell Amplifier Box

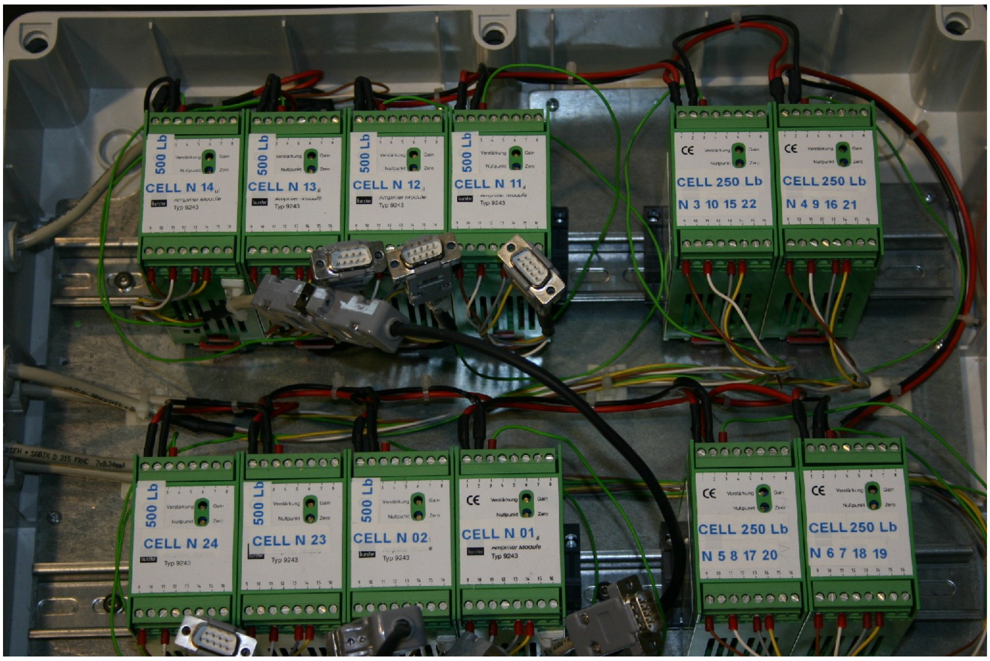


Figure 49 – Lateral Supports, Load Cell Amplifiers

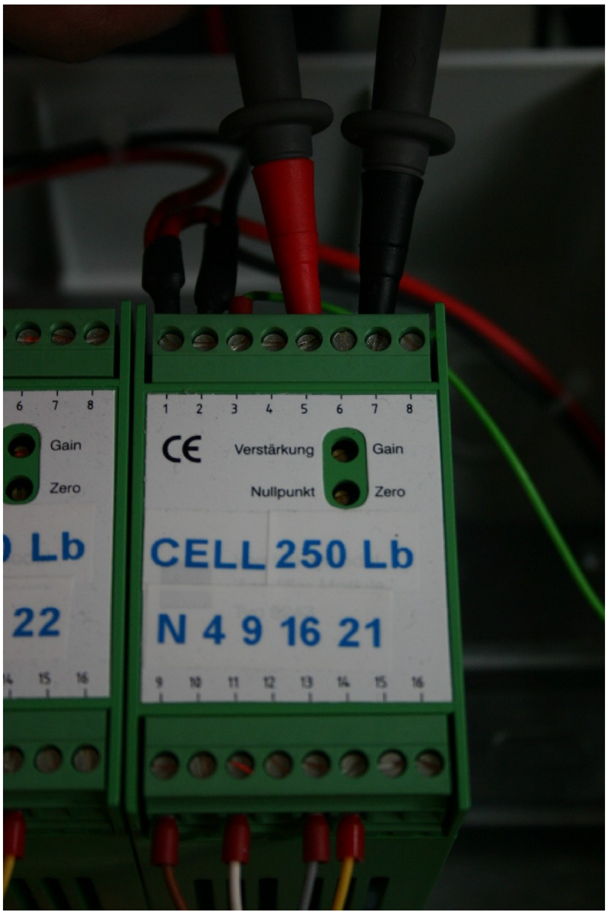


Figure 50 – Lateral Supports, Load Cell Amplifier: connections

Every load cell must be connected to its own amplifier because these have been calibrated on a test bench both in offset and in zero load. So, the eight amplifiers numbered 01, 02, 11, 12, 13, 14, 23 and 24 are those that must be connected to the load cells integrated in the arms with equal number, conversely the other four amplifiers must be connected with the removable load cells.

Figure 51 – Lateral Supports, removable load cells

The steps foreseen to calibrate all astatic levers are four:

I) sector from astatic lever nr.1 through astatic lever nr.6
II) sector from astatic lever nr.7 through astatic lever nr.12
III) sector from astatic lever nr.13 through astatic lever nr.18
IV) sector from astatic lever nr.19 through astatic lever nr.24

To calibrate one of the four sectors, the delrin pads of the arms without integrated load cell must be removed from and replaced with removable load cells equally numbered. Afterwards the two integrated load cells must be connected respectively to the electrical cables of the amplifiers equally numbered and the removable load cells respectively to the electrical cable of the amplifiers where is the same number.
Now it is possible to feed the electrical box and to measure the voltage that every load cell is measuring, connecting the channels 5 and 7 to the voltmeter.

The correspondence between the read voltage [mV] and the measured force [N] that charges the load cell is either 1 V = 400 N or 1 mV = 0.4N

If one or more load cells are measuring a load, it is necessary to recalibrate the respective arm lengths because it is necessary to reposition the counterweights axis along the vertical direction. The procedure is the following:

1. unscrew the two M6 screws on the load cell support and on the support of the spherical joint to release, but maintaining a certain friction torque, the rotation of the arm length adjustment

2. screw left or right the arm length adjustment and adjust the length until the read force is 0 N ± 1N and fix the length screw the two M6 screws
3. repeat the above two points for all remaining astatic levers of the sector.

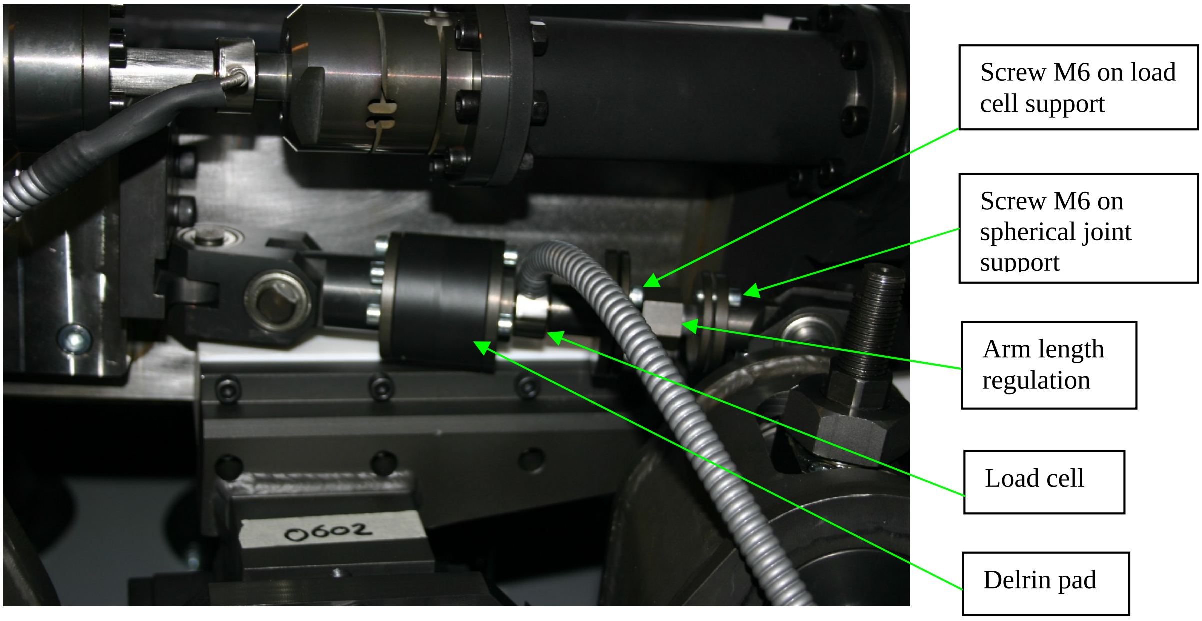


Figure 52 – Lateral Supports, lever arm adjusting

Now the adjustment of the arm length is done, but not the verification (and the possible adjustment) of the load that the counterweight explain against the dummy when the mirror cell starts rotating. So, before disconnecting all load cells from the electrical box, to remove the removable load cells from the arms and to replace them with own delrin pads, the first sector must be verified also following the instructions reported in the next section.

6.3.5 Calibrating the Counter-Weight of the Astatic Levers

When the mirror cell starts rotating, the load that the three lateral fixed points have to read must be always between 0N and 300N, for each angular position that the mirror cell can reach in the range between 90° and 0°. If this does not happen, it means that the counterweights of the astatic levers are not positioned correctly, so the astatic lever, acting against the mirror dummy, causes a wrong balancing load. In this case it is necessary to recalibrate the position of the counterweight in the following way:

1. verify that the resulting force on the lateral fixed points is less than about 50 N each one when the mirror cell is at 90°; if required, the procedure to adjust the arm length can be repeated as described in the previous chapter
2. rotate the mirror cell at 0°, verifying that the angle is accurate within 2’ by a square and spirit level
3. in the following two tables the theoretical values are shown that should be read from the load cells for each astatic lever at different angles; at 0° the voltage measured from each amplifier is reported in the column V(0°).

N°	Fx	Fy	Fz	Ft	Arm weight	Angle lever/arm	V(75°)	V(60°)	V(45°)	V(30°)	V(15°)	V(0°)
1	101,0580799	-1158,070764	6,347207	1162,4891	12,29	0,087043666	0,760108	1,468416	2,076653	2,543371	2,836761	2,936831
2	276,0958089	-1057,012684	18,609069	1092,63489	11,27	0,255495374	0,714042	1,379424	1,9508	2,389232	2,664842	2,758848
3	377,1538889	-881,9749549	29,602755	959,688074	6,42	0,404091319	0,624783	1,206989	1,70694	2,090566	2,331723	2,413978
4	377,1538889	-679,8587951	38,579061	778,422367	6,42	0,506485227	0,507309	0,980045	1,385994	1,697489	1,893302	1,960091
5	276,0958089	-504,8210661	44,926268	577,140862	6,42	0,500474037	0,377082	0,728467	1,030208	1,261742	1,40729	1,456934
6	101,0580799	-403,7629861	48,211824	419,000793	6,42	0,24525215	0,275143	0,531536	0,751705	0,920647	1,026848	1,063072
7	-101,0580799	-403,7629861	48,211824	419,000793	6,42	-0,24525215	0,275143	0,531536	0,751705	0,920647	1,026848	1,063072
8	-276,0958089	-504,8210661	44,926268	577,140862	6,42	-0,500474037	0,377082	0,728467	1,030208	1,261742	1,40729	1,456934
9	-377,1538889	-679,8587951	38,579061	778,422367	6,42	-0,506485227	0,507309	0,980045	1,385994	1,697489	1,893302	1,960091
10	-377,1538889	-881,9749549	29,602755	959,688074	6,42	-0,404091319	0,624783	1,206989	1,70694	2,090566	2,331723	2,413978
11	-276,0958089	-1057,012684	18,609069	1092,63489	11,27	-0,255495374	0,714042	1,379424	1,9508	2,389232	2,664842	2,758848
12	-101,0580799	-1158,070764	6,347207	1162,4891	12,29	-0,087043666	0,760108	1,468416	2,076653	2,543371	2,836761	2,936831
13	101,0580799	-1158,070764	-6,347207	1162,4891	12,29	0,087043666	0,760108	1,468416	2,076653	2,543371	2,836761	2,936831
14	276,0958089	-1057,012684	-18,609069	1092,63489	11,27	0,255495374	0,714042	1,379424	1,9508	2,389232	2,664842	2,758848
15	377,1538889	-881,9749549	-29,602755	959,688074	6,42	0,404091319	0,624783	1,206989	1,70694	2,090566	2,331723	2,413978
16	377,1538889	-679,8587951	-38,579061	778,422367	6,42	0,506485227	0,507309	0,980045	1,385994	1,697489	1,893302	1,960091
17	276,0958089	-504,8210661	-44,926268	577,140862	6,42	0,500474037	0,377082	0,728467	1,030208	1,261742	1,40729	1,456934
18	101,0580799	-403,7629861	-48,211824	419,000793	6,42	0,24525215	0,275143	0,531536	0,751705	0,920647	1,026848	1,063072
19	-101,0580799	-403,7629861	-48,211824	419,000793	6,42	-0,24525215	0,275143	0,531536	0,751705	0,920647	1,026848	1,063072
20	-276,0958089	-504,8210661	-44,926268	577,140862	6,42	-0,500474037	0,377082	0,728467	1,030208	1,261742	1,40729	1,456934
21	-377,1538889	-679,8587951	-38,579061	778,422367	6,42	-0,506485227	0,507309	0,980045	1,385994	1,697489	1,893302	1,960091
22	-377,1538889	-881,9749549	-29,602755	959,688074	6,42	-0,404091319	0,624783	1,206989	1,70694	2,090566	2,331723	2,413978
23	-276,0958089	-1057,012684	-18,609069	1092,63489	11,27	-0,255495374	0,714042	1,379424	1,9508	2,389232	2,664842	2,758848
24	-101,0580799	-1158,070764	-6,347207	1162,4891	12,29	-0,087043666	0,760108	1,468416	2,076653	2,543371	2,836761	2,936831

Table 11 – Lateral Supports, force data

N°	V(75°)	V(60°)	V(45°)	V(30°)	V(15°)	V(0°)
1	0,760108	1,468416	2,076653	2,543371	2,836761	2,936831
2	0,714042	1,379424	1,9508	2,389232	2,664842	2,758848
3	0,624783	1,206989	1,70694	2,090566	2,331723	2,413978
4	0,507309	0,980045	1,385994	1,697489	1,893302	1,960091
5	0,377082	0,728467	1,030208	1,261742	1,40729	1,456934
6	0,275143	0,531536	0,751705	0,920647	1,026848	1,063072
7	0,275143	0,531536	0,751705	0,920647	1,026848	1,063072
8	0,377082	0,728467	1,030208	1,261742	1,40729	1,456934
9	0,507309	0,980045	1,385994	1,697489	1,893302	1,960091
10	0,624783	1,206989	1,70694	2,090566	2,331723	2,413978
11	0,714042	1,379424	1,9508	2,389232	2,664842	2,758848
12	0,760108	1,468416	2,076653	2,543371	2,836761	2,936831
13	0,760108	1,468416	2,076653	2,543371	2,836761	2,936831
14	0,714042	1,379424	1,9508	2,389232	2,664842	2,758848
15	0,624783	1,206989	1,70694	2,090566	2,331723	2,413978
16	0,507309	0,980045	1,385994	1,697489	1,893302	1,960091
17	0,377082	0,728467	1,030208	1,261742	1,40729	1,456934
18	0,275143	0,531536	0,751705	0,920647	1,026848	1,063072
19	0,275143	0,531536	0,751705	0,920647	1,026848	1,063072
20	0,377082	0,728467	1,030208	1,261742	1,40729	1,456934
21	0,507309	0,980045	1,385994	1,697489	1,893302	1,960091
22	0,624783	1,206989	1,70694	2,090566	2,331723	2,413978
23	0,714042	1,379424	1,9508	2,389232	2,664842	2,758848
24	0,760108	1,468416	2,076653	2,543371	2,836761	2,936831

Table 12 – Lateral Supports, theoretical load cell reading at altitude angles

4. read the force on the two astatic levers on which the load cells are always applied and on the four astatic levers to which the load cells have been applied

5. adjust the distance of the counterweight in order to reach the theoretical value in the following way:

a) release the two headless screws just the necessary to radially unlock the bar that supports the counterweight
b) unscrew the locking bar nut
c) unscrew the special nut to unlock the adjustment shaft
d) screw or unscrew the adjustment shaft to decrease or increase the voltage read on the voltmeter to arrive to the theoretical value (± 2mV) given in the table above
e) screw the special nut to lock the regulation shaft
f) screw the nut that lock the bar
g) screw the two headless screws to radially lock the bar

6. move back the mirror cell to 90°
7. rotate the mirror cell to 0°
8. repeat the procedure to adjust the force on the 2+4 astatic levers until the error is within ± 1 N
9. rotate the mirror cell to 0°
10. remove the four removable load cells from the arms and mount their own delrin pads

Repeat the same procedure reported in sections 6.3.4 and 6.3.5 (adjustment of the arm length and of the counterweight) for the other three sectors.

11. At the end, rotate the mirror cell at 0°
12. verify that the total load on the lateral fixed points is less than 50 N
13. evaluate the possible overload and spread it proportionally to each astatic lever; there is a linear correspondence between load and voltage (mV), so every overload share must be transformed into mV and added or subtracted to the values reported in the column labeled as V(0°)
14. repeat the procedure to adjust the force on all astatic levers by adjusting the distance of the counterweights and fixing the counterweight position
15. if necessary, repeat the whole procedure

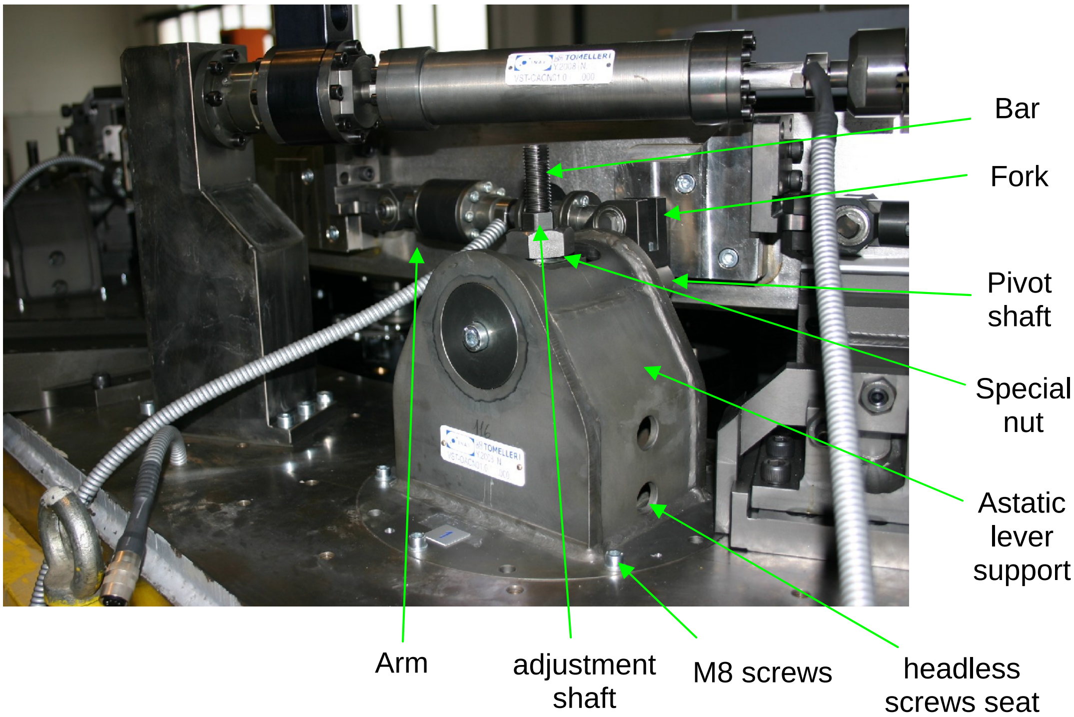


Figure 53 – Lateral Supports, adjusting the position of the counter-weight

6.3.6 Verifying the Safety Devices

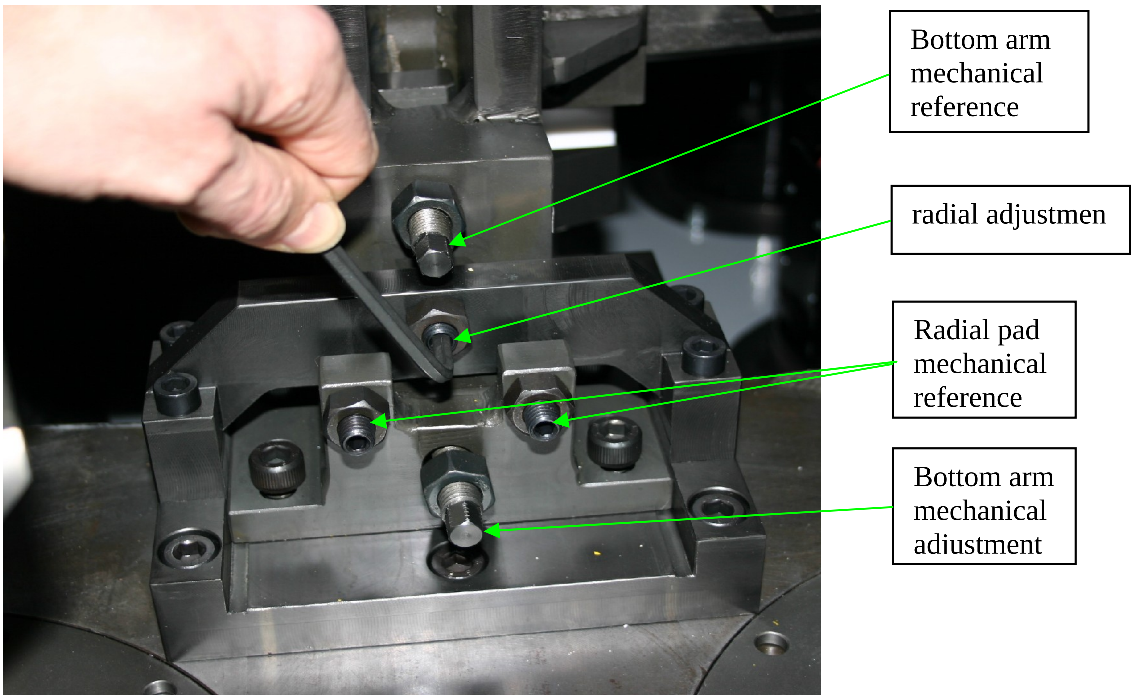


Figure 54 – Safety Devices, adjusting the Bottom and Radial Pads

a) Acting on the radial adjustment (see picture above), move the sliding structure against the lateral surface of the dummy; at this point the radial adjustment has to be unscrewed of about 2mm and needs to act on the two radial mechanical references to have a gap, between the dummy lateral surface and the radial pad, within 0.8mm and 1mm. This must be verified with a plastic feeler gauge at all four corners of the radial pad
b) tighten the two M10 nuts that lock the rotation of the two radial mechanical references; **from this moment on, these two mechanical references must not be touched because they have become the references for the next radial repositioning of the safety devices**
c) screw the radial adjustment until it gets in contact with the sliding structure and lock it with its own nut
d) screw the six M10 screws to fix the sliding structure to the base with a tightening torque of about 70 Nm
e) acting on the bottom arm mechanical adjustment (see figure above), move the bottom arm against the bottom surface of the dummy; at this point the radial adjustment has to be unscrewed until the gap, measured with a plastic feeler gauge between bottom dummy surface and pad and at both sides of pad, is within 0.4mm and 0.6mm
f) screw the bottom arm mechanical reference until it gets in contact with the arm and lock it with its own M12 nut; **from this moment on, these this mechanical reference must not be touched because is has become the reference for next bottom/axial repositioning of the safety devices**
g) lock also the bottom arm mechanical adjustment with its own M12 nut

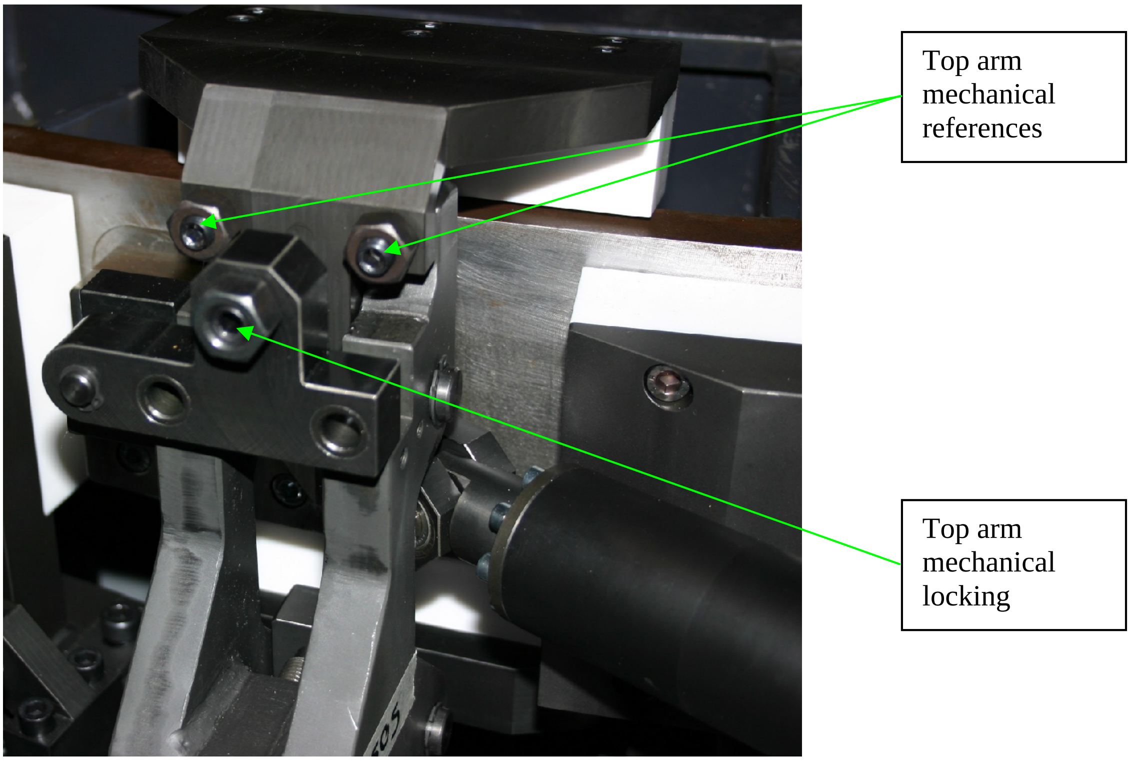


Figure 55 – Safety Devices, adjusting the Top Pads

h) close the top arm over the dummy
i) unscrew the two top arm mechanical references (see picture above) to move the top arm against the top surface of the dummy; at this point the two top arm mechanical references have to be screwed until the gap, measured with a plastic feeler gauge between the top dummy surface and the pad and at both sides of he pad, is within 0.4mm and 0.6mm
j) lock the two top arm mechanical references with their own M10 nuts; **from this moment on, these mechanical references must not be touched because they have become the references for next top/axial repositioning of the safety devices**
k) screw the top arm mechanical locking until it gets in contact with the arm and lock its rotation with its own M12 nut

6.3.7 Verifying Safety Devices 0501 and 0515

a) Acting on the angular gearbox (see figure 40, section "integration of the safety devices 0501 and 0515"), move the sliding structure against the lateral surface of the dummy; at this point the angular gearbox has to be acted in the opposite direction to have a gap, between the dummy lateral surface and the radial pad, within 0.8mm and 1mm; this must be verified with a plastic feeler gauge at all four corners of the radial pad

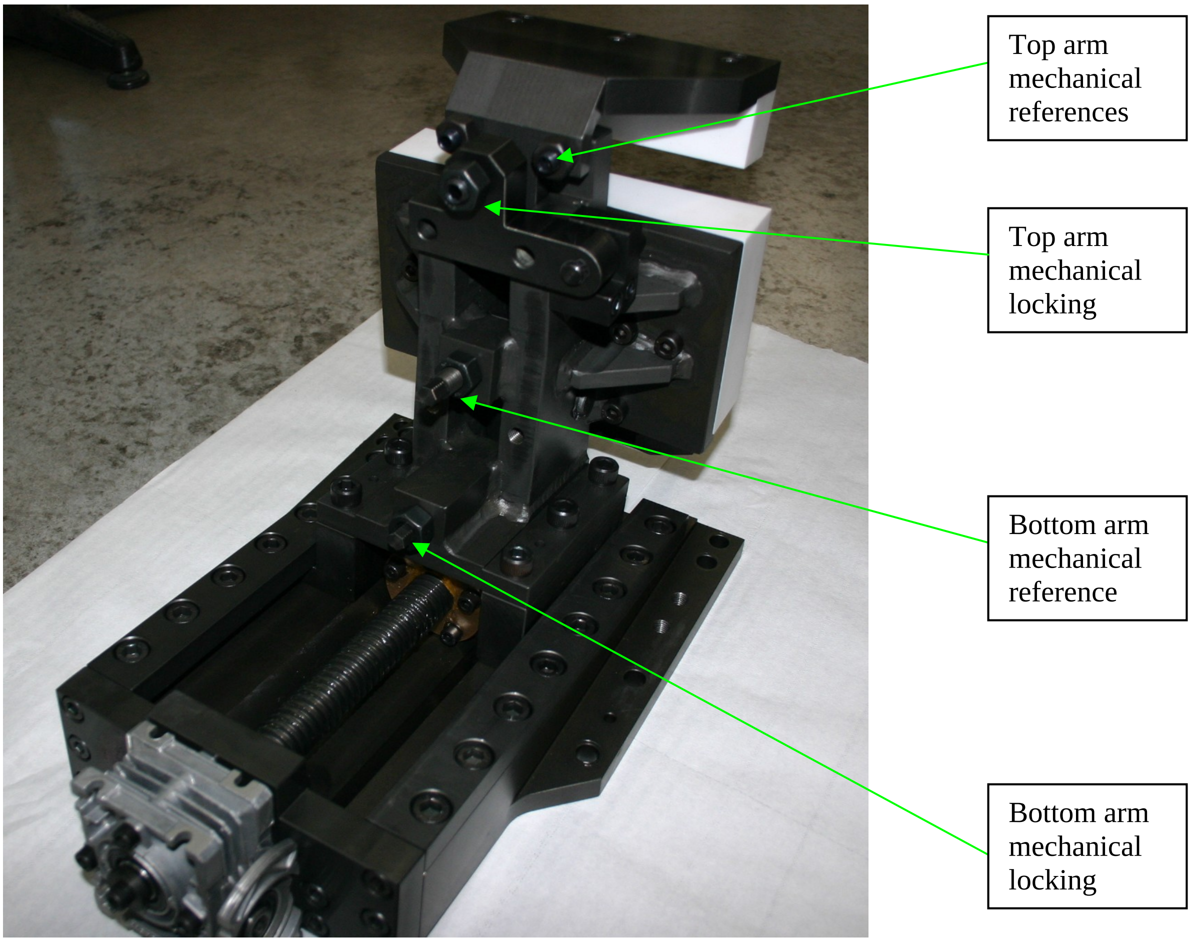


Figure 56 – Safety Devices 0501 and 0515, position adjusting elements

b) screw the two sliding structure mechanical references against the blocks and tighten the two M10 nuts that lock the rotation of the two mechanical references; **from this moment on, these two mechanical references must not be touched because they have become the references for next radial repositioning of the safety devices sliding structure**
c) acting on the bottom arm mechanical locking (see picture above), move the bottom arm against the bottom surface of the dummy; at this point the mechanical locking has to be unscrewed until the gap, measured with a plastic feeler gauge between the bottom dummy surface and the pad and at both sides of pad, is within 0.4mm and 0.6mm
d) screw the bottom arm mechanical reference until it gets in contact with the arm and lock it with its own M12 nut; **from this moment on, this mechanical reference must not be touched because it has become the references for the next bottom/axial repositioning of the safety devices**
e) lock also the bottom arm mechanical locking with its own M12 nut
f) close the top arm over the dummy
g) unscrew the two top arm mechanical references (see picture above) to move the top arm against the top surface of the dummy; at this point the two top arm mechanical references have to be screwed until the gap, measured with a plastic feeler gauge

between the top dummy surface and the pad at both sides of the pad, is within 0.4mm and 0.6mm

h) lock the two top arm mechanical references with their own M10 nuts; **from this moment on, these mechanical references must not be touched because they have become the references for the next top/axial repositioning of the safety devices**

i) screw the top arm mechanical locking until it gets in contact with the arm and lock its rotation with its own M12 nut.

6.3.7.1 Special Tools for the Calibration of Safety Devices 0501 and 0515

Because there are some problems to get adequate accessibility to this two type of safety devices, it is necessary to use some special tools to perform all operations that are necessary for them best positioning near the dummy or mirror surfaces.
In the following it is better specified what the tools are:

- **Shaft Extension**: it is needed to operate the stroke of the sliding structure by means of the trapezoidal screw. Inserting this tool in the lateral hole of the angular gearbox, it is possible to position the safety device near the lateral surface of the dummy or of the mirror during telescope nominal working conditions. Otherwise, when removing the dummy or the mirror, it is necessary to move the safety devices backwards to their external mechanical end of stroke.
- **Key Extension:** onto this tool it is possible to mount different fittings that are necessary to adjust the positioning of the mechanical references during the integration phases and lock them definitively**.**

Figure 57 – Shaft Extension (bottom) and Key Extension (top) for safety devices 0501 and 0515

- **Plastic Feeler Gauge Support**: this tool is needed to control the backlash that, both axially and radially, the two safety devices have from the dummy or from the mirror.

[MISSING PICTURE: plastic feeler gauge support being produced]

Figure 58 – Safety Devices 0501 and 0515, Plastic Feeler Gauge with Extension

6.4 Subsequent Integrations of the Mirror Dummy

6.4.1 Intial Set-Up

1. The mirror cell lays horizontally on the supports within 0,1 mm/1000
2. all Axial Force Actuators are at the lower end of stroke position
3. the top arms of the Axial Safety Devices are open in the external position
4. the Lateral Safety Devices have been shifted backwards 8mm away from the working position
5. the astatic levers lay on their own supports and are locked with their own springs
6. the three lateral fixed points, disconnected from the invar lateral special pads, are fixed to the related squares and lay on their own supports
7. the lateral absolute transducers are locked in the rear position by the proper locking device
8. the dummy is on the appropriate support (e.g. three columns) at the same height within ±1 mm.

6.4.2 Lifting the Mirror Dummy

1. Mount the Hydra Set to the crane hook
2. mount the handling to the Hydra Set ring
3. mount the tripod to the Dummy, verifying that the numbers of the three connections is correct
4. move the hook right on top of the centre of the dummy
5. slowly lift the dummy while the dummy is still in contact with the columns, moving the crane laterally in order to share the load among all tie rods
6. lift the dummy about 100 mm over the supports
7. verify that it is horizontal within ± 2 mm.

6.4.3 Integrating The Mirror Dummy in the Mirror Cell

1. Lift the dummy 500 mm over its final height in the mirror cell
2. move the dummy horizontally until it is about on top of its final position in the mirror cell
3. verify that the dummy orientation, around the z axis, is correct
4. lower the dummy down to 100 mm over any possible contact point with the safety devices of the support system
5. move the dummy horizontally until it is about on top of its final position in the mirror cell
6. lower the dummy down to 8 mm over any possible contact point with the safety devices of the support system
7. move the dummy horizontally until it is about on top of its final position in the mirror cell
8. move the dummy horizontally in the two directions until it has backlash within 5mm and 15mm in relation to the lateral safety devices

9. lower the dummy down until the bottom of the dummy it is at the same height as the top of the lateral safety devices of the support system
10. move the dummy horizontally in the two directions until it has backlash within 7mm and 13mm in relation to the lateral safety devices
11. lower the dummy with the Hydra Set until it touches the three axial absolute transducers that are at 20mm height above the final position
12. rotate the dummy around z in order to reach its final orientation within 5mm tangential distance between the pads of the dummy and the pads of the astatic levers
13. disengage the lateral absolute transducers in order to read the lateral position of the dummy; verify the lateral position of the dummy to be centered within 3mm
14. lower the dummy with the crane, step by step, verifying its height by means of the axial absolute transducers until it is about 4mm above its final position
15. mount the three lateral pads of the Lateral Fixed Points on the dummy centering them by means of their pins, then insert the three invar bars and screw them to the lateral fixed points
16. move the four main safety devices radially until they have 1mm gap from the lateral cylindrical surface of the dummy
17. lock the position of the four safety devices
18. lower the dummy with the Hydra Set, step by step, continuously verifying the load on the three fixed points until the load read is between 200 N e 400 N each one
19. adjust the position of all Lateral Safety Devices with 1mm gap
20. lock the position of all Lateral Safety devices
21. slowly lower down the dummy with the Hydra Set until it lays on all axial force actuators and axial fixed points, verifying that the force increases on the axial force actuators and verifying the axial displacement by means of the axial absolute transducers
22. disengage the handling from the dummy and lift it
23. switch on the Axial Force Actuators, set the theoretical mean force and read the remaining loads on the three axial fixed points
24. verify that the dummy is back to the previous height at all three absolute transducers
25. move and lock the upper safety devices in their operational position.

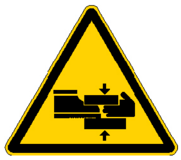
7 ORDINARY MAINTENANCE

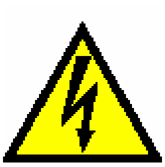
The present section describes the ordinary maintenance operations and warns against the main risks for the operator. **Anyway all general safety prescriptions must be followed, as best specified by the safety responsible, with reference made to the telescope as a whole system.**

WARNINGS

If the Mirror Cell is placed at or above 2m height, it is mandatory to set up a suitable staircase and a gangway as by the norms in force.

Beware of machine parts in motion.





Beware of electrical connections and parts at high voltage.

The operators carrying out all ordinary maintenance operations must wear the appropriate safety equipment (helmet, protection shoes, gloves, glasses and so on), as by the norms in force and as described in the use and maintenance manual of the telescope as a whole system.

Do not touch the screws marked with a red dot: they can be released only for extra-ordinary maintenance reasons.

Ordinary maintenance is summarised in the table below, that gives in an eye glance all information necessary to prevent failures of the M1 Support System.

MAINTENANCE TABLE

ref. chap.	frequency	description / remarks	personnel	instruments & tools	time required
7.1	every mirror removal	Axial Force Actuators and Axial fixed Points: verification with mirror removed	nr. 1 mechanical technician	grease	2 hours
7.2	every mirror removal	Lateral Fixed Points: zero adjusting with mirror removed	nr. 1 electronics technician	multi-meter	1/2 hour
7.3	every mirror removal	Lateral Supports (astatic levers): verification with mirror removed	nr. 1 mechanical technician		1/2 hour
7.4	every mirror removal	Safety Devices: gap verification with mirror mounted back in the cell	nr. 1 mechanical technician	special spacer	1 hour
7.5	every mirror removal	Axial Force Actuators and Axial Fixed Points: re-greasing with the mirror removed	nr. 1 mechanical technician	pump and Lubcon grease	12 hours
7.6	every 5 years	Safety Devices: verification of the pad	nr. 1 mechanical technician	test bench	1/2 hour

Table 13 – Ordinary Maintenance: frequency, sub-system and resources

7.1 Axial Force Actuators and Axial Fixed Points: Spheres

	every mirror removal	Axial Force Actuators and Axial fixed Points: verification with mirror removed	nr. 1 mechanical technician	grease	2 hours

For all axial force actuators and the three axial fixed points, verify by hand that each sphere is free to rotate and that each sphere block is still fixed to the actuator/fixed point.
In case the sphere block is found to be loose, than tighten it by hand.
In case the sphere doesn’t rotate, than grease it and try again to rotate it. In case it is still malfunctioning, than remove the sphere block and replace it with a spare one.

Figure 59 – Axial Force Actuator, top side view with sphere and spacer removed

Note that the sphere of the axial fixed points is larger than that of the axial force actuators.

WARNING

When replacing a sphere block, pay attention and do not forget to set back the spacer placed just below the sphere block.

In case a thicker spacer replaces the previous one, the force on the mirror can be higher. Conversely, in case a thinner spacer replaces the previous one, the force on the mirror can be lower.

7.2 Lateral Fixed Points, Load Cell Offset

	every mirror removal	Lateral Fixed Points: zero adjusting with mirror removed	nr. 1 electronics technician	multi-meter	1/2 hour

When the mirror is removed from the cell, the lateral fixed points are still connected to the mirror cell through the column support. The offset of the load cell will be checked.

Open the box containing the three amplifiers of the lateral fixed points, so to access the amplifiers of the lateral fixed points. Connect a multi-meter to the output nodes of the one axial fixed point at a time at a time.
Take a string and pass it around the spacer 15 (as defined in the assembly procedure, VST-TRE-TOM-22300-2124) and support the lateral fixed point with the string, making sure to avoid any axial load along the load cell of the lateral fixed point.
Turn the offset regulation screw of the related amplifier so to read a voltage equal to 2.5V ± 5 mV.

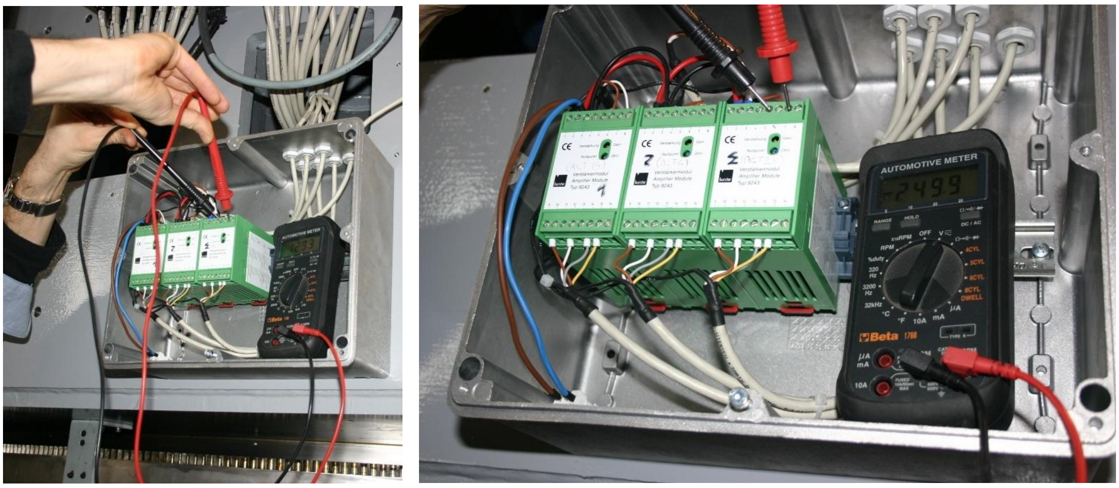


Figure 60 – Lateral Fixed Point, multi-meter connected to the load cell amplifier

Figure 61 – Lateral Fixed Point supported by means of a string

WARNING

Pay attention and do not move a lateral fixed point over 8mm in neither vertical or horizontal direction.

7.3 Lateral Supports, Rotations

	every mirror removal	Lateral Supports (astatic levers): verification with mirror removed	nr. 1 mechanical technician		1/2 hour

The risk is that unexpected loads may damage the ball bearings and friction doesn't allow free motion of the astatic levers.

When the mirror is removed from the cell, the astatic levers have four degrees of freedom, namely (refer to the assembly procedure, VST-TRE-TOM-22300-2125):
- pad (42) around fork (20)
- fork (20) around the arm
- the arm around shaft (2)
- shaft (2) in the welded support

Move by hand the astatic lever so to check that the four above mentioned motions are all allowed.

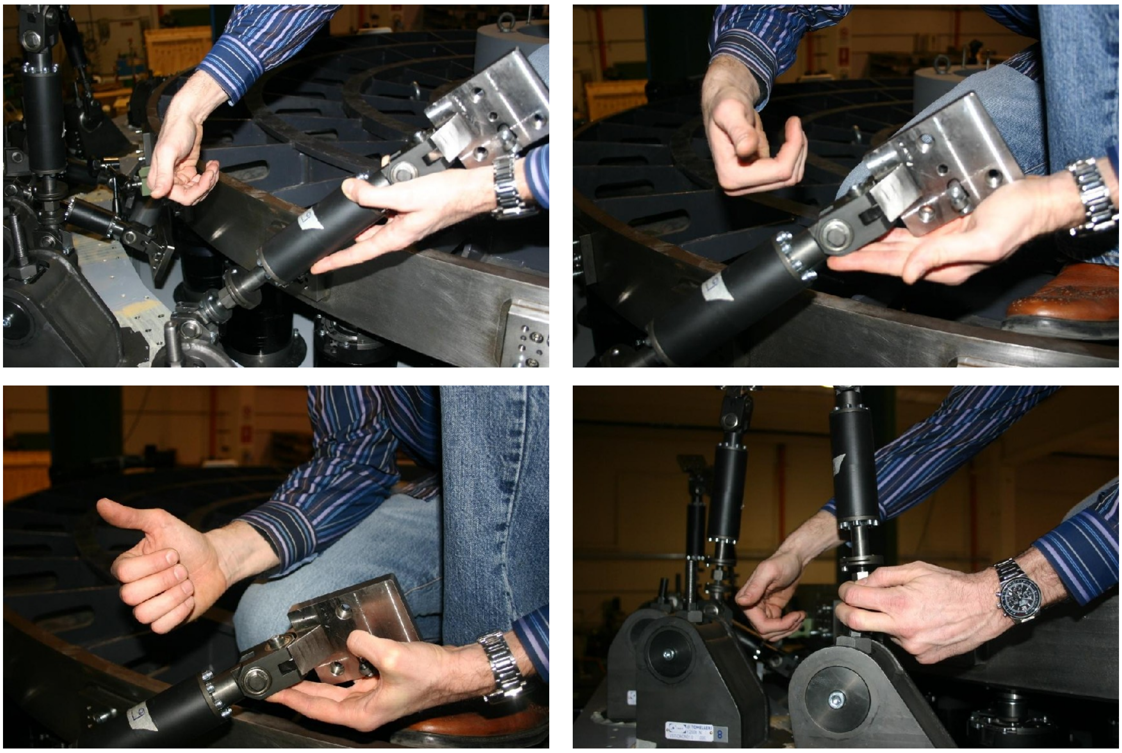


Figure 62 – Checking the movements of the four joints of the Lateral Supports: the right hand thumb is parallel to the joint axis

7.4 Safety Devices, Gap

	every mirror removal	Safety Devices: gap verification with mirror mounted back in the cell	nr. 1 mechanical technician	special spacer	1 hour

After mirror has been removed and then set back in the mirror cell, it is time to check the gap between the safety devices and the mirror.
The operation consists of checking how much gap is there between the safety devices and the mirror: it should be:

- within 0.8mm and 1.0 mm, along the radial direction
- within 0.4mm and 0.5 mm, along the axial direction for both the top and bottom arms of the safety devices

[MISSING PICTURE, spacer being produced]

Figure 63 – Safety Devices, verifying the gap

The safety devices nr. 0501 and 0515, that is those placed at he very East and at the very West sides of the cell, can be reached with the special spacer realised on purpose.

[MISSING PICTURE, spacer being produced]

Figure 64 – Safety Devices 0501 and 0515, verifying the gap

WARNING

Pay attention and do not touch the top surface of the mirror, apart from the areas strictly below and above the axial safety devices.

7.5 Axial Force Actuators and Axial Fixed Points, Greasing

	every mirror removal	Axial Force Actuators and Axial Fixed Points: re-greasing with the mirror removed	nr. 1 mechanical technician	pump and Lubcon grease	12 hours

This operation requires that all Auxiliary Units have been removed from the Mirror Cell.

Fill in the pump with Lubcon grease and verify that the pump is completely full. To make sure it is so, try and pump grease out until grease is getting out of the pump at each pumping action.

Remove the bottom cover of each axial force actuator and of each axial fixed point, then grease it with just one only pumping action.

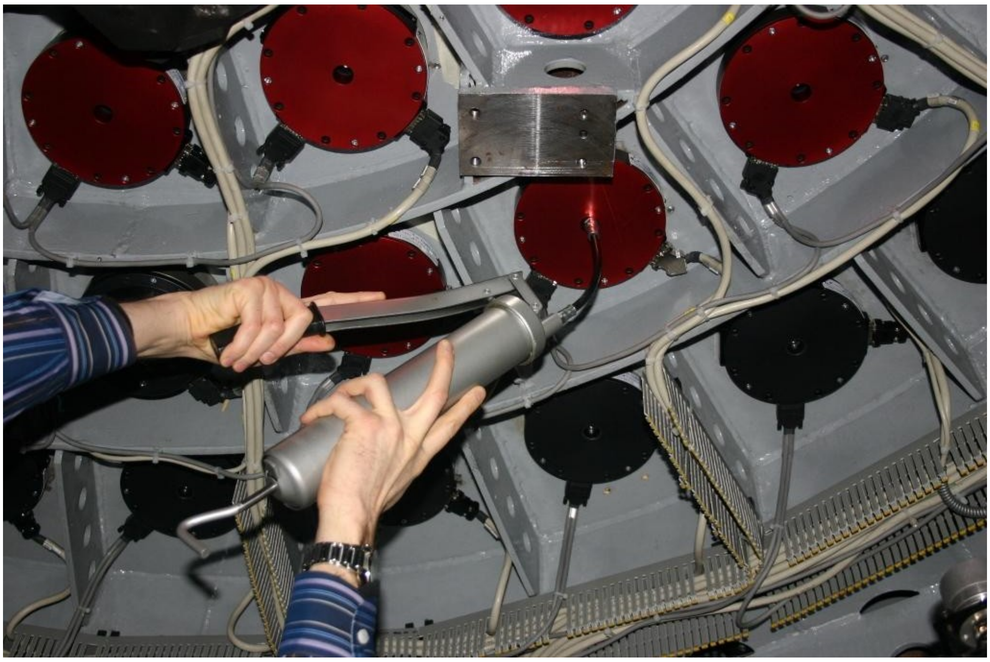


Figure 65 – Greasing with the Pump

WARNING

Pay attention and do not pump grease in the same axial force actuator or axial fixed point more than once.

7.6 Safety Devices, Pad

	every 5 years	Safety Devices: verification of the pad	nr. 1 mechanical technician	test bench	1/2 hour

Remove all/ poly-urethane pads from the safety devices. Place the poly-urethane pads on the test bench that has been designed for the axial force actuators and can be used to test the stiffness of the pads of the safety devices as well.
Set the gauge to zero and load 15kg on a cm^2 pad surface area, as by test bench design.
The height change is expected to be in the range 2,2mm $\pm$ 0,2mm.

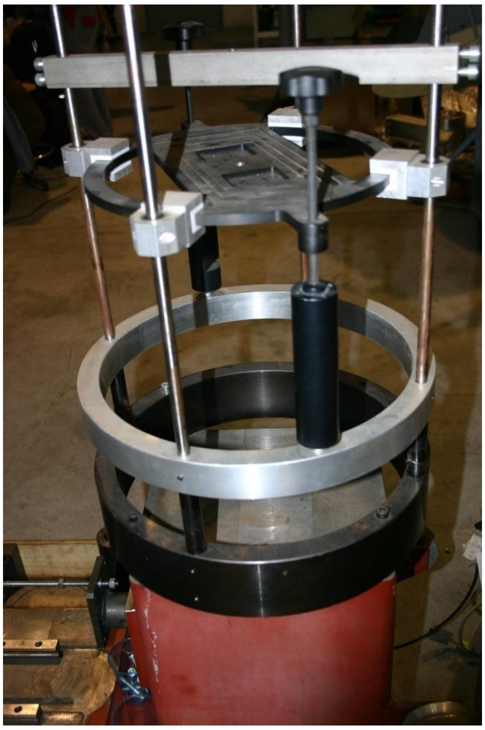


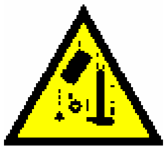
Figure 66 –Test Bench, to be used for the Pad of the Safety Devices as well

8 EXTRA-ORDINARY MAINTENANCE

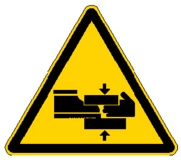
The present section describes the extra-ordinary maintenance operations and warns against the main risks for the operator. **Anyway all general safety prescriptions must be followed, as best specified by the safety responsible, with reference made to the telescope as a whole system.**

WARNINGS

If the Mirror Cell is placed at or above 2m height, it is mandatory to set up a suitable staircase and a gangway as by the norms in force.



Beware of machine parts in motion.



Beware of electrical connections and parts at high voltage.

The operators carrying out all extra-ordinary maintenance operations must wear the appropriate safety equipment (helmet, protection shoes, gloves, glasses and so on), as by the norms in force and as described in the use and maintenance manual of the telescope as a whole system.

Do not touch the screws marked with a red dot: they can be released only for extra-ordinary maintenance reasons.

8.1 Failure of an Axial Force Actuator

Equipment: Motor Control Handset
Personnel: nr.1 electronics technician

In case of failure of the electronics or of the load cell, the electric motor can still be moved down and reach the lower end-of-run. This can be achieved thanks to the Manual Control System, that is a power source outside the mirror cell. Proceed as follows:

- refer to the document "VST-TRE-TOM-22300-2105, M1 Harness Description" and see which PDB supplies the failed axial force actuator or axial fixed point
- cut the power supply
- open such PDB and identify the male connector of the failed axial force actuator or axial fixed point
- plug the connector of the Manual Control System in the related male connector
- lower down the failed axial force actuator or axial fixed point, as described in the Manual Control System User Manual
- remove the Manual Control System

Figure 67 – Motor Control Handset plugged in the PDB

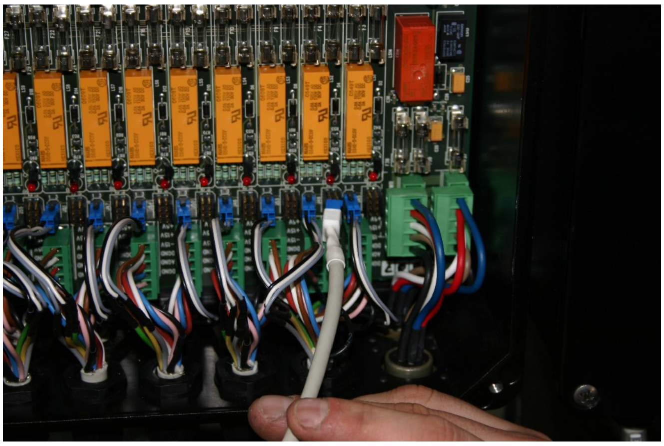


Figure 68 – Motor Control Handset plugged in the PDB: detail

8.2 How to replace an Axial Force Actuator or an Axial Fixed Point

Spares: Axial Actuator (Axial Force Actuator or Axial Fixed Point as required)
Personnel: nr. 2 mechanical technicians

In case of absence of signal from the load cell of an axial force actuator or an axial fixed point, proceed to:

- remove the axial force actuator or axial fixed point, according to the instructions of respectively sections 4.1.2 or 4.2.2
- replace it with a spare, according to the instructions of respectively sections 4.1.1 or 4.2.1

Figure 69 – Mounting an Axial Force Actuator with the Support Rod

8.3 How to Replace a Lateral Fixed Point

Spare Part: nr.1 Lateral Fixed Point
Personnel: nr.1 mechanical technician, nr. 1 electronics technician

In case of absence of signal from the Load Cell of the lateral fixed point, proceed as follows:

- take the spare lateral fixed point and connect the cable to the load cell
- hold the lateral fixed point in horizontal position with the help of a string supporting the spacer 15 (as defined in the assembly procedure, VST-TRE-TOM-22300-2124)
- set the offset of the related amplifier at 2.5 V
- remove from the lateral fixed point to be replaced
- remove the counter-weight shaft from the lateral fixed point just removed
- fix the counter-weight shaft (part 13 in the assembly procedure, VST-TRE-TOM-22300-2124) to the spare lateral fixed point
- mount the spare lateral fixed point onto the mirror cell, according to the procedure detailed in section 4.3.1-How to Mount the Lateral Fixed Points

Figure 70 – Lateral Fixed Point, adjusting the length and checking the gaps

8.4 How to Replace an Amplifier of the Lateral Fixed Points

Spare: amplifier, temporarily borrowed from the Calibration Box
Personnel: nr. 1 electronics technician

In case the output voltage between nodes 5 and 7 of the amplifier of the lateral fixed points is quite different from 2.5 V $\pm$ 0.1 V, proceed as follows:

- switch power off and remove the amplifier
- take an amplifier from the Calibration Box
- set the dip switches of the amplifier as required for the 1000 Lb Load Cells
- connect the amplifier to the lateral fixed point
- disconnected the lateral fixed point from the mirror
- keep the lateral fixed point in horizontal position
- switch power on and set the offset at 2.5 V
- replace the amplifier borrowed from the Calibration Box with a new one

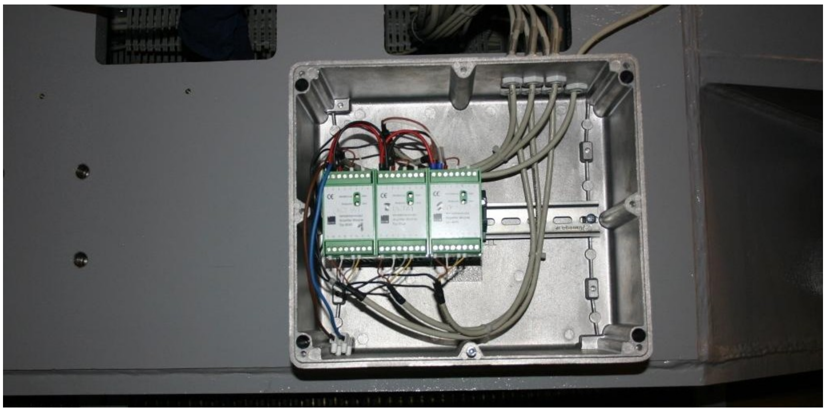


Figure 71 – Lateral Fixed Points, Box of the Load Cell Amplifiers

8.5 How to Replace a PDB fuse

Spare: 500 mA fuse, 5x20mm (F), 10-537-1240
Personnel: 1 electronics technician

In case of absence of power supply to any axial force actuator or axial fixed point, proceed as follows:

- refer to the document “VST-TRE-TOM-22300-2105, M1 Harness Description” and see which PDB should supply that one axial force actuator or axial fixed point
- open that PDB and see whether a red LED is on, then check that the LED on is associated to that actuator (or fixed point)
- if it is so, than change the fuse that supplies that axial force actuator or axial fixed point

Figure 72 – PDB: changing the fuse

8.6 How to replace a Cable

Material: power cable or CAN bus of appropriate length
Personnel: 1 electronics technician

When it comes to changing a cable, do not remove anything, before you have taken a picture of it. It is in fact necessary to take pictures of the whole path of the cable to be changed, from the PDB to the axial force actuator (or axial fixed point). These pictures must then be used as reference in order to repeat the same path with the new cable.

It is suggested to:
- take an overall picture of the cabling: from the axial force actuator (or axial fixed point) to the PDB
- take a picture of each cable segment that is significant for the cable path
- for each picture taken, mark a number (1, 2, 3..) on the cell structure with an erasable pen

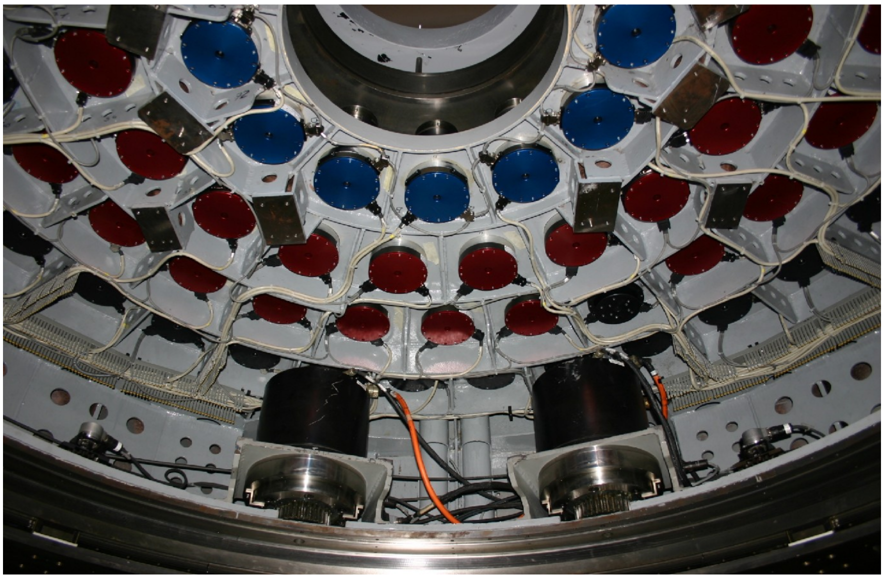


Figure 73 – overall picture of the cabling for traceability, example

9 Attachement: CONFORMITY DECLARATION

TOMELLERI s.r.l.

Via Orione 6, Sommacampagna (VR), Italy

MANUFACTURER DECLARATION

ATTACHEMENT II-B, *Machine Directive 98/37/CE*

THE UNDERSIGNED

TOMELLERI s.r.l., viale del Lavoro 12-A, Villafranca (VR), Italy

DECLARES ON HIS OWN RESPONSABILITY THAT THE NEW MACHINE

VST M1 SUPPORT SYSTEM

MAY NOT BE RUN BEFORE THE MACHINE into which IT IS INCLUDED is DECLARED IN COMPLIANCE WITH THE INSTRUCTIONS OF DIRECTIVE 89/392/CE and following modifications, as well as with the national instructions in force.

IS IN COMPLIANCE WITH THE INSTRUCTIONS OF DIRECTIVE 89/392/CE and following modifications, as well as with the national instructions in force.

Raffaele Tomelleri

Villafranca (VR), Italy, March 4th, 2009