D0 Roman Pot Castles Manual

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VERSION 4

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Abstract

We describe here the main points that someone should know when working with the FPD castles. It is not a construction manual.Compared to version 3, version 4 of this manual has a more detailed description of the baking procedures (chapter 3), some rewording of sections 8.1 and 8.3, and a slightly different technical information (chapter 10).

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1 Introduction

The D0 FPD castle is shown on figure 1. It has four arms identified as up, bottom, left and right according to the system shown in the figure. For an observer sitting on the castle having the top arm in between the observer and the ion pump (or its flange), the castle right arm is the one to the right.

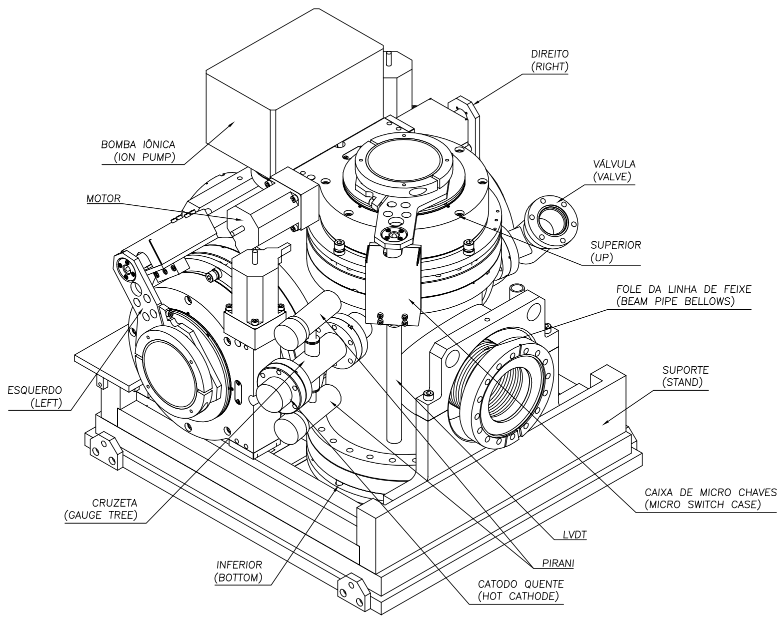


Figure 1: FPD castle

The parts shown on the figure are:

Ion pump: device responsible for the for the establishing and maintaining ultra high vacuum (UHV) inside the castle

PIRANI: a vacuum gauge.

Hot Cathode: a vacuum gauge (for pressures lower than the ones measured by the PIRANI)

Gauge tree: piece where the PIRANI and the hot cathode are connected.

Valve: connection port to the pump down.

Motor: used to mechanically move the pot

LVDT: electronic device that measures the pot position.

Bellows: flexible connection that allows the castle to connect to the beam pipe (there are two of them although only one is visible on the figure)

Micro Switch Case: a box housing the control switches.

Stand: adjustable structure that holds the castle

Encoder (not shown on figure): electronic device that counts the turns of the motor.

The D0 FPD castles are found in two versions: QUAD castles and DIP castles. QUAD castles have the four arms instrumented whillst DIP castles have only one arm instrumented. A QUAD castles weight about 170 kg. A DIP castle weights about 91 kg. They are all made with 316L SS.

We have a total of six castles individually identified as LARANJEIRAS, PACOVAL, MATINADA, GENTIL, MACACÃO and GUAJARÁ.

LARANJEIRAS: QUAD castle. It uses SPECIALLY machined metric screws for attaching the ion pump. The use of a different screw will create a conflict between one of the LVDT's and the ion pump screws. It has one ion pump, two pirani gauges, one hot cathode and one vacuum valve. LARANJEIRAS CF40 flange (for either pre vacuum or the gauge tree) comes in a 8 degree angle relative to the central chamber.

PACOVAL: The ion pump flange sits at a bigger distance from the chamber than LARANJEIRAS' making it possible to use regular screws to attach the ion pump. Either metric or American standard screws may be used for this purpose, although we suggest screws of the same type as the ones used for LARANJEIRAS just to avoid mixing different standards for similar parts. It has one ion pump, two pirani gauges, one hot cathode and one vacuum valve. The CF40 flange (for either pre vacuum or the gauge tree) comes in a 10 degree angle relative to the central chamber.

MATINADA: Same as PACOVAL.

GENTIL: Same as PACOVAL.

MACACÃO: DIP castle with only the right arm instrumented. MACACÃO has all the mechanical parts that ended up different during construction (these are small differences that have no effect on its performance). MACACÃO has also a different flange at one of its bellows. It has a 1.2 mm thick SS ring between the fixed and rotating part of the flange. That's was made to compensate for defect on the original LESKER flange. It has one vacuum valve. It has no ion pump and no gauges.

GUAJARÁ: DIP castle with only the left arm instrumented. It has one vacuum valve. It has no ion pump and no gauges.

2 Stand

The purpose of the stand is to hold the vacuum chamber and its Roman pots. The stand allows the positioning of the center of the castle vacuum chamber in the nominal position with respect to the center of the beam line (during alignment). It also allows the adjustment of the castle position in all directions over a range of 15 mm with an accuracy of 0.1 mm.

Figure 2 shows the FPD stand.

The stand consists of:

1: fixed aluminum bottom plate. This piece is shimmed to the tunnel floor and aligned with the beam direction.

2: adjustable aluminum plate. This plate is the base of the whole stand and is fixed to the fixed plate by means of five bolts.

3: spindles. There are three spindles that allow adjustment of the castle angular position.

4: frame. The spindles act on this frame, adjusting its angular position and, as a consequence, the castle angular position.

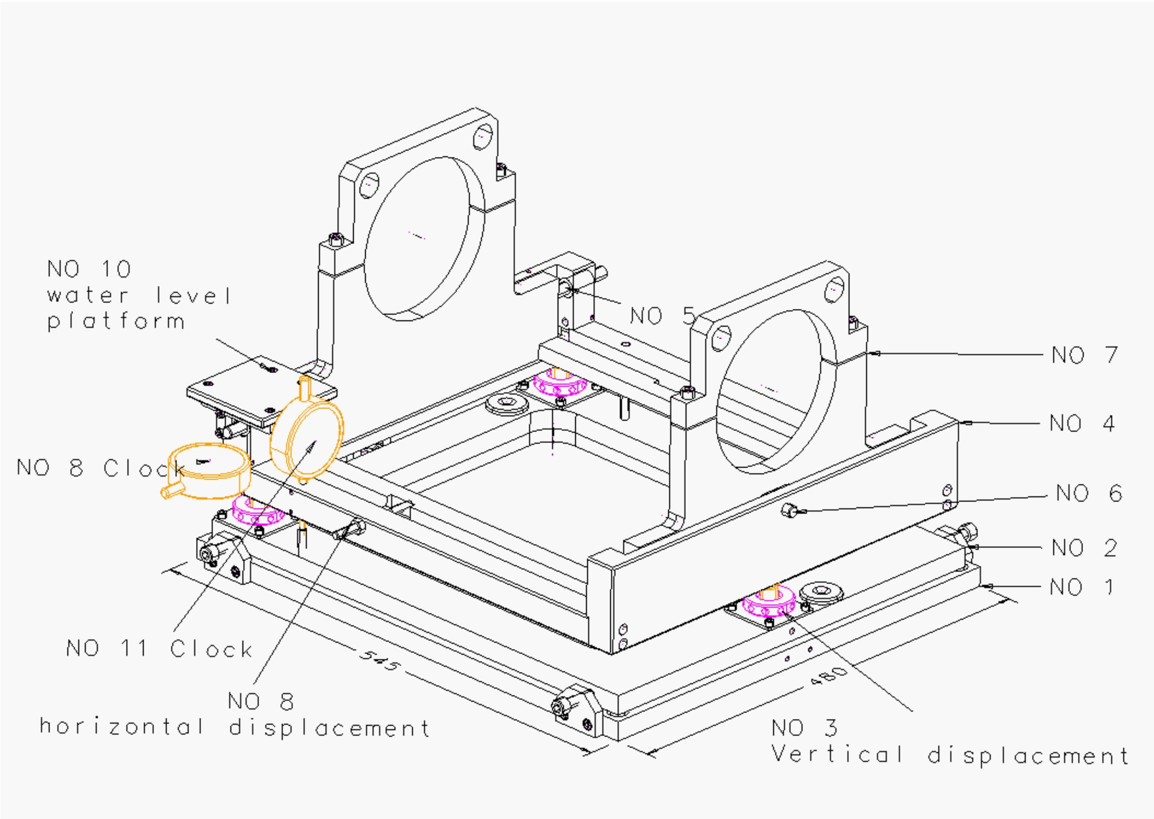


Figure 2: FPD stand

7: u-shaped frame. That's the piece where the castle rests (see fig 1). This piece can be moved in the direction perpendicular to beam by acting on the horizontal displacement bolts mounted in the frame.

8/11: position gauges (clocks). Mounted on the frame, show the distance between the frame and the adjustable plate and the distance between the frame and the u-shaped frame. These gauges has a range of 30 mm and an accuracy of 0.01mm.

10: water level platform. By placing level on this platform one can see how parallel the frame is relative to the floor. This parallelism can be adjusted by means of the spindles.

3 Baking procedure

Baking is an important operation to be performed with the castles and should be done only by personel well acquainted with the castles characteristics and with the necessary knowledge on the process. Don't do it if you don't know what is it about or if you have any doubt on the castles operation.

The motors and the encoders do not withstand the baking temperature and must be removed before baking and reinstalled once the baking is completed (see sections about removing and installing the motors and encoder). All other parts are bakeable, including the switches and their associated wires and connectors.

The castles have to be baked for ultra high vacuum (UHV) operation. They should not be baked at temperatures higher than 150 degrees Celsius. Above this temperature some parts may be damaged with serious consequences for the castle operation. A most critical component is the grease used to lubricate the pot internal mechanism. This grease may loose its lubricant properties if overheated and its substitution requires disassembling the castles and a painful removal of the damaged grease.

Table 1 lists the minimum material needed for the baking.

Item	Quantity	Observation
Heating tape	6	One for each pot; One for the body; One for the beam pipe bellows
Thermocouple	7	One for each pot; One for the body; One for each beam pipe bellows

Table 1: Minimum material needed for baking the castles. The associated equipment, like controllers and electronic interface is not listed.

An important part that must be baked is the internal driving bellows. Since they are well inside the driving assembly (not visible from outside the castle) it may take time for them to reach 150 degrees Celsius. It may be convenient to insert some heating tape inside the pot itself to assure homogeneous heating. This operation should be carried with extreme care due to the risk of damaging the thin foil window that separates the pot from the UHV inside the castle. In all stages, **one must make sure that temperature never goes above 150 degrees Celsius**. This implies the use of independent heating circuits inside each pot (one thermocouple attached to the inside of each pot and one independent heating tape inside each pot).

The castles temperature should be raised slowly taking at least 48 hours to reach 150 degrees Celsius. This guarantees an homogeneous temperature all over the castles reducing the risk of damage. For this purpose, there should be an independent heating circuit for the castle body, with one thermocouple attached to the external body. A good place to attach the thermocouple is the area close to the ion pump neck. The beam pipe bellows must also have their temperature controlled. A thermocouple should be attached to each one of them and an independent heating circuit also be dedicated to this task. Once all the heating circuit is wrired up, the castle should be wrapped in a thermal insulator. The castle should then be kept at 150 degrees Celsius for other 48 hours. During the first 40 hours at 150 degrees Celsius the castle should be pumped by a turbo molecular pump (this guarantees that the internal surface of the components are clean). Then the ion pump should be turned on and the valve to the turbo molecular pump should be closed. Once the baking is completed the castles should slowly be brought back to room temperature (about 48 hours). **Be sure to cool down first the chamber and, only then, all the bellows at the same time.**

The first time we move the pots after baking (when the castle is cool again) we should do a complete slow move of the pots towards their in limit and then bring them back to their home position. This should be done at very low speed to allow some redistribution of the grease.

The easiest and safest way is to have the castle baked in an oven. This assures uniform heating and guaranties that the castle will never be overheated. In this proceedure the whole castle (including the ion pump and vacuum gauges) is placed in an oven and a controlled baking is performed. The pre-vacuum and ion pumps are used as described in the procedure for baking with heating tapes and the castle is kept in the oven until the desired UHV is achieved. It will then be taken to the accelerator, already in UHV, and installed following the standard proceedure for this kind of operation, namely purging the castle with dry nitrogen, removing the blank flanges attached to the external bellows, attach the castle to the accelerator, turn on the pre-vacuum system to stablish vacuum in the castle and then turn on the ion pump to restablish the UHV. If necessary, an in situ baking can then be done by means of heating circuits. If the castles are pre-baked in an oven, the in situ baking is likely to be unnecessary or, at least, easily facilitaded.

4 Replacing the motors

Figure 3 shows a closer view of the motor.

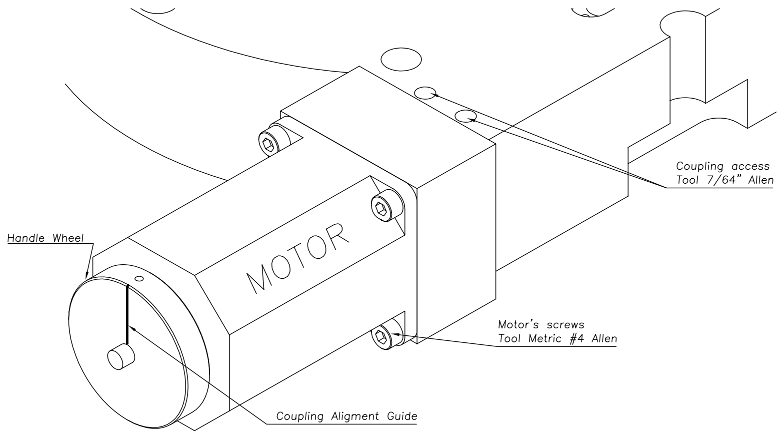


Figure 3: Motor

To remove the motor first loosen up the two screws marked "Coupling Access". You will need a 7/64 Allen wrench (you may have to remove the aluminum caps that may be protecting the access holes).

To be sure that the screws are in the access holes just turn the "handle wheel" until the "Coupling Alignment Guide" is aligned in between the two holes. You should then easily be able to reach the screws with the wrench. Unscrew them only about 1/4 of a turn. Do not remove them.

Use a metric 4 mm Allen wrench to remove the motor's screws completely. This will set the motor free. Do this operation carefully. Be sure to hold the motor or it may fall when the screws are completely removed. The bottom motor may require some patience due to its location.

Once the motor's screws are removed, hold the motor firmly and pull it gently out of its place. Move it in the direction along its axle. Once it comes loose you can carefully remove the motor. The motor shall come out with the coupling attached to its axle.

To reinstall the motor, hold it firmly and, carefully insert it into its place. You will have to try a little bit to fit the coupling to the internal axle. It should go smooth. Take your time, do not force the coupling. Once in place, first fix the motor with the four motor's screws. Then align the coupling alignment guide with the center of the line between the two coupling access holes. Tight up the coupling screws only enough for a firm grip.

The operation is complete.

5 Replacing the encoder

The encoder is located opposite to the motor (see figure 4). To replace the encoder, first remove the nuts (5 mm)that hold it in place. Pull the encoder out of its place gently. You now must remove the magnetic encoder wheel. Simply loosen up the two screws following the same proceedure as for the motor. The screws that hold the encoder magnetic wheel in place (8/32 Allen) can be reached through the holes on the aluminum case, similarly to the ones from the motor (tilt the Allen wrench to reach the screws that are place at 90 degrees from each other). Loose the screws only about one quarter of a turn. Do not remove them completely. Pull out the wheel.

To install the encoder follow the proceedures in the reverse order. Before tightening up the encoder magnetic wheel screws push the wheel all the way until it stops. There shall be a small gap (something between 0.5 mm and 1.0 mm) between the wheel and the aluminum case.

6 Replacing the LVDT

Disconnect the LVDT cable. Hold the LVDT (see figures 1, 4 and 5) firmly and slowly unscrew it from its place. It takes many turns to completely release the LVDT, so be patient and take your time. Try to keep the LVDT as aligned as possible.

To install the LVDT simply follow the same steps in the reverse order. The LVDT moving rod should go first. Replacing the LVDT does not change alignment, but one must log the new LVDT readout as described in the section about the control switches ahead in this manual.

Notice that the LVDT nut has been machined so its length is only 5 mm. You should use this nut when replacing the LVDT, otherwise the LVDT rod will not work properly.

7 Placing the castle in the stand

When lifting the castle you should wrap the proper slings or steel cables around the piece protecting the beampipe bellows (see figure 1). Be sure that the sling or cable is not pressing any of the castle sensible parts (like the micro switch case). This piece was designed to both protect the bellows and give a safe place for lifting. The castle should gently and carefully be brought to the stand u-shaped frame (whose upper part has been previously removed). Once the castle is resting on the stand, with no parts coming out or short of the stand limits, just put the u-shaped upper part and screw the bolts (metric, Allen 4 mm) firmly. Rotate the castle gently if necessary before tightening up the bolts.

8 Alignment

Alignment allows us to place the castle in a known position relative to D0 detector as well as to know the pots relative positions. We can position the castle at different heights, angles and horizontal position by acting on the stand spindles and bolts. We can set the pots in different angles relative to the castles by acting in the driving assembly alignment screws. The pots in and out position can be set by a proper adjustment of the control switches.

8.1 Stand

The adjustment perpendicular to the beam axis can be performed through properly acting on the stand (see chapter 2 for details on the stand).

1 In the horizontal plane, rotate the nuts on the horizontal adjustment bolt. The gauge (9) (clock) can measure the movement on the u-shaped frame(4).

2 The vertical movement can be done by rotating the three stand spindles. The movement can be measured by the gauge (11). The horizontal plane can be measured by placing a level on the platform(10) and measure in two directions.

Only the surveying crew should do the alignments. Don't play with the spindles and bolts. Leave them alone. Once the castle final alignment is reached one should log the gauges readings.

8.2 Driving assembly

Figure 4 shows the FPD castle driving assembly. It is the part that holds all the moving systems.

The pot interior is accessed from the opening on top of the system. The bellows and window assembly are hidden from view inside the castle main chamber. The window can, however, be seen through the pot opening.

The window is a sensitive part of the system. The detector is the only thing that should be inserted into the pot. No tools or any other item should ever be inserted into the pot.

To keep things from accidentally dropping into the pot, this should always be kept closed by the proper transparent plastic lid provided with the castles except, of course, when the detector is in its place. Do not leave the pot uncovered even for a short period of time. Any damage to the thin window should be considered a major accident that may completely damage the pot, break the vacuum and require extensive and complex work to be repaired.

The four angle adjustment screws (metric 6 mm) allow adjustment of the pot angle relative to the castle. Only the surveying crew should adjust them and, once the proper angle is achieved they should be left alone. Never play with them, or the alignment will be lost.

8.3 Control switches

Figure 5 show the control switches box with the LVDT and the three control switches. The box can easily be open by removing the four screws in front of it (be aware to the fact that the

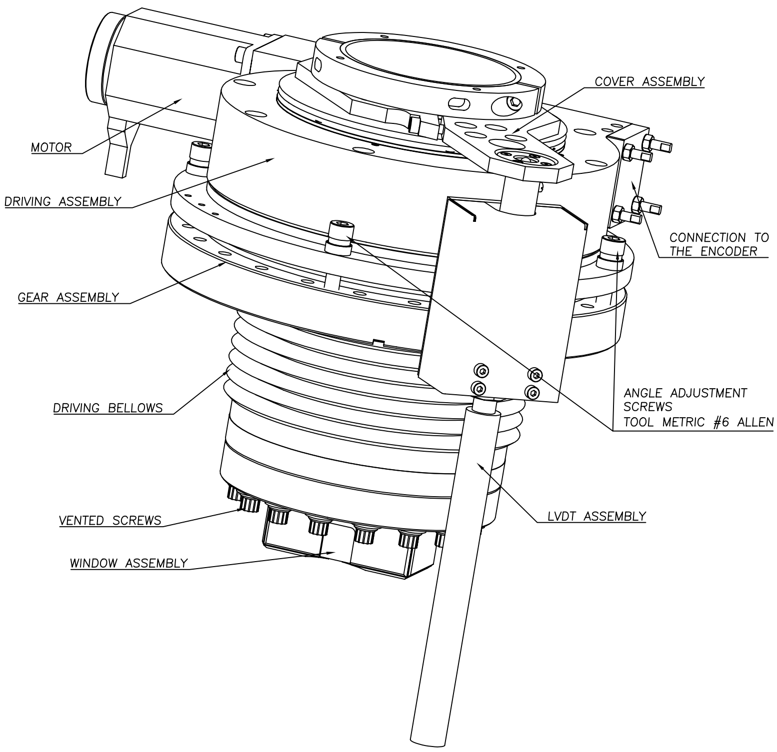


Figure 4: Driving assembly

bottom arm has a box of different shape for compatibility with the stand). This will give access to the switches and to the switch activating mechanism shown in figure 6.

The switches are used to monitor and control the pot movements.

POT HOME SWITCH: this switch marks the pot home posititlon. This position is used as a reference position and, mainly, by beams division personel to know that the pot is retracted clearing the beampipe

POT OUT SWITCH: this switch marks the pot out position. It indicates that the pot has reached its furthest distance from beamline. The pot can not be moved beyond this point. This switch is set to be activated a little bit before the mechanical limit

POT IN SWITCH: this switch marks the pot in position. It indicates that the pot has reached its closest distance to beamline. The pot can not be moved beyond this point. This switch is set to be activated a little bit before the mechanical limit

Figure 6 shows the switch activating mechanism.

When the pot moves, so it does the piece with the switch activating mechanism. The LVDT rod is also moved with the piece. When the pot is totally inserted (the closest achieved position to the beam) the POT IN LIMIT switch is activated by the POT IN screw. When the pot is totally removed (its furthest achievable distance from the beam) the POT OUT LIMIT switch is activated by the POT OUT screw. The POT HOME switch is activated by the POT HOME LEVEL .

The pot in position and the pot out position can be set by the corresponding POT IN and POT OUT screws. The POT HOME position is adjusted by flexing the POT HOME switch lever to the desired position.

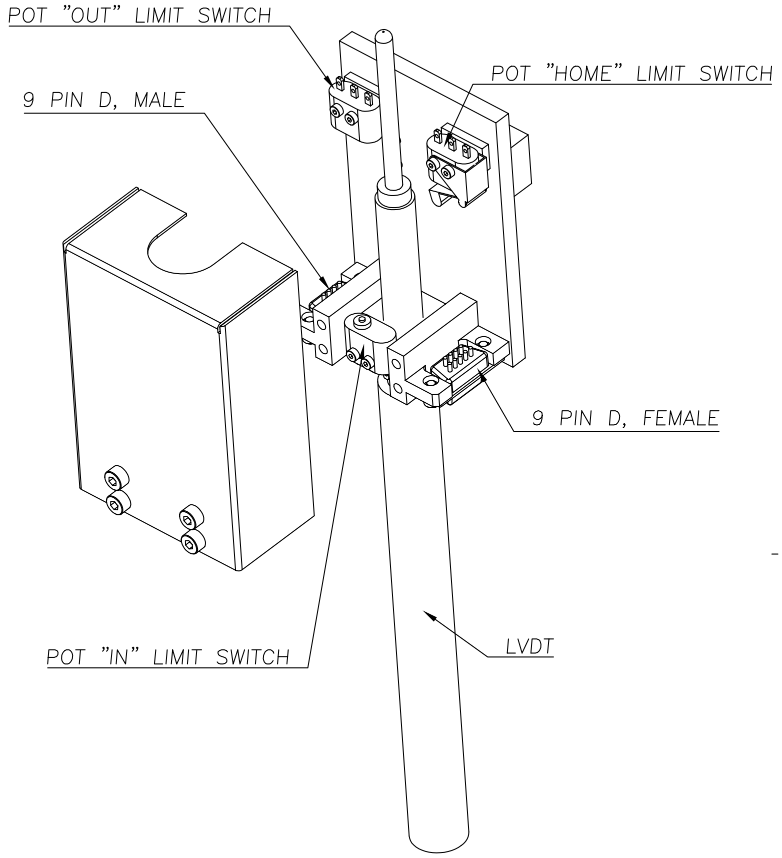


Figure 5: Control switches

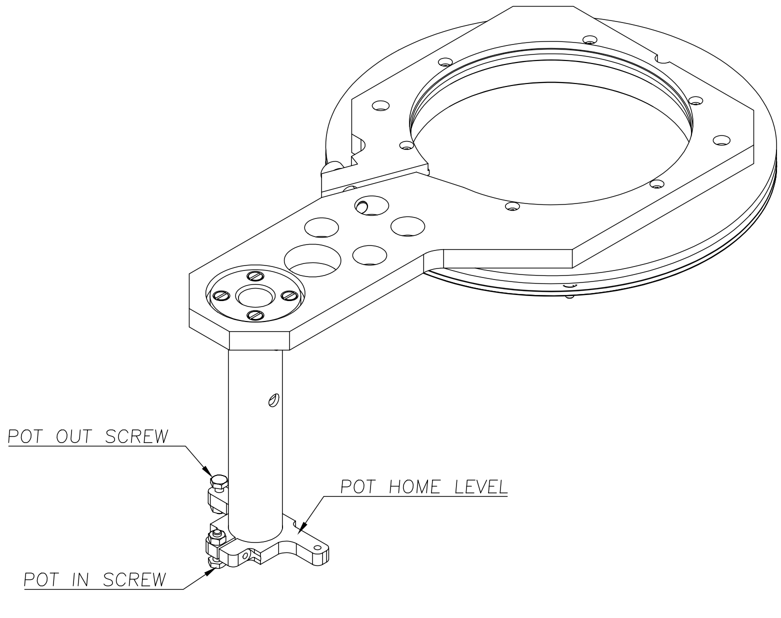


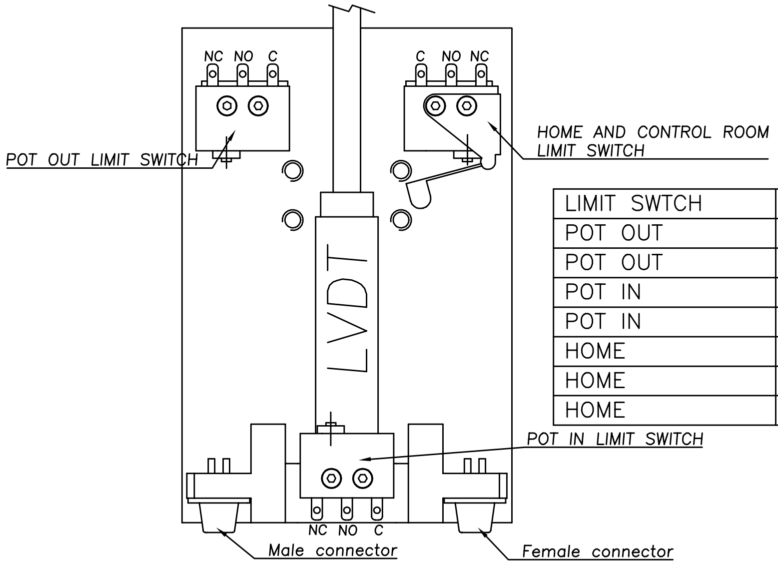
Figure 6: Switch activating mechanism

All these operations should be done only when surveying the castle. Once the surveying is done the screws should be left alone. Any change in the screws adjustments will mean redoing the castle surveying.

The castle has been built in such a away that the pots can not be moved indefinitely either towards or away from the beam. Even if the information from the switches is not available to the pot control system, the pots will forcibly stop when the mechanical limit is reached. However, keeping trying to move the pot beyond these limits may put to much stress on the motor and driving mechanism. The POT IN and POT OUT switch should be set to operate before these limits are reached.

Once the alignment is completed one should log all the information and the corresponding LVDT readout.

Figure 7 shows how the switches are wired to the connectors.



LIMIT SWTCH	TERMINAL	CONECTION	PIN
POT OUT	C	MALE	1
POT OUT	NC	MALE	2
POT IN	C	MALE	3
POT IN	NC	MALE	4
HOME	C	FEMALE	1
HOME	NO	FEMALE	2
HOME	NC	DON'T USE	

Figure 7: Switch wire up: NC (normally open); NC (normally closed); C (common)

9 Acknowledgments

The castles were built and assembled at Laboratório Nacional de Luz Síncrotron (LNLS), Campinas, Brazil. The window assembly and the stands were built at NIKHEF, Amsterdam, Holland. The castles were completed on January 2000.

10 Technical Information

Motor	PARKER OS22B-DNFLY
LVDT	Macrosensors GHSA 750-1000-XXXX, ± 1 inch range 150C, Alternate Current
Castle material	316L SS
Worm-gear system reduction	120
Pot movement	2 mm per gear turn
Pot displacement	40 mm
Pot speed	16.66 microns per motor revolution
Maximum motor speed	15 rpm (recommended)
Encoder resolution	Motor half turn (corresponding to 8.5 microns)
Pot window thickness	150 microns
Maximum temperature	150 degrees Celsius

11 Conclusion

This manual does not give all the possible and imaginable information about the D0 FPD castles. More detailed information on the construction and performance should be obtained from other sources.

This manual should be updated periodically. Before any work with the castles, be sure you have the most recent manual in your hands. Any changes in proceedures or correction to this manual should be logged and informed, so we can issue new updated versions.

In case you suspect that things have changed or that they are not like described here, please contact the closest FPD person.

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