S-AA-M-31

Cryogenic Target Handling System Operations Manual Volume IV–CTHS Description

Chapter 9: Lower Pylon (LP)

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Chapter 9
Lower Pylon (LP)

9.1 INTRODUCTION

The equipment shown in Fig. 9.1-1 has been installed in the OMEGA target area to allow cryogenic targets to be positioned and shot. The lower pylon, supported by the target chamber (TC), extends downward from the center of the TC and through the Target Bay floor. Rigidity is provided by additional lateral support to the Target Bay floor. The lower pylon is basically a cylindrical vacuum vessel fitted with a kinematic dock inside its upper end and an isolation valve and flange at its lower end. The moving cryostat (MC) is placed at target chamber center (TCC) by the lower pylon equipment.

When the MC arrives at the TCC (see Fig. 9.1-1), the MC mates with the kinematic dock built into the lower surface of the top of the lower pylon and is clamped into place. This places the layering sphere and target within approximately 100 μm of the convergence point of the laser beams. The position of the target is checked and adjusted using the standard OMEGA Target Viewing System and the positioner built into the MC.

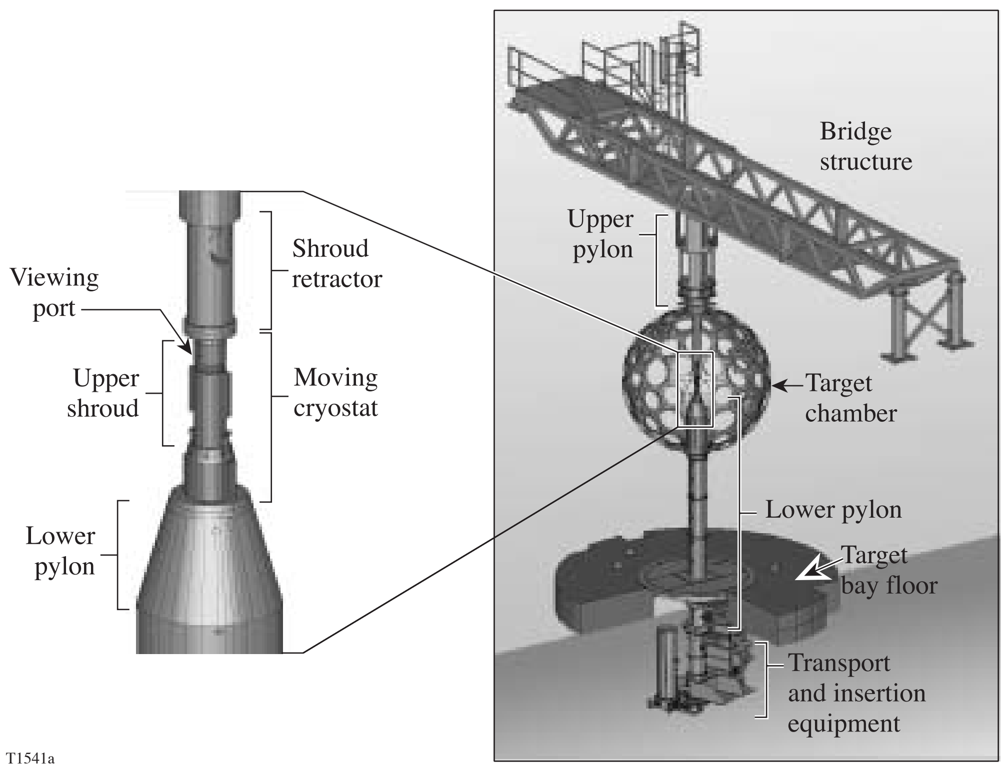


Figure 9.1-1
(a) Lower pylon with MC docked at TCC; (b) Lower pylon overview.

The upper pylon is supported by a bridge structure and extends into the TC through a bellows joint at the top of the TC. The linear induction motor and shroud retractor are housed within the upper pylon and are used to remove a thermal shroud that protects the target until shot time.

Figure 9.1-2 shows the lower pylon below the target chamber, with the transport cart docked to it. The vertical cylinder in the foreground is an evacuated "chain locker." When the system is ready, the isolation gate valves are opened, and the MC is driven to TCC by the action of the chain being driven out of the locker and along guide rails inside the transport cart and lower pylon vacuum vessels. A major feature of the MCTC is the umbilical spool that manages the electrical and fluid lines that connect the MC to the cart. The umbilical spool allows the MC to extend 20 ft above the cart into the target chamber center.

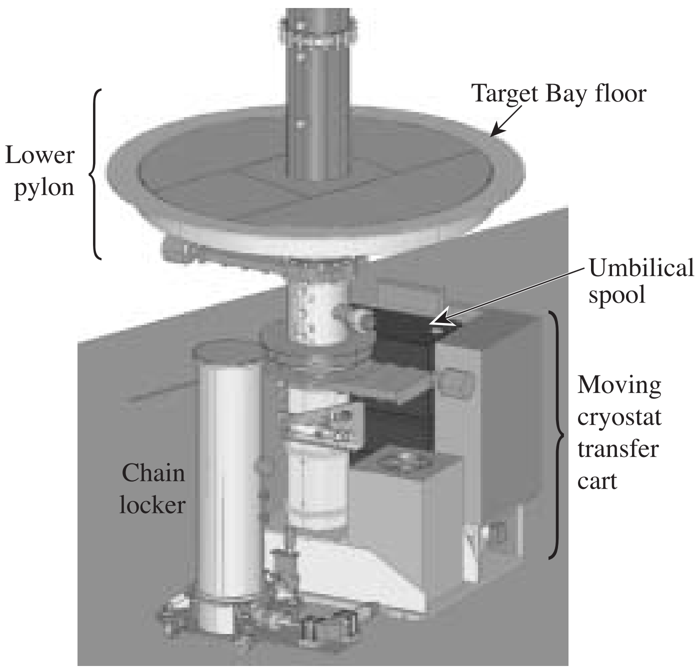


Figure 9.1-2
MCTC docked at the lower pylon underneath the Target Bay floor.

9.2 EQUIPMENT OVERVIEW

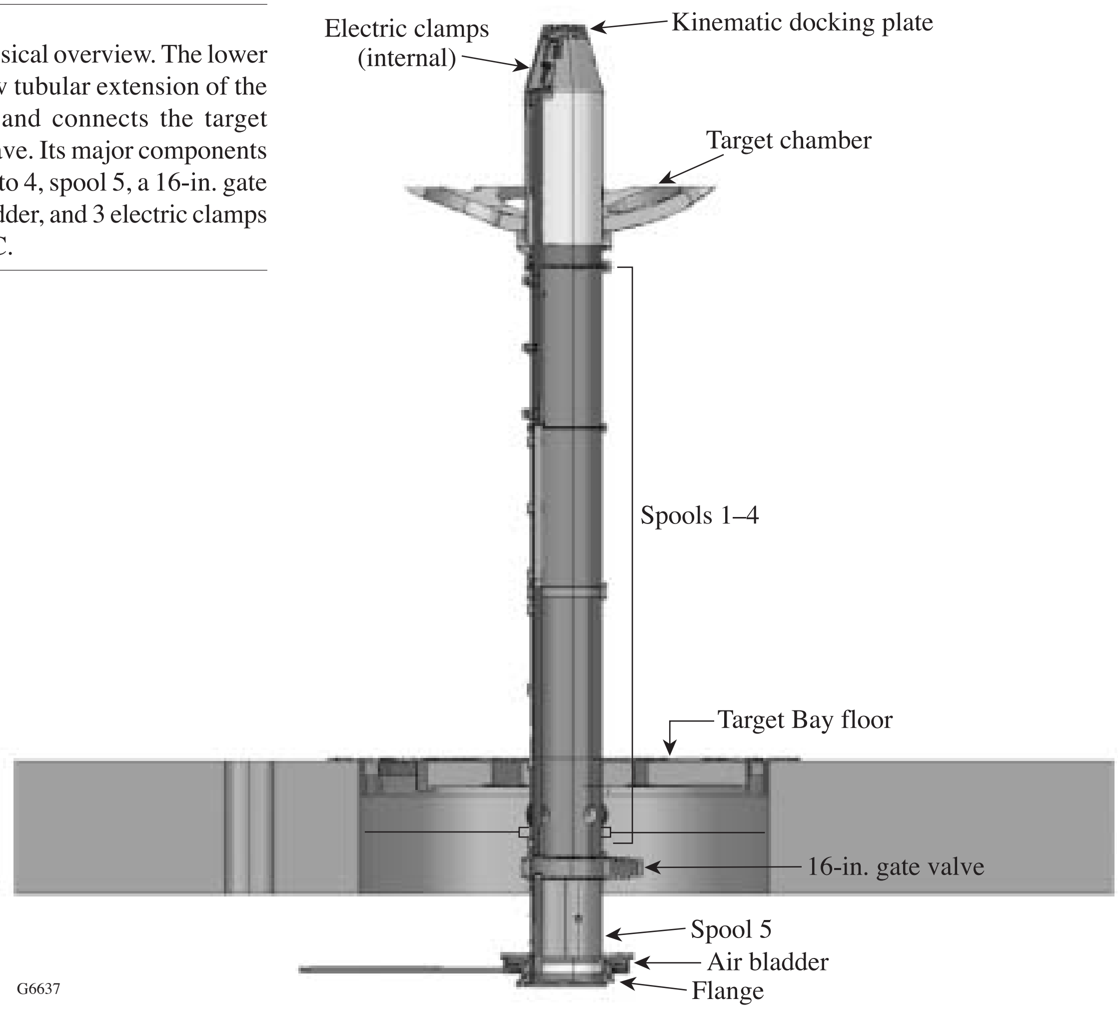
9.2.1 Lower Pylon

A mechanical diagram of the lower pylon is shown in Fig. 9.2-1. When the MCTC is mated to the lower pylon and the vacuum pressures are equalized, the lower pylon's 16-in. gate valve and the MCTC's 16-in. gate valve are opened and the MC is driven to TCC. A guide rail inside (see Fig. 9.2-2) the lower pylon guides the MC to TCC. When it arrives at TCC, the MC mates with the kinematic dock, which is built into the lower surface of the top of the lower pylon, and is clamped into place. The MC is clamped by three electric clamps that secure the MC once it is mated to the docking plate.

9.2.1.1 Gate Valve

The 16-in. gate valve isolates the target chamber and the upper portion of the lower pylon from ambient pressure during normal operations and while the MCTC is being positioned and connected to the lower pylon. Once the connection is made between the MCTC and the LP and the interspace is evacuated to 5×10^{-5} Torr, this 16-in. gate valve and the MCTC gate valve are opened to allow the MC to move up through the LP to the target chamber.

Figure 9.2-1
Lower pylon physical overview. The lower pylon is a narrow tubular extension of the target chamber and connects the target chamber to LaCave. Its major components include spools 1 to 4, spool 5, a 16-in. gate valve, the air bladder, and 3 electric clamps to secure the MC.



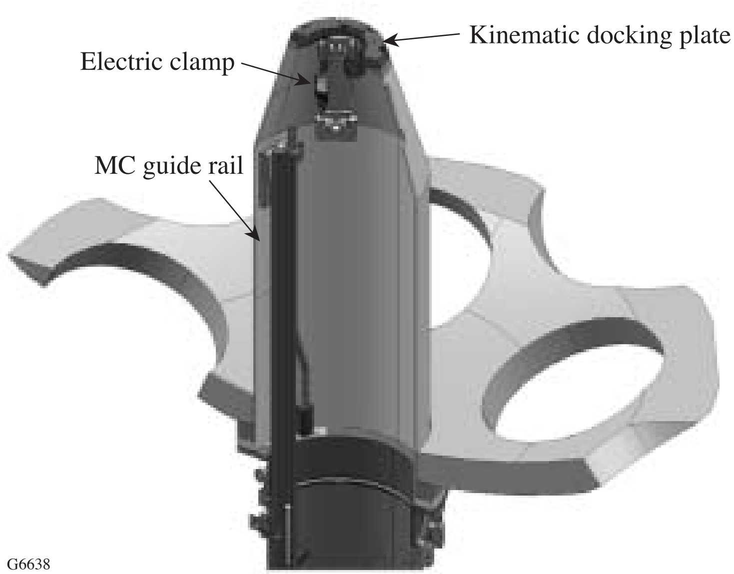


Figure 9.2-2
Docking plate, electric clamp, and MC guide rail.

9.2.1.2 Kinematic Docking Plate

The mechanical interface between the MC and the LP is the kinematic docking plate shown in Fig. 9.2-3(a). This device is located on the top surface of the LP and provides a kinematic interface formed by three vees oriented in a radial direction [Fig. 9.2-3(b)]. The MC has three spherical balls that mate kinematically to these vees to provide repeatable docking location of the MC relative to TCC.

Figure 9.2-3
(a) The top view of the docking plate; (b) the bottom view of the docking plate showing the three vees.

9.2.1.3 Electric Clamps

The MC is held against the docking plate with three clamps that are electric-motor–driven linear actuators that drive a cam. One of the three electric clamps is shown in Fig. 9.2-4 and the caming action is shown in Fig. 9.2-5. The three electric clamps provide proper preload to the joint between the MC spherical surface and the vee surface in the docking plate. The electic clamps are extended until the motor stalls, thus providing a known clamping force to the joint. The electric clamp cams apply this preload force directly below the spherical surfaces on the MC to avoid any bending moments in the MC.

9.2.2 Chain Locker

The chain locker (Fig. 9.2-6) contains the chain used to transfer the moving cryostat to TCC via the lower pylon. Figure 9.2-7 shows a cross-sectional view of the chain locker. The chain is stored in a spiral guide track that consists of two mated metal plates machined with a spiral groove.

The chain locker and the chain guide tube are connected to the main vacuum system and also have onboard vacuum turbo pumps and associated controls. The chain locker is typucally kept at vacuum at all times, except during routine maintenance and extended periods of downtime.

Figure 9.2-4
One retracted electric clamp assembly.

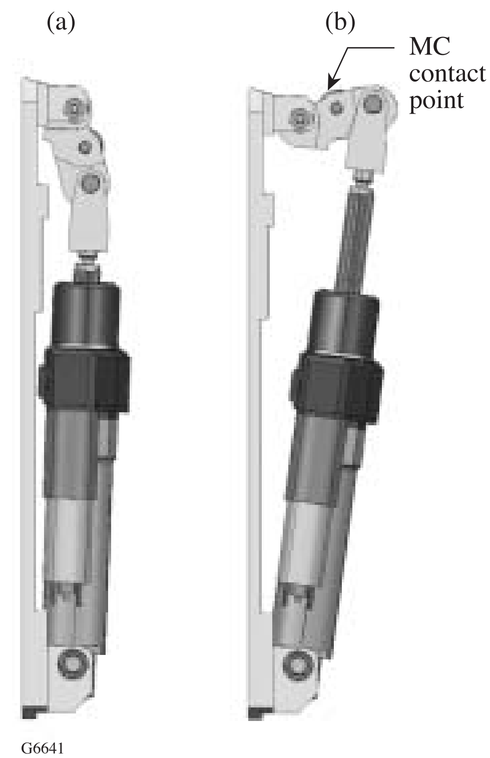


Figure 9.2-5
(a) The electric clamp retracted; (b) the electric clamp extended.

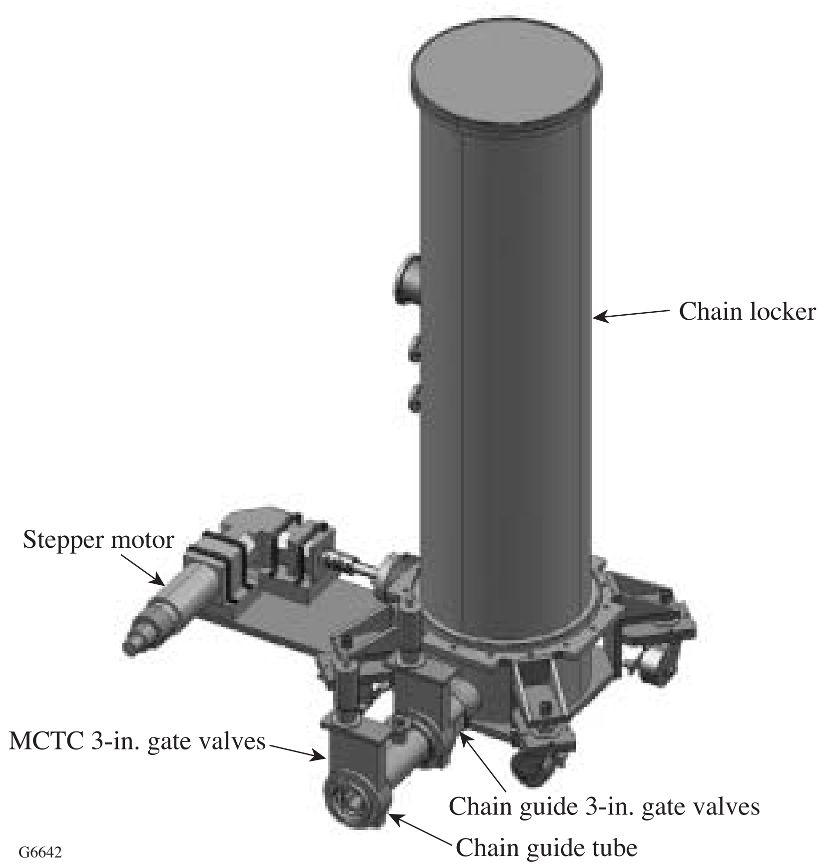
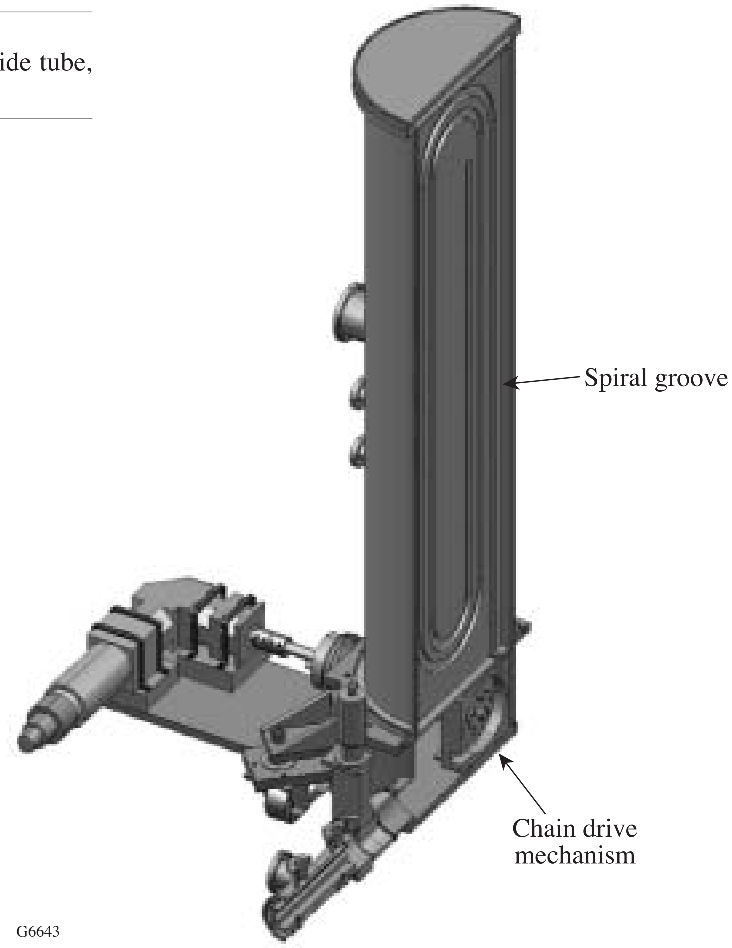


Figure 9.2-6
Chain locker physical overview. The chain locker is an evacuated tube that contains the chain used to drive the MC through the lower pylon to TCC.

Figure 9.2-7
The spiral groove, the stepper motor, guide tube, and drive mechanism.



The chain is driven through the chain guide tube up the lower pylon by the action of the chain locker stepper motor and controls. As the chain passes through the MCTC, it picks up the MC and drives it to TCC. All of the chain locker controls and associated equipment are controlled by the lower pylon PLC.

9.2.3 LaCave Vacuum System

Figure 9.2-8 illustrates the LaCave Vacuum System, which provides both the roughing and turbo backing services. In addition, the OMEGA (auxiliary) roughing line is used to evacuate the shroud parting joint seconds before the shot. The LaCave vacuum system discharges to the TC TRS (covered in Vol. I) where the tritium is removed from the effluent before it is discharged to the stack.

The operator can switch the cryo vacuum line between the roughing opertion and turbo backing operations. The Cryo Vacuum System uses “Backing”, “Roughing”, and “Blimit” flags to manage the two modes of operation. These flags are described as follows:

1. **Roughing Flag:** The roughing flag is used to inhibit connecting the turbo pumps to the cryo vacuum line. The roughing flag can be set after the backing customers are isolated from the vacuum line. When the roughing flag is set, the roughing permissives are enabled and the backing permissives are disabled.

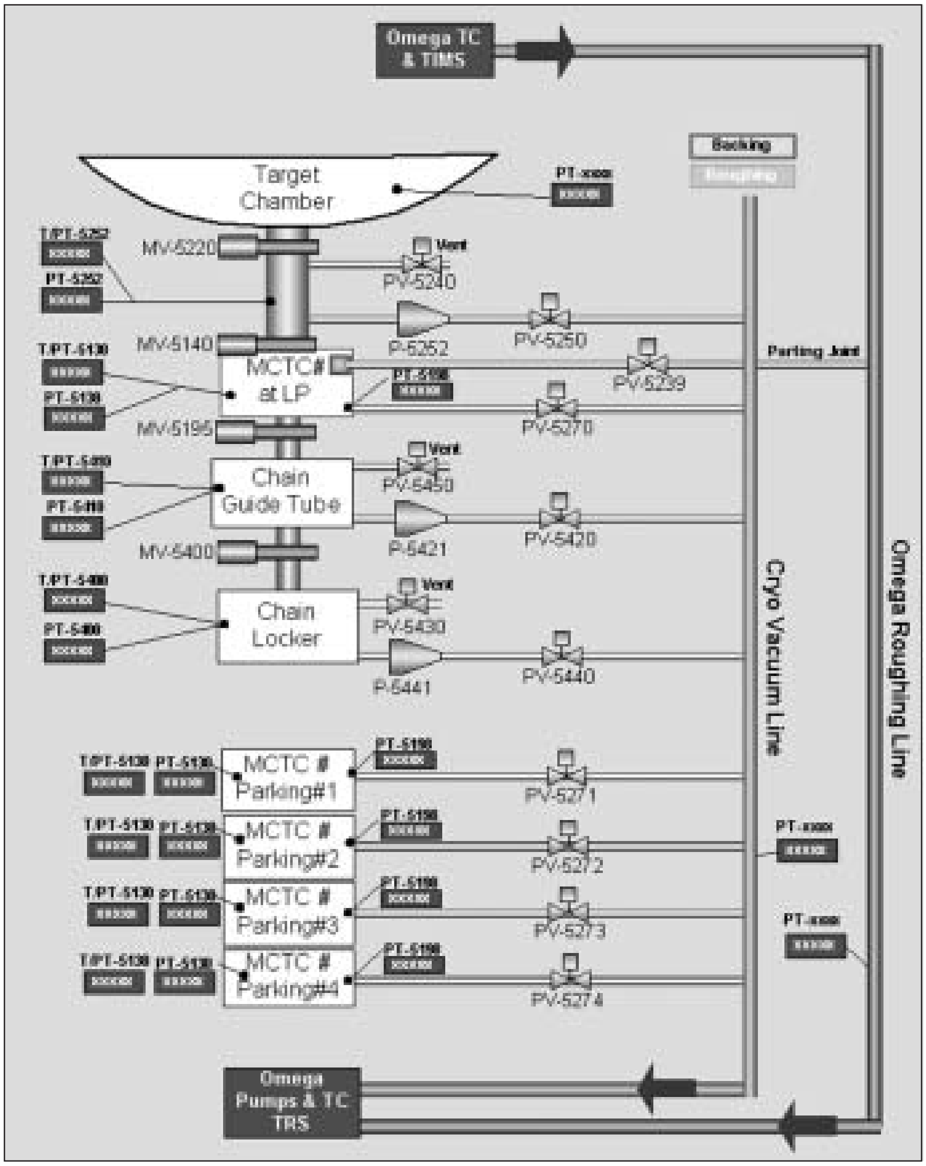


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Figure 9.2-8
LaCave Vacuum System Process GUI.

2. **Backing Flag:** The backing flag is used to inhibit high-pressure customers from connecting to the cryo vacuum line. The backing flag can be set after the high-pressure customers are isolated from the vacuum line. When the backing flag is set, the backing permissives are enabled and the roughing permissives are disabled.

3. **BLimit:** This is the maximum-allowable pressure for a customer when the backing flag is set.

The vent valves are interlocked to ensure that the turbo pumps are not damaged and high pressure is not introduced into the system when in the backing mode. In addition, the vacuum system and OMEGA target chamber are protected by a series of gate-valve interlocks. The gate valves (MV-5140, MV-5195, and MV-5400) are inhibited from opening if there is a high delta pressure across them.

9.3 LOWER PYLON OPERATIONS

9.3.1 Lower Pylon MCTC Docking Operations

The lower pylon is a collection of subsystems that, when integrated, provides an evacuated passage way that allows the chain locker system to elevate the MC to TCC. The integrated system is shown in Fig. 9.3-1. The lower pylon operations are summarized as follows:

1. **Dock the MCTC at the lower pylon:** The MCTC at low vacuum is docked at the lower pylon and the MCTC 16-in. spool is clamped to the lower pylon spool 5. The cart is then connected to Ethernet communication, plant air supply, and cryo vacuum line. Additionally, the power to the cart is transferred to the local supply.

2. **Evacuate the chain guide and lower pylon spool:** The lower pylon spool and chain guide tubes are connected to the cryo vacuum line in the roughing mode (via PV-5240 and PV-5420). When the chambers are below the backing limit, the Cryo Vacuum System is switched to backing mode and the turbo pumps are turned on (P-5252 and P-5421).

3. **Open the gate valves:** The five vacuum spaces are connected (target chamber, lower pylon, MCTC, chain guide tube, and the chain locker) from the chain locker to the target chamber (MV-5220, MV-5140, MV-5195, and MV-5400).

4. **Raise the MC to TCC:** The chain (from the chain locker) is used to raise the MC to the TCC.

5. **Dock and clamp MC at TCC:** The MC is mated to the kinematic mounts and the electric clamps engage the MC and hold it in place.

6. **Position target within 5 μm of TCC:** The TVSTPS system automatically positions the target by the Target Viewing System Target Positioning System (TVSTPS) working in consert with the Target Auto Positioning System (TAPS).

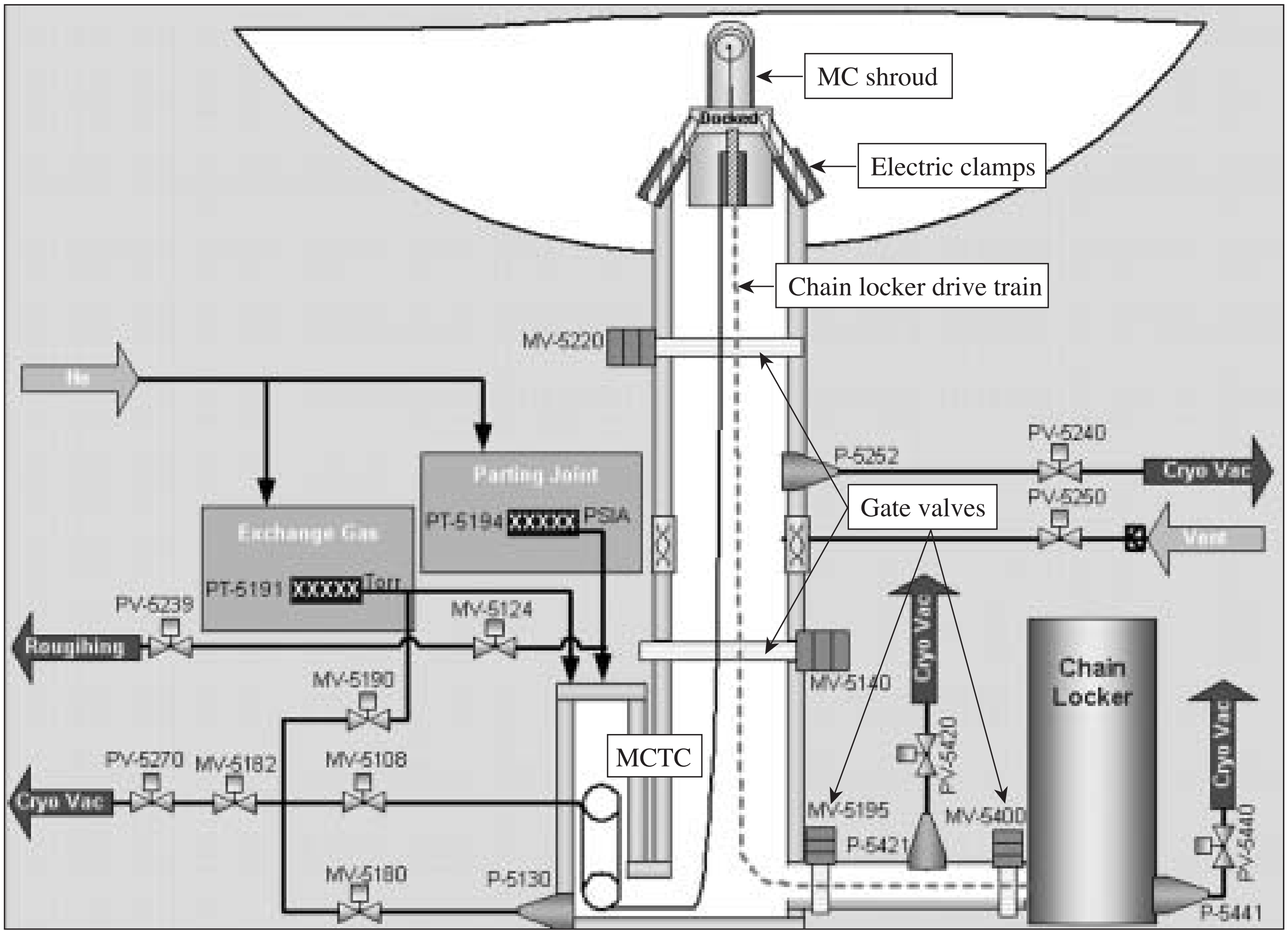

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Figure 9.3-1
LaCave integrated equipment diagram. The major equipment items in LaCave include the lower pylon, the MCTC, and the chain locker.

9.3.2 Target Auto Positioning System (TAPS)

After the MC is docked and clamped at TCC, the target can be viewed by the TVSTPS in two axes through windows in the layering sphere, the middle shroud, and the outer shroud. Images are acquired by TVSTPS and passed to Target Auto Positioning Software (TAPS) for processing. There are two distinct parts of TAPS: finding the current target position (Find Target Position or FTP) and moving the target to the desired position (Auto Position or AP).

The Target Auto Positioning Software (TAPS) calculates the position of a spherical target, calculates the required moves, and passes the move commands to TVSTPS. TVSTPS automatically moves the target to the position specified by the reticle in use. The system will operate with any cryogenic MC target positioner or the warm Target Positioning System (TPS-2).

Figure 9.3-2 is an overview diagram of the automatic target positioning process. The operator uses the GUI shown in Fig. 9.3-3 to load a reticle record that defines the required location of the target. Each MCTC has its own experimentally determined offset correction to compensate for static errors introduced by the shroud windows. TVSTPS applies the appropriate offsets to the reticles after determining which MCTC is being used. The operator positions the target to within the capture range of Find Target Position (FTP) and initiates the TAP process:

1. TVSTPS captures an image of the target.

2. TVSTPS passes image names to the Find Target Position (FTP) module to trigger the analysis cycle.

3. FTP finds the target location in pixel coordinates in both *x*- and *y*-axis views and passes this information to the Auto Position (AP) module.

4. The AP module performs the following functions:

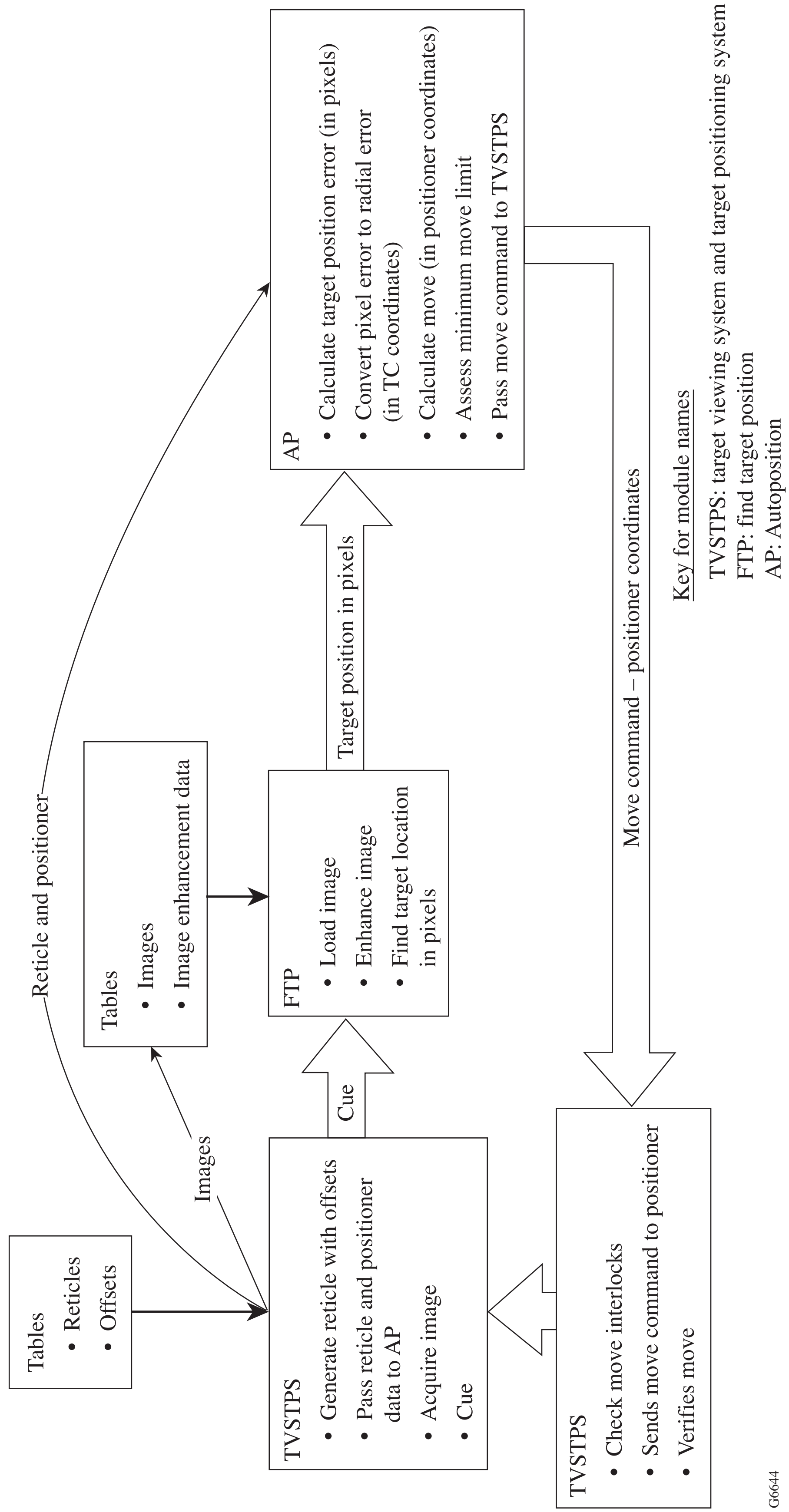
   (a) Calculates the target position error (in pixels) as compared with the reticle coordinates.
   (b) Converts the pixel error to a radial error in TC coordinates.
   (c) Checks radial error against the defined convergence criteria.
   (d) IF the error is within the tolerance, no move is necessary.
   (e) IF NOT, AP calculates the required move in MCTC or TPS2 coordinates, as appropriate.
   (f) The move command is passed to TVSTPS (zero/no move means done).

5. The TVSTPS module checks the interlocks and sends the move command to the PLC:

   (a) Checks the interlock before the move.
   (b) Sends the move command to the target positioner.
   (c) Verifies that the move took place.

6. Depending on the TAPS operating mode, the process may be repeated.

Figure 9.3-2
TAPS software architecture.



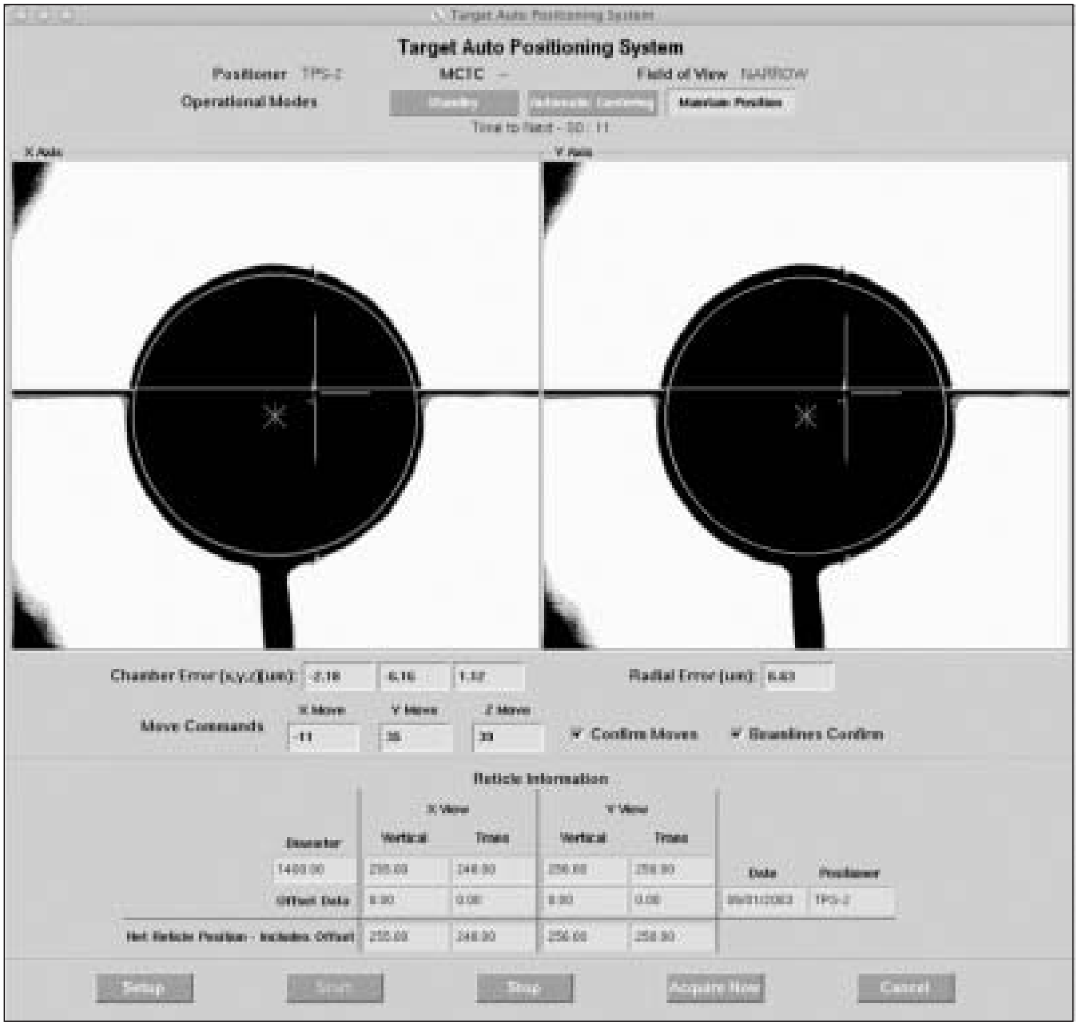


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Figure 9.3-3
TAPS operator GUI.