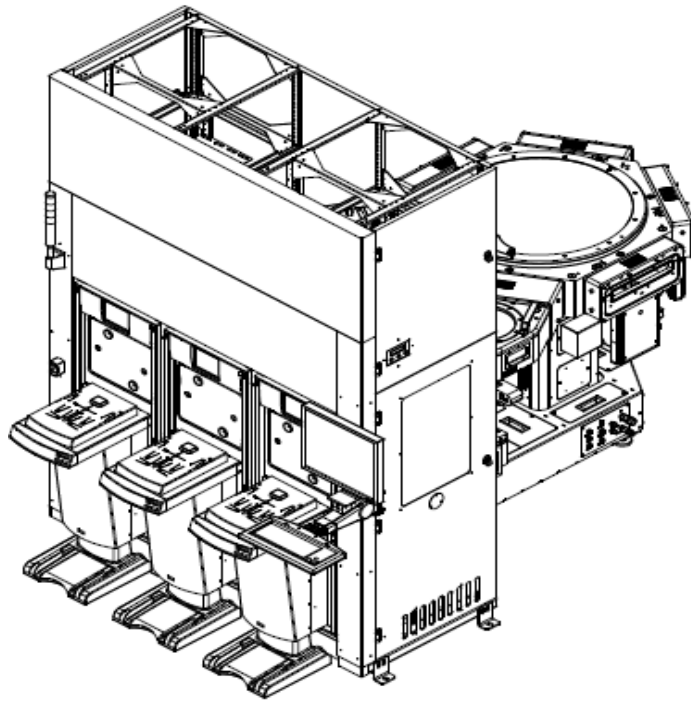




Marathon 2 (M2)

User Manual

Part Number 607538 Rev. A

Brooks Automation, Inc.

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1. Introduction

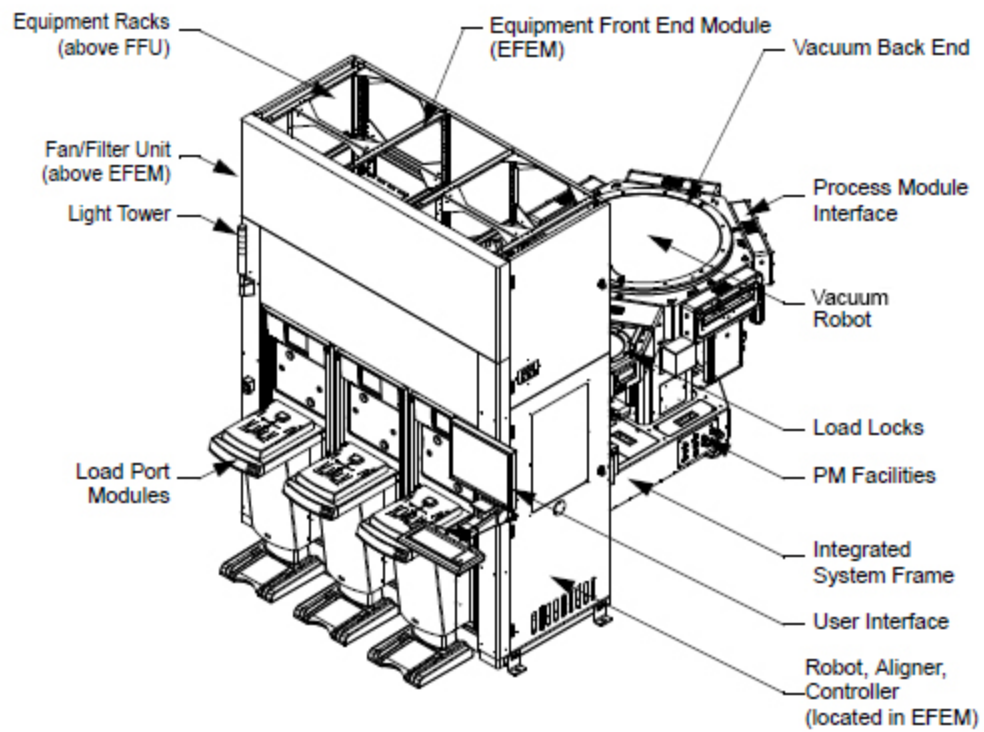
This Introduction provides a brief overview of Brooks Automation M2 system Vacuum Transport System, highlighting its features, subsystems, and operation. Additionally, information about using this manual is presented.

The M2 system is intended for use by industrial customers and should be serviced only by Brooks or Brooks trained representatives. The service manuals and related materials are provided in English at no charge and are intended for use by experienced technicians. It is the responsibility of the user to obtain and assure the accuracy of any needed translations of manuals. If you require assistance please contact Brooks service department. Contact information can be found at - www.brooks.com.

M2 system Vacuum Transport System Overview

The M2 system Vacuum Transport System is a complete tool automation solution for OEMs building semiconductor manufacturing tools for processing 200 mm and 300 mm wafers. The M2 system is a vacuum-based cluster tool integration platform with a Brooks atmospheric Equipment Front End Module. This system provides clean material transfer from the factory interface into a controlled, high vacuum environment with access between multiple user installed Process Modules. The M2 system is simple to integrate and offers a variety of options including wafer aligner, factory interfaces, vacuum systems, and minienvironment systems.

The M2 system Vacuum Transport System offers integral support for all system structures. The integrated frame architecture of the Vacuum Back End supports SEMI standard roll-up style Process Modules with standard interfacing to frame and facet. The Equipment Front End Module supports MESG bolt-on style Load Port Modules and supports all LPM functions, such as CID and E84. Uniform hardware interlock capability, modularity, and expendability of electronics makes the M2 system a superior platform for integration. Identical components are used for all M2 system configurations simplifying integration and maintenance across the platform.

**Figure 1-1: Marathon 2**

Features

- Equipment Front End Module
 - Minienvironment with Integrated Fan/Filter Unit
 - Atmospheric Automation
 - EFEM Service Light
 - Selection of BOLTS compatible Load Port Modules
 - EMO button for user defined and supplied Emergency Off circuit
- Vacuum Back End
 - Transport Chamber on steel frame
 - Brooks Automation MagnaTran 7, MagnaTran 8, or LEAP vacuum robot
 - Separate Load Locks - optional active wafer cooling
 - Metal lid with viewports or InSight™ clear dome
 - Manual lid lifter
 - Provides complete slot valve/process module/robot hardware interlocking
 - AC Power Distribution provides a single AC connection point to the tool
 - Modular facet adapter plates (FAP) with configurable slot valves located between the Transport Chamber and the Process Modules and the Load Locks
 - Facilities distribution interface for CDA, N2, He, or any other inert gas or process gases, and cooling water provides central access through floor, side, or back
 - Vacuum, Vent, and Pneumatic Systems

Options

Options are available for the M2 system that increase its functionality. All options are available at the time of purchase for installation and configuration by Brooks Automation.

- Equipment Front End Module
 - Teach Pendant
 - Ionizer
 - Single multicolor light tower
 - Light Curtain
 - EFEM mounted Operator Interface (swing-out arm, wing panel, or BOLTS insert (in place of LPM))
 - Wafer Mapping
 - E84 interface for AMHS material transfer handshaking
 - Wafer Buffer
 - Two 9U 19" racks above the FFU for user electronics on EFEM
- Vacuum Back End
 - CenterSmart™ Automatic Wafer Centering
 - PM Facilities Package
 - Rough Vacuum Package including pumps
 - Material Transport Plane (MTP) at 1100 mm or 1200 mm as specified at time of order
 - Process Gas Lines, routed through the mainframe
 - Optional floor mounted facilities interface

Subsystems

All M2 system systems are made up of several functional subsystems designed for ease of use, maintenance, and repair. These subsystems are modular in design to allow ease of maintenance and to minimize Mean Time To Repair (MTTR). The individual modules that make up the M2 system are described briefly below and in detail in ["Operation" on page 110](#).

Equipment Front End Module

The Brooks Automation Equipment Front End Module (EFEM) is SEMI-standard compatible, using proven Brooks automation components. The EFEM is designed for manual, AGV, or OHT loading of FOUPs or cassettes that contain wafers waiting for horizontal material transfer. The wafers are then removed, aligned, and passed to the Vacuum Back End for processing.

Minienvironment

The minienvironment is available in 2, 3, or 4 load port configurations. The minienvironment provides a localized, controlled, ultra-clean environment for material transfer between multiple Load Port Modules and the Vacuum Back End, isolating the substrates in transfer from contamination. The minienvironment supports the robot, aligner, load ports, and electronics and provides a single connection point for all facilities.

Vacuum Back End

The Brooks Automation Vacuum Back End is a multi-faceted radial Vacuum Transport System with separate modular Load Locks utilizing proven Brooks components.

Vacuum Transport Chamber

The multi-faceted Transport Chambers for the M2 system systems are designed to provide an ultra-clean, high-vacuum environment for transfer of material among Process Modules.

The frame supporting the chamber may be configured to locate the chamber's Material Transport Plane (MTP) at 1100 mm or 1200 mm. The chamber provides for installation of the material handling robot and includes ISO compatible ports for vacuum system components, such as gauges and pumps, associated with the chamber. Support is provided at each facet for the Material Sensor system and at the Load Lock facets for the Automatic Wafer Centering system.

Vacuum Robot

Refer to the applicable robot manual for more information.

Load Locks

The Load Locks mount to the facets facing the Equipment Front End Module and provide the mechanism for transferring material from atmospheric pressure to the vacuum environment. The Load Lock chamber is machined from a single aluminum block to provide greater structural and vacuum integrity. The chamber includes ISO compatible ports for vacuum system components, such as gauges and pumps, associated with the chamber.

The chamber provides for installation of either an aluminum blank-off plate that supports a two-level shelf system or an aluminum cool platen and lift mechanism. The cool platen option is used to cool wafers after a hot process before they are transferred to the wafer carrier. Silicon Nitride (Si₃N₄) balls support the wafer slightly above the surface of the cool platen to ensure the wafer never comes into direct contact with the aluminum surface.

Controls

Refer to the applicable controls manual for more information.

Configuration

The configuration of the M2 system is determined by the user and is based on the Basic Configuration needed and the System Integration Level required. The system can be custom configured to three levels of integrated tool automation solutions ranging from a mechanical component set to an integrated platform with vacuum systems.

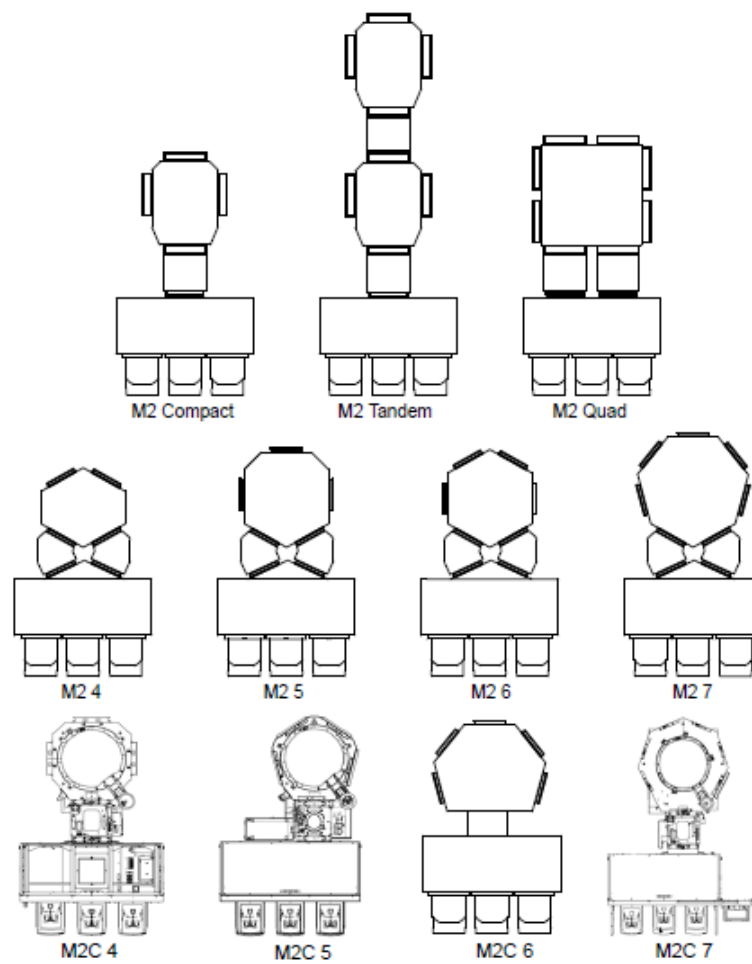


Figure 1-2: Marathon 2 Configurations

System Integration Level

The System Integration Level is determined by the user's requirements for system integration and controls and is available in Levels as described below. This manual provides complete coverage for the hardware used in all integration levels of the M2 system and the software used through the Level 2.5 integrated systems.

See System Block Diagram and associated manuals for more information.

Using this Manual

This user manual provides documentation for operation and maintenance of the Brooks Automation M2 system. While this document covers specific information and adjustments for the M2 system, there may be information in other manuals which affect the settings or operating mode of the M2 system and attached components.

The M2 system is configured to the customer's specifications and acceptance tested at Brooks Automation. Before adjusting or changing settings on an M2 system, consult the following Brooks Automation documentation:

- Brooks Automation Equipment Front End Module User Manuals
- Brooks Automation Load Port Module User Manual
- OEM Components Manuals
- Process Module User Manual Transport, Process Module, and System Controller User Manuals
- System Wiring Diagrams

NOTE: All documents cited shall be the latest revision.

This manual is intended to provide information about a wide variety of M2 system configurations and options. It may contain references to items not installed on a specific system.

The commands for controlling the robots and other components used in the M2 system are defined in their User Manuals. The Marathon 2 User Manual may refer the reader to these manuals for additional information.

This manual contains, as addendums and attachments, customized documents for a specific build of the M2 system. These documents are provided to allow service personnel to identify specific parts within the system and aid in maintenance and troubleshooting.

2. Safety



DANGER

Read the Safety Chapter

Failure to review the *Safety* chapter and follow the safety warnings can result in death or serious injury.

- All personnel involved with the operation or maintenance of this product must read and understand the information in this safety chapter.
- Follow all applicable safety codes of the facility as well as national and international safety codes.
- Know the facility safety procedures, safety equipment, and contact information.
- Read and understand each procedure before performing it.



NOTICE

It is the responsibility of each person working on this product to know the applicable regulatory safety codes as well as the facility safety procedures, safety equipment, and contact information.

This product is intended for use by industrial customers and should be serviced only by Brooks or Brooks trained representatives. The service manuals and related materials are provided in English at no charge and are intended for use by experienced technicians. It is the responsibility of the user to obtain and assure the accuracy of any needed translations of manuals. If you require assistance please contact Brooks service department. Contact information can be found at www.brooks.com.

If additional safety related upgrades or newly identified hazards associated with the Marathon 2 are identified, Brooks Technical Support notifies the owner of record with a Technical Support Bulletin (TSB).

Regulatory Compliance and Declaration of Conformity

The Marathon 2 (M2) meets the requirements of the European Union's Machinery Directive 2006/42/EC and 2014/30/EU as a completed machine. In accordance with the Directive, Brooks Automation has issued a Declaration of Conformity and the Marathon 2 (M2) has a CE mark affixed.

	Declaration of Incorporation of Partly Completed Machinery	Document #:
	According to EU Directive 2006/42/EC Annex II 1. B.	XXXXX Rev.: X

Description Marathon 2 System
Part Number:
Serial Number:

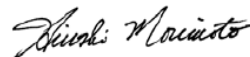
Business name and full address of the manufacturer of the partly completed machinery:
Brooks Automation Inc., 15 Elizabeth Drive, Chelmsford, MA, USA 01824

Name and address of the person, established in the Community, authorized to compile the relevant technical documentation:
Brooks Automation (Germany) GmbH, Göschwitzer Straße 25, 07745 Jena, Germany

The manufacturer declares:

- That the following Annex I essential health and safety requirements of Directive 2006/42/EC are applied and fulfilled and that the relevant technical documentation is compiled in accordance with part B of Annex VII and assembly instructions in accordance with Annex VI are provided:
1.1.2, 1.1.3, 1.1.5, 1.1.6, 1.2.1, 1.2.2, 1.2.3, 1.2.4, 1.2.5, 1.2.6, 1.3.1, 1.3.2, 1.3.3, 1.3.4, 1.3.7, 1.3.9, 1.4.1, 1.5.1, 1.5.2, 1.5.3, 1.5.4, 1.5.6, 1.5.8, 1.5.9, 1.5.11, 1.6.1, 1.6.2, 1.6.3, 1.6.4, 1.7.1, 1.7.2, 1.7.3
- That the safety objectives set out in directive 2006/95/EC (LVD) have been applied to this partly completed machinery.
- That this partly completed machinery conforms with the provisions of directive 2004/108/EC (EMC).
- We will transmit, in response to a reasoned request by a national authority, relevant information on the partly completed machinery, on paper or in electronic form, without prejudice to our intellectual property rights.

The partly completed machinery must not be put into service until the final machinery into which it is incorporated has been declared in conformity with the provisions of Directive 2006/42/EC



Hiroshi Morimoto
Manager
Product Safety and Regulatory Compliance

(Date)

Figure 2-1: Typical M2 Declaration of Incorporation (DoI)

Explanation of Hazards and Alerts

This manual and this product use industry standard hazard alerts to notify the user of personal or equipment safety hazards. Hazard alerts contain safety text, safety icons, signal words, and color.

Safety Text

Hazard alert text follows a standard, fixed-order, three-part format.

- Identify the hazard,
- State the consequences if the hazard is not avoided,
- State how to avoid the hazard.

Safety Icons

- Hazard alerts contain safety icons that graphically identify the hazard.
- The safety icons in this manual conform to ISO 3864 and ANSI Z535 standards.

Signal Words and Color

Signal words inform of the level of hazard.

	Danger indicates a hazardous situation which, if not avoided, will result in death or serious injury. Danger signal word is white on a red background with an iconic exclamation point inside a yellow triangle with black border.
	Warning indicates a hazardous situation which, if not avoided, could result in death or serious injury. Warning signal word is black on an orange background with an iconic exclamation point inside a yellow triangle with black border.
	Caution indicates a hazardous situation or unsafe practice which, if not avoided, may result in minor or moderate personal injury. Caution signal word is black on a yellow background with an iconic exclamation point inside a yellow triangle with black border.
	Indicates a situation or unsafe practice which, if not avoided, may result in equipment damage. Notice signal word is white on blue background with no icon.

Alert Example

The following is an example of a *Warning* hazard alert.

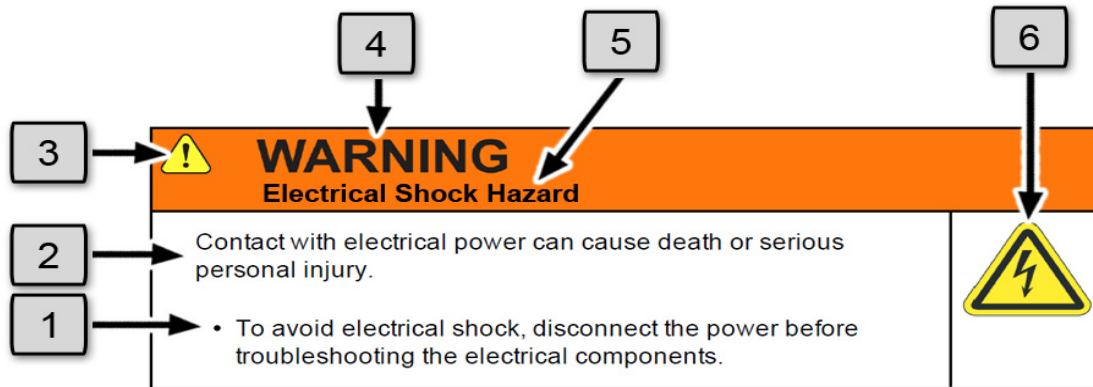


Figure 2-2: Components of a Safety Alert

Number	Description
1.	How to Avoid the Hazard
2.	Source of Hazard and Severity
3.	General Alert Icon
4.	Signal Word
5.	Type of Hazard
6.	Hazard Symbol(s)

General Safety Considerations

 CAUTION Unauthorized Service	
Personal injury or damage to equipment may result if this product is operated or serviced by unauthorized personnel. - Only qualified personnel are allowed to transport, assemble, operate, or maintain the Product. - Properly qualified personnel are those who have received certified training and have the proper qualifications for their jobs.	

 CAUTION Training and Unauthorized Service	
Personal injury or damage to equipment may result if this product is operated or serviced by untrained or unauthorized personnel. Only qualified personnel who have received certified training and have the proper qualifications for their jobs are allowed to transport, assemble, operate, or maintain the product.	

 CAUTION Personal Protective Equipment	
This product contains heavy objects that may cause personal injury. - Use safety shoes and head protection when installing or maintaining the product. - Wear protective eyewear when setting up or testing the system.	

 CAUTION Seismic Restraint	
The use of this product in an earthquake prone environment may cause equipment damage or personal injury. The user is responsible for determining whether the product is used in an earthquake prone environment and installing the appropriate seismic restraints in accordance with local regulations.	

 CAUTION Inappropriate Use	
Use of this product in a manner or for purposes other than for what it is intended may cause equipment damage or personal injury. • Only use the product for its intended application. • Do not modify this product beyond its original design. • Always operate this product with the covers in place.	

 CAUTION Damaged Components	
The use of this product when components or cables appear to be damaged may cause equipment malfunction or personal injury. • Do not use this product if components or cables appear to be damaged. • Place the product in a location where it will not get damaged. • Route cables and tubing so that they do not become damaged and do not present a personal safety hazard.	

NOTICE
It is the responsibility of each person working on this product to know the applicable regulatory safety codes as well as the facility safety procedures, safety equipment, and contact information.

NOTICE
Please follow all facility and local wiring regulations before operating or servicing the product.

Illustration of Hazard Locations

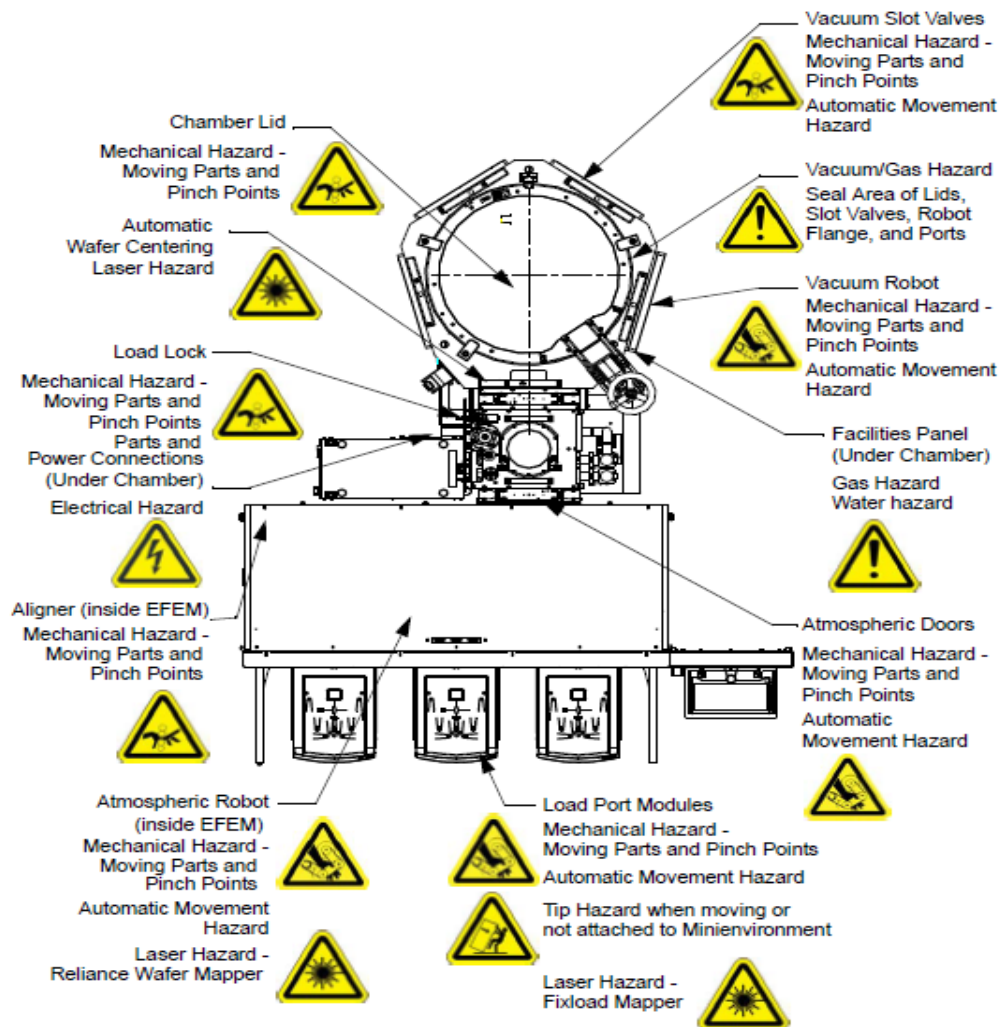


Figure 2-3: Typical Location of Hazardous Points

Safety and Identification Labels

Safety labels are placed on the Marathon 2 (M2) to identify hazards. Identification labels provide information about the product.

- Safety labels provide instructions on how to avoid the hazard.
- Items that weigh over 4.5 kg (10 lb) and that may be removed for service have a mass label attached.

NOTICE

Do not change or remove the safety or equipment identification labels.

To replace a lost or damaged label call Brooks Technical Support.

Table 2-1: Safety Labels placed on Product

	Warning Label - Moving Parts P/N: 104162 Qty: 2 Location: On sides of Lid Lifter Hazard Type: Moving Parts Possible injuries: Crush or cut How to avoid the hazard: Avoid moving parts
	Warning Label - Impact Hazard P/N: 130432 Qty: 1 Location: On Lid Lifter between lifter arms On front of Lid Hinge Hazard Type: Impact Hazard Possible injuries: Crush or cut How to avoid the hazard: Secure the lid before performing any service within the chamber
	Caution Label - Do Not Step P/N: 103948 Qty: 1 Location: On top of optional pump Hazard Type: Surface not for support Possible injuries: Fall How to avoid the hazard: Do not step or stand on the indicated surface



Caution Label - Two Person Lift

P/N: 154721

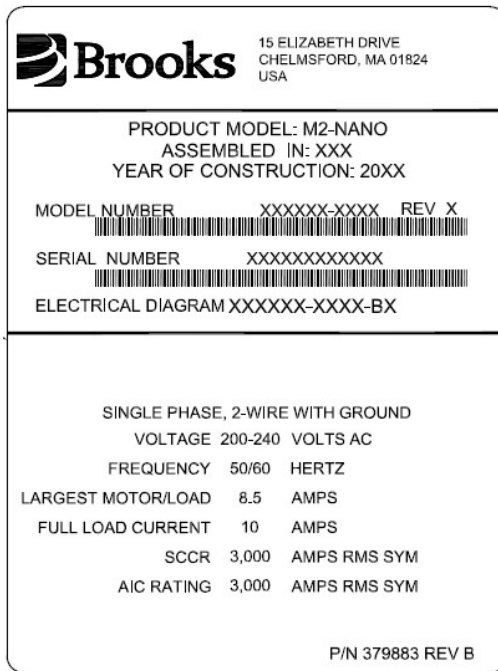
Qty: 1

Location: On top of Lid

Hazard Type: Heavy Object

Possible injuries: Muscle strain or back injury

How to avoid the hazard: Use two person lift to open or close the lid

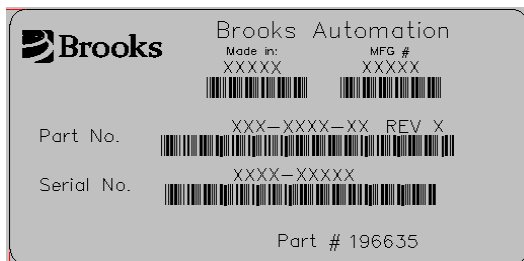


Electrical Rating Label

P/N: 144544

Qty: 1

Location: On Frame below ACPD



Product Information Label

P/N: 002-5271-01

Qty: 2

Location: On Chamber and Frame

**ATTACH SEISMIC
ANCHORS HERE**

Seismic Tie Down Point Label

P/N: PB47521

Qty: 4 minimum

Location: On Frame

Illustration of Hazard Locations

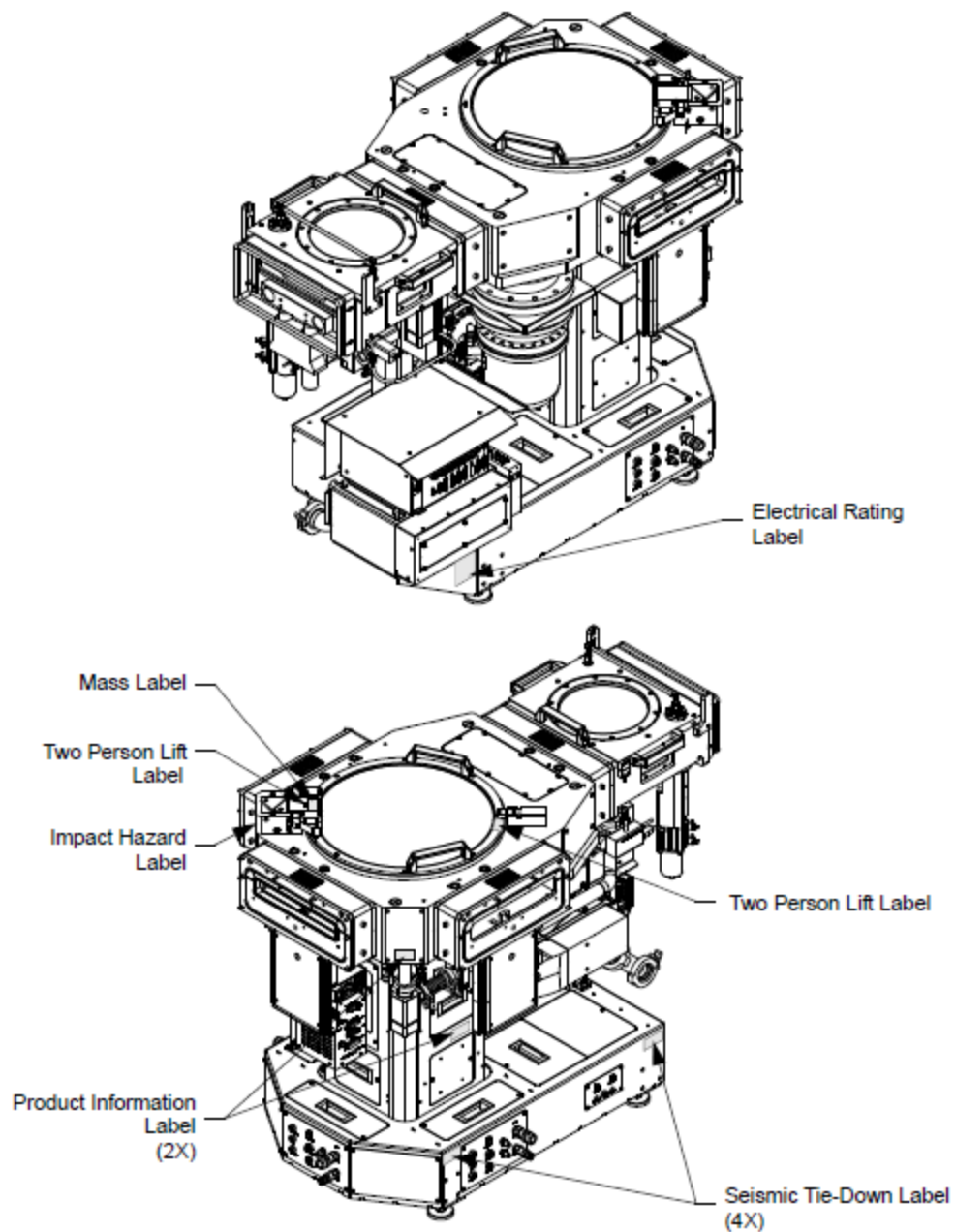


Figure 2-4: Typical Label Locations on the M2 Compact, M2C 4, M2C 5, M2C 6 and M2C 7

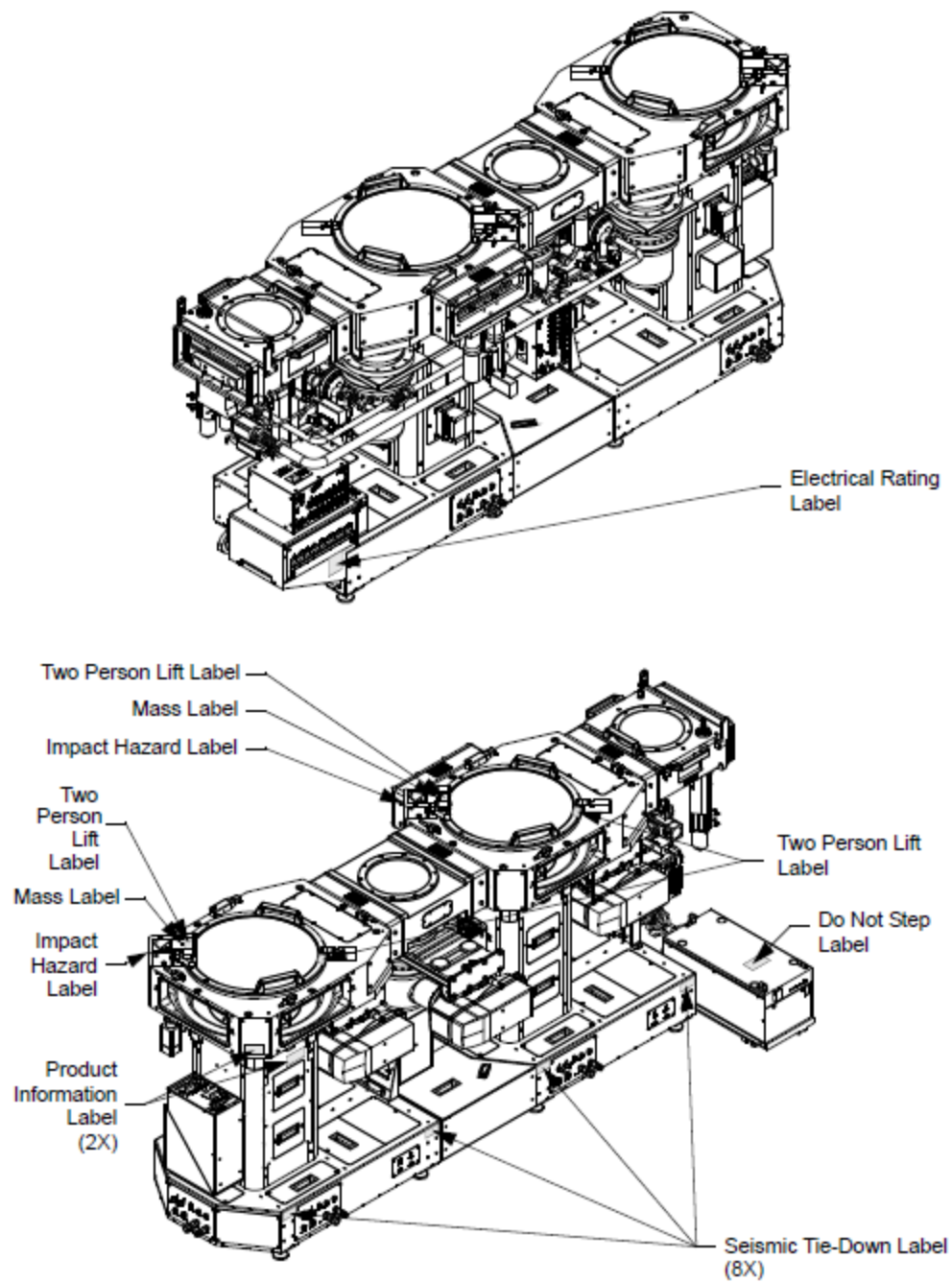


Figure 2-5: Typical Label Locations on the M2 Tandem

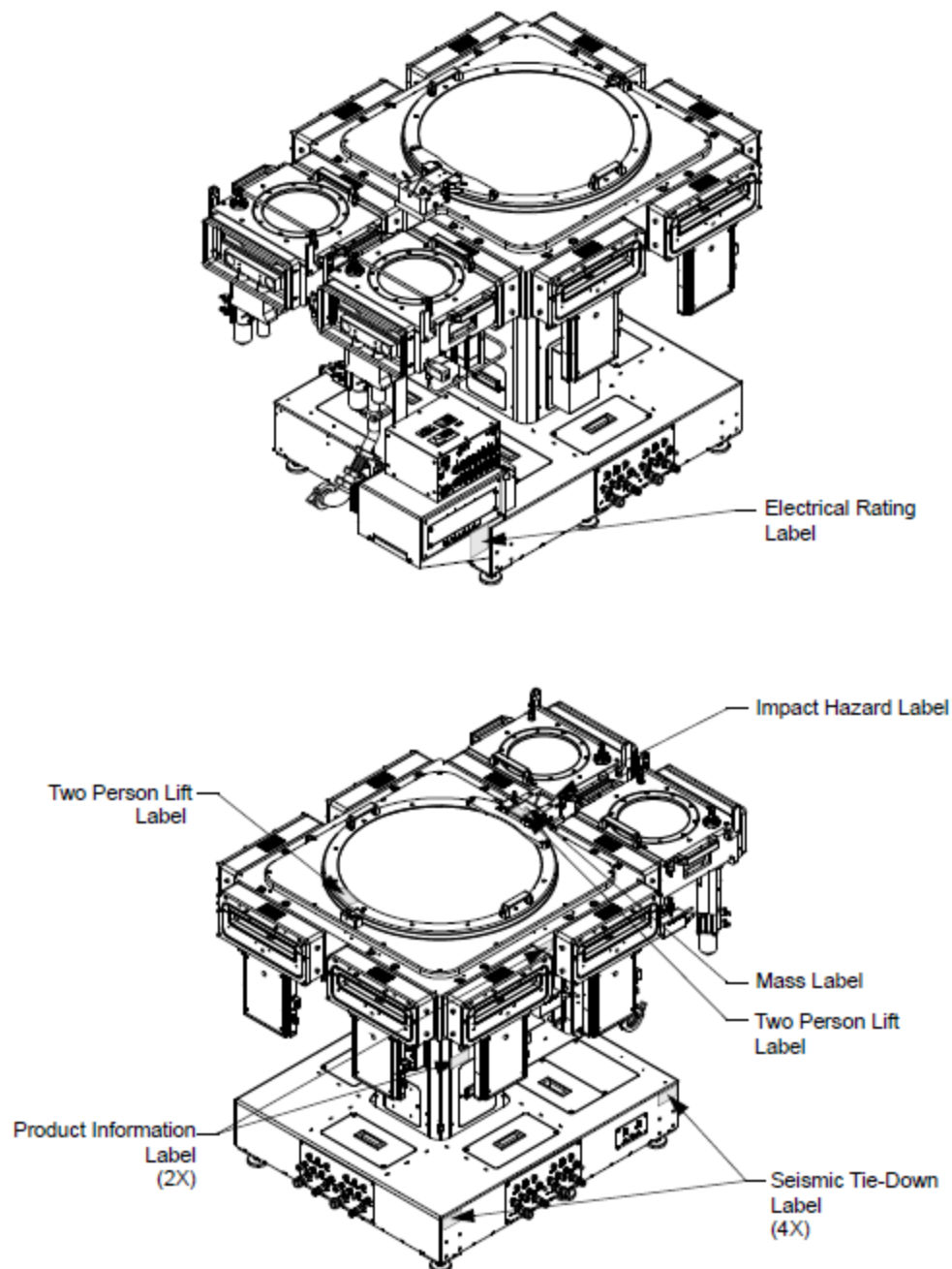


Figure 2-6: Typical Label Locations on the M2 Quad

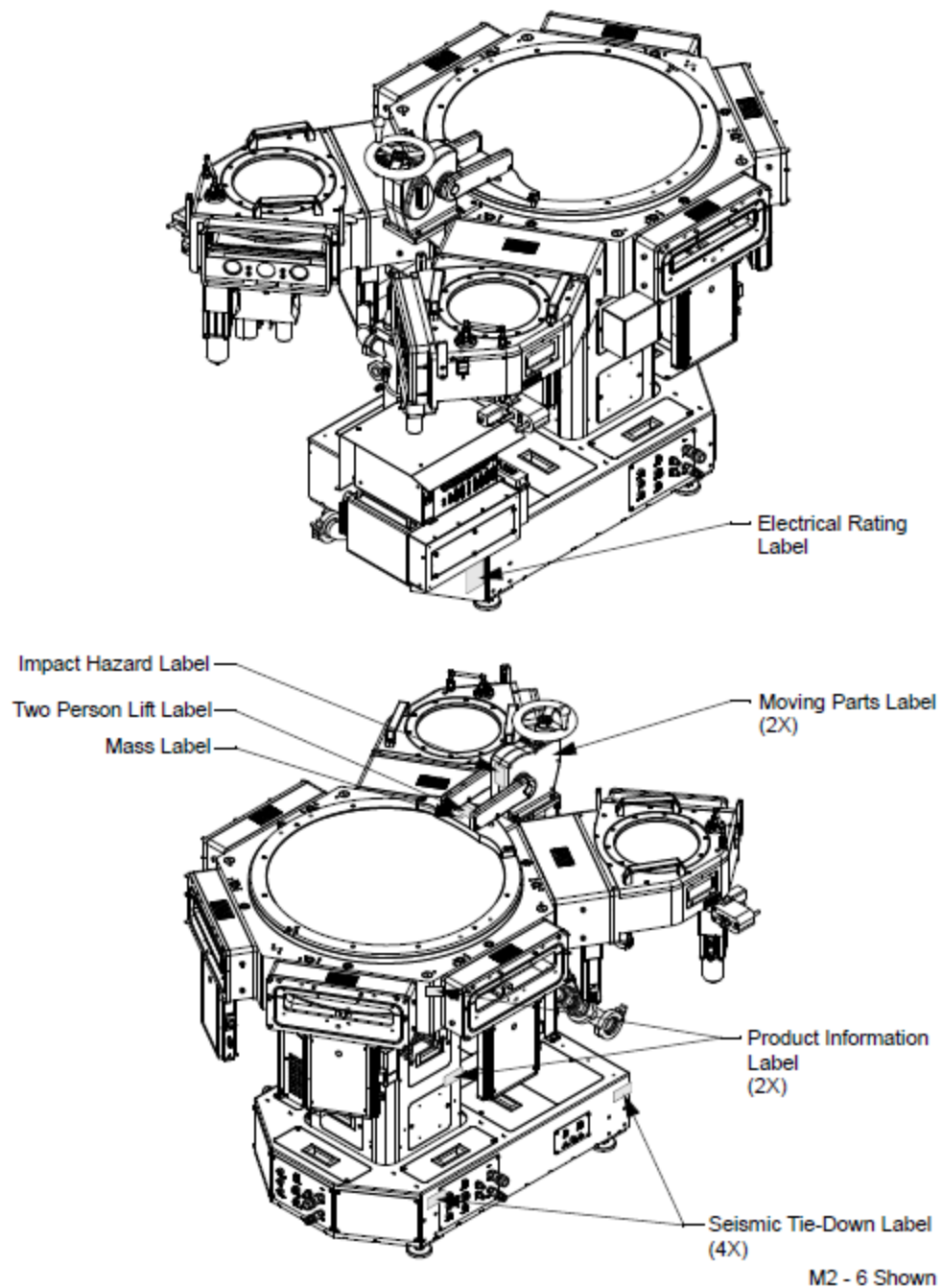


Figure 2-7: Typical Label Locations on the M2 4, 5, 6, and 7

Table 2-2: Labels Used on the Load Locks

	Caution Label - Heavy Object P/N: 70035511 Qty: 1 Location: On top of Lid Hazard Type: Heavy Object Possible injuries: Muscle strain or back injury How to avoid the hazard: Use the lid lifting mechanism to open or close the lid
---	--

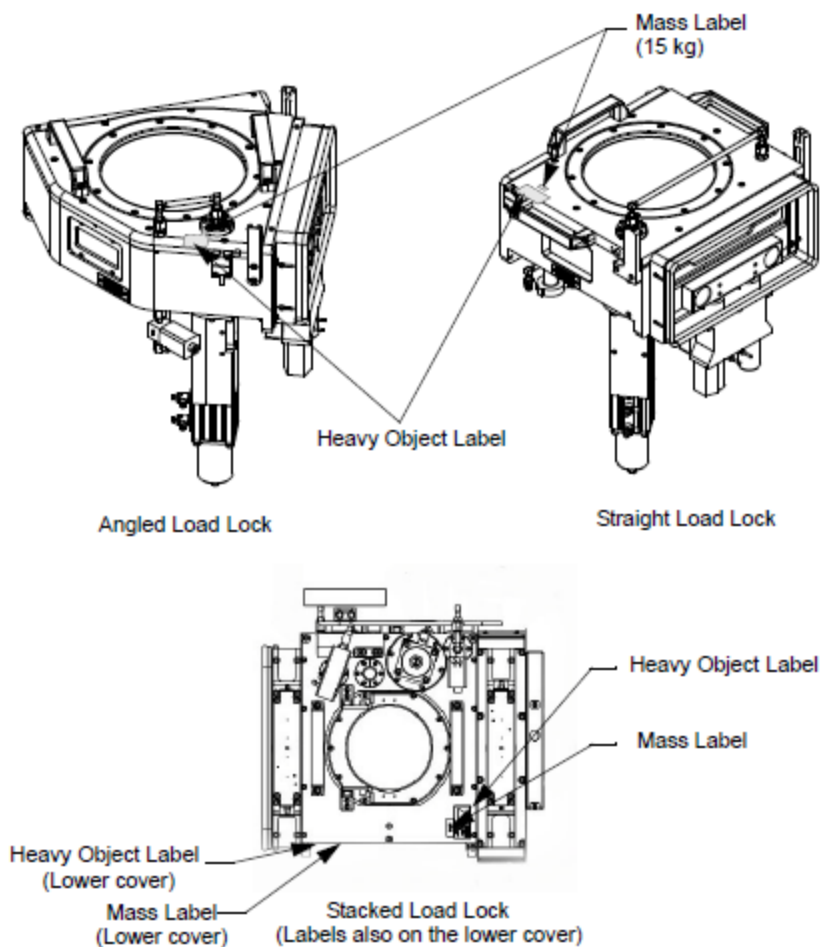
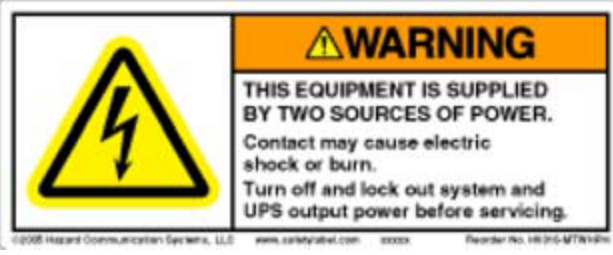


Figure 2-8: Typical Label Locations on the Load Locks

Table 2-3: Labels Used on the ACPD

 WARNING THIS EQUIPMENT IS SUPPLIED BY TWO SOURCES OF POWER. Contact may cause electric shock or burn. Turn off and lock out system and UPS output power before servicing. ©2008 Hazard Communication Systems, LLC www.cshylabel.com 00000 Reorder No. H0305-M781000	Warning Label - Dual Voltage P/N: 131011 Qty: 1 Location: On side of ACPD Hazard Type: Hazardous voltage Possible injuries: Electric shock or burn How to avoid the hazard: Do not service while the ACPD is energized
 WARNING Hazardous Voltage. Contact may cause electric shock or burn. Turn off and lock out system power before servicing. ©1999 HCB, Inc. 800-444-0241 Reorder No. H0010-M99HFK	Warning Label - Hazardous Voltage P/N: 70020026 Qty: 1 Located: On top of ACPD Hazard Type: Hazardous voltage Possible injuries: Electric shock or burn How to avoid the hazard: Do not service while the ACPD is energized

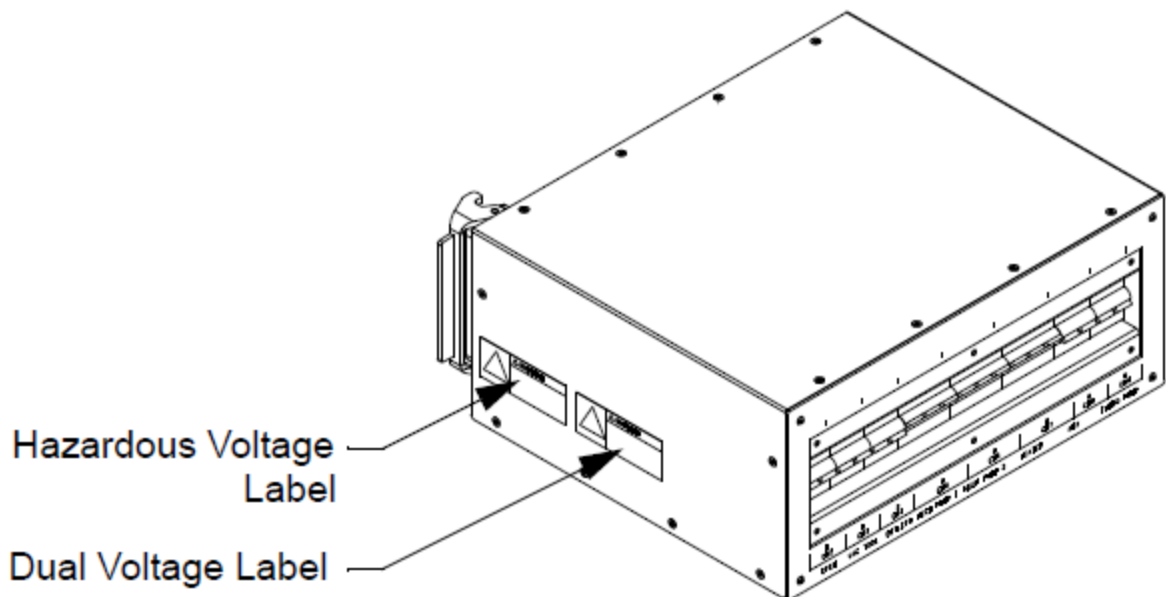


Figure 2-9: Typical Label Locations on the ACPD

Table 2-4: Labels Used on the Mini Hub

	Warning Label - Hazardous Voltage P/N: 70020026 Qty: 1 Located: On top of ACPD Hazard Type: Hazardous voltage Possible injuries: Electric shock or burn How to avoid the hazard: Do not service while the ACPD is energized
FIELD REPLACEABLE UNIT NO USER SERVICEABLE PARTS INSIDE	Label - Field Replaceable Unit P/N: 130165 Qty: 1 Location: On side of Mini Hub

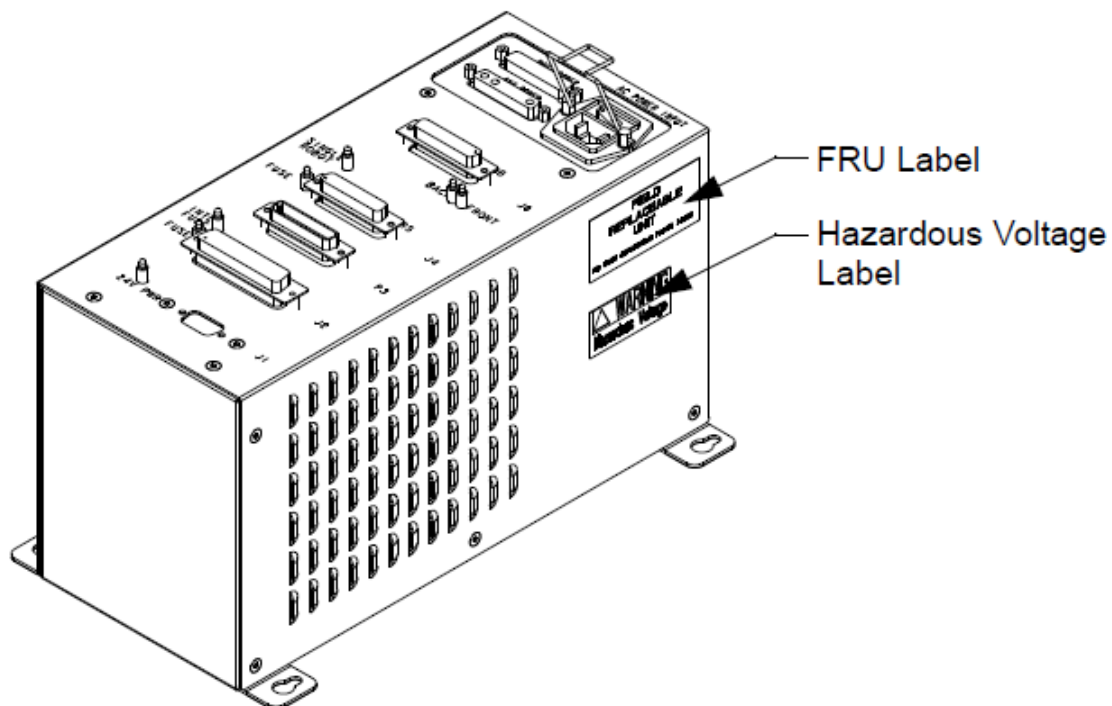


Figure 2-10: Typical Label Locations on the Mini Hub

Table 2-5: Labels Used on the Safety Node¹

 ©2004 HCS, LLC www.safetylabel.com Reorder No. H8014-RDC18PK	Caution Label - Heavy Object P/N: 70025562 Qty: 1 Location: On top of Safety Node Hazard Type: Heavy Object Possible injuries: Muscle strain or back injury How to avoid the hazard: Use proper lifting techniques when moving
 ©1999 HCS, Inc. 0004744-0241 Reorder No. H8010-STW1PK	Warning Label - Hazardous Voltage P/N: 70020026 Qty: 1 Located: On top of Safety Node Hazard Type: Hazardous voltage Possible injuries: Electric shock or burn How to avoid the hazard: Do not service while the Safety Node is energized
FIELD REPLACEABLE UNIT NO USER SERVICEABLE PARTS INSIDE	Label - Field Replaceable Unit P/N: 130165 Qty: 1 Location: On top of Safety Node

¹If a Drip Shield is installed above the Safety Node these labels will also be applied to the Drip Shield.

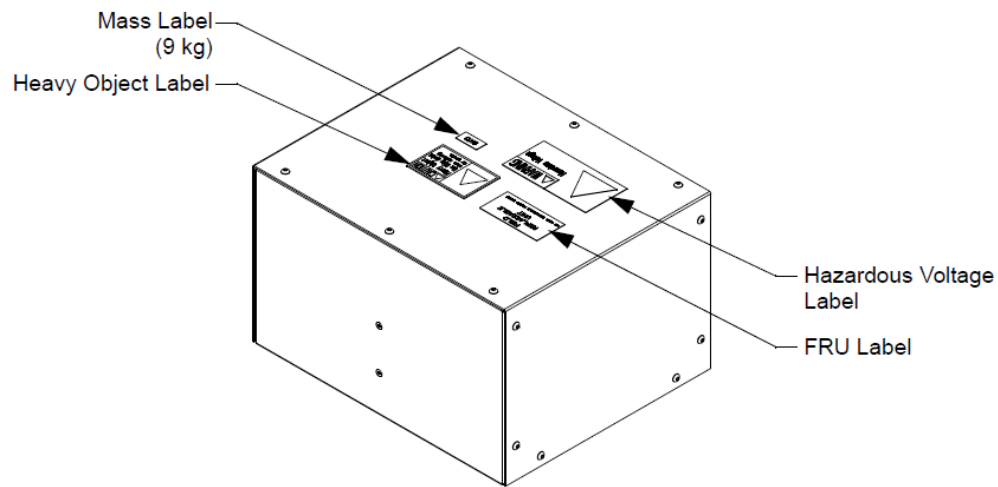


Figure 2-11: Typical Label Locations on the Safety Node

Table 2-6: Labels Used on the Micro Hub

FIELD REPLACEABLE UNIT NO USER SERVICEABLE PARTS INSIDE	Label - Field Replaceable Unit P/N: 130165 Qty: 1 Location: On top of Mini Hub
--	---

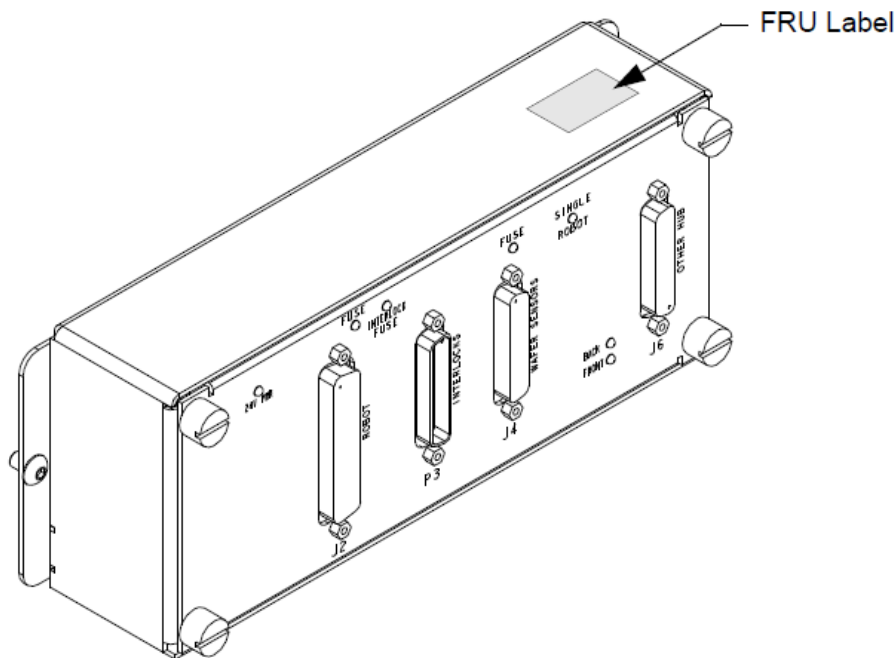


Figure 2-12: Typical Label Locations on the Micro Hub

Interlocks

Safety interlocking capabilities exist for user safety and operational interlocks exist to protect the M2 System and the material moving through it.

 WARNING Emergency Off (EMO)	
This device is not equipped with an EMO disconnect device. Using this product without an Emergency Off (EMO) circuit may cause death or personal injury. • The integrator and user are responsible for installation of the EMO disconnect device that complies with the mandated safety codes. • Personnel servicing this product are responsible for disconnecting power as specified by the facility Lockout/Tagout procedures.	 

 WARNING Safety Barriers of Obstructions	
Using this product without an Emergency Off (EMO) circuit may cause death or personal injury. • User must provide safety barriers or obstruction interlocks when operating the product as a stand alone unit	

The following Safety Interlocks exist on the M2 System:

- Emergency Off - refer to ["Safety Interlocks" on page 124](#).
- Door interlock - refer to ["Door Interlock" on page 37](#) and ["Safety Interlocks" on page 124](#).
- Lid interlocks
- Load Port Modules (LPM) have some hardware interlocks to protect operators against pinch point hazards.

The following Operational Interlocks may exist on the M2 System based on the System Integration Level:

- Operational interlocks are configured using the Discrete I/O capabilities of the robot.
- The vacuum robot is connected to the SLOT VALVE OPEN status signal, which provides a software interlock against extending towards a closed slot valve.
- The vacuum robots generate a ROBOT NOT EXTENDED signal, which is used for a software interlock to prevent closing a slot valve on the robot arm. Transport Chamber Material Sensors at the process module facets are read by the vacuum robot to determine successful PICKS and PLACES.

Refer to the individual Brooks Automation component manuals for additional interlock information.
Refer to ["Start-up" on page 162](#) for detailed operation information.

Door Interlock

A safety switch is provided to prevent movement of the robot in the EFEM with the minienvironment door panel open or removed. This switch can be defeated by a trained service person.

The Door Interlock provides a safety interlock for robot motion ensuring that when an EFEM door is opened, robot motion will stop and no other motion of the robot can be commanded. The Safety Interlock feature provides a motor enable interlock that disables all robot motors and load ports.

Bypassing the Safety Motor Enable Interlock Feature

 WARNING Safety Interlocks	
Overriding the safety interlocks could cause personal injury or death. • Always use the safety interlocks.	

The M2 System has available interlocking based on Control Level as configured. Some examples are: Robot to Slot Valve, Lid to Robot, and EFEM door to Robot. Please see the Block Diagram, Controls Manual, and other associated manuals for more information.

Lockout/Tagout

 WARNING Lockout / Tagout	
Working with energized equipment may cause sudden movement or electrical shock and may result in death or serious injury. • All energy must be removed from the equipment per the facility's Lockout/Tagout procedure before servicing. • If local procedures are not available, follow the procedure for Lockout/Tagout in OSHA Standard 29CFR 1910.147.	 

The following are general recommendations for LOCKOUT or TAGOUT for systems manufactured by Brooks Automation.

- Use LOCKOUT for all power sources (high voltage electrical, air, nitrogen, water, etc.)
- Use TAGOUT for low voltage (below 40 volts) electrical circuit repair.
- Use TAGOUT for maintenance, cleaning, or lubricating moving parts.
- Use TAGOUT for clearing jammed parts or mechanisms.

Mechanical Hazards

 WARNING Potential Robot Movement	
The product has the potential for automatic motion that may cause death or serious injury. • Avoid working inside the movement path or under extended components. • Use physical barriers to prevent injury when working in the movement path.	
 WARNING Moving Mechanisms	
Moving mechanisms do not have obstruction sensors and can cause death or serious injury. • Be aware of the potential movement area of the product whenever power is applied. • Never place any part of your body between the robot arms and fixed surfaces. • Do not operate the robot without the guards and protective covers in place and all safety interlocks enabled.	 
 CAUTION Pinch Point	
Moving parts of the product may cause squeezing or compression of fingers or hands resulting in personal injury. • Do not operate the product without the protective covers in place.	

Electrical Hazards

Refer to the specifications of this Marathon 2 (M2) for the electrical power.

 DANGER Electrical Shock	
Working with energized equipment may cause electrical shock and may result in death or serious injury. • All energy must be removed from the equipment per the facility's Lockout/Tagout procedure before servicing. • Follow the Lockout/Tagout procedures specified by the local facility. • If local procedures are not available, follow the procedure for Lockout/Tagout in OSHA Standard 29CFR 1910.147. • Refer the units specifications for the actual system power requirements and use appropriate precautions.	 

Grounding

The power source to which this product is connected must be properly grounded in accordance with local electrical codes and all electrical codes pertaining to high voltage electrical equipment in an industrial environment.

 DANGER Electrical Shock Hazard	
Contact with electrical power can cause death or serious personal injury. • To avoid electrical shock, disconnect the power before troubleshooting the electrical components.	

Disconnect Devices

The integrator and end user are responsible for the M2 System's main disconnect device, ensuring that it is readily accessible and complies with the correct electric codes. The main circuit breaker on the ACPD is rated at 10,000 AIC, the main user installed disconnect device must meet, or exceed, the minimum AIC rating specified by SEMI S2. Personnel servicing the M2 System and any equipment connected to it are responsible for the status of the M2 system's main disconnect device

as specified by the facility's lockout/tagout procedure. If no such procedures exist, follow the guidelines provided in "[Laser Hazards](#)" on page 41.

NOTICE

Before disconnecting main power to the M2 System, ensure all circuit breakers on the M2 System and any related equipment are in the OFF position.

Laser Hazards

The M2 System uses low power laser light for material detection in optional wafer mappers and in the Automatic Wafer Centering system. The proper precautions for operating and servicing lasers must be observed. Any precautions specified within the facility where the product is being used must also be observed.

The atmospheric robot may utilize a wafer mapping laser is located on the end effector, and is active whenever power is applied to the M2 System and wafer mapping is taking place. The laser is turned off at all other times. It is a Class I laser. Under normal operation, no hazardous levels of laser radiation are emitted.

The Load Port Module's wafer mapping laser is located on the wafer mapper, and is active whenever power is applied to the M2 System and wafer mapping is taking place. The laser is turned off at all other times. It is a Class I laser. Under normal operation, no hazardous levels of laser radiation are emitted.

An Automatic Wafer Centering (AWC) laser is located on the material transfer port at each facet of the Vacuum Back End, and is active whenever power is applied to the M2 system. It is a red light Class II laser that is enclosed and not visible during normal operation, so it is Class I as implemented. Under normal operation, no hazardous levels of laser radiation are emitted.

Class I: Very low power (<CW: 0.41Watts at visible wavelengths) -- does not emit laser radiation at known hazard levels (eye damage occurs at 11W).

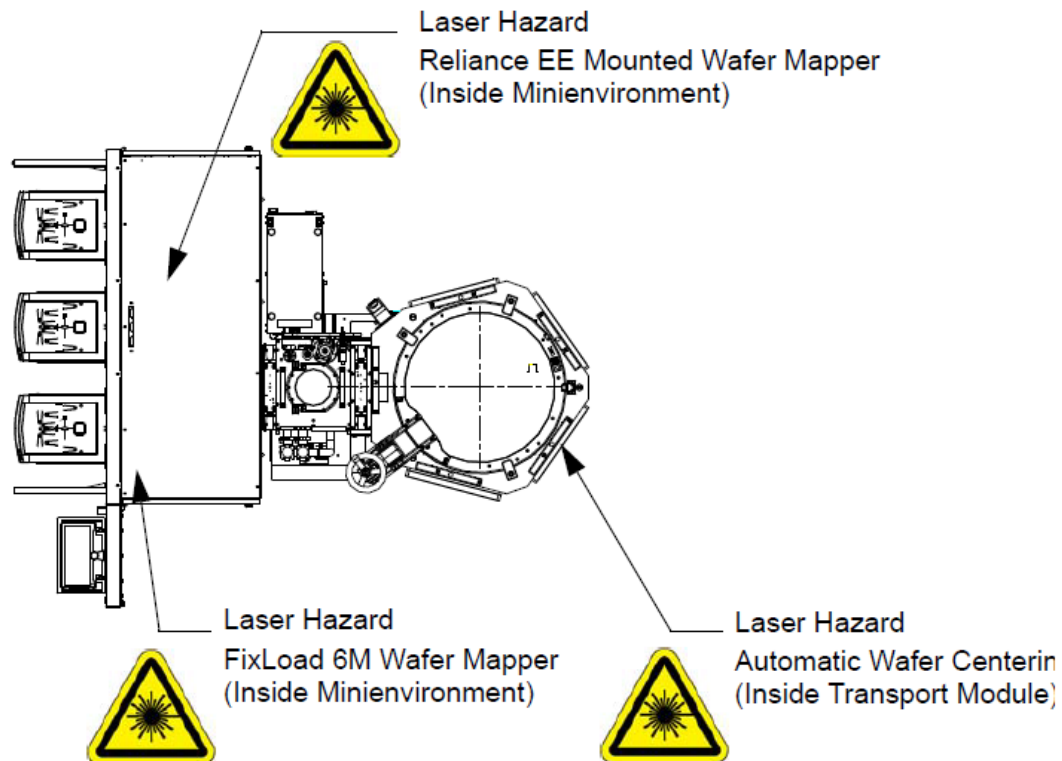


Figure 2-13: Typical Laser Location

 CAUTION Laser Radiation	
Laser radiation may cause serious eye injury. • Know the power and hazard level of all lasers. • Avoid exposure to laser hazards. • Do not look directly at or into the laser beam (no matter what Class of laser). • Follow any posted laser warnings or labels. • Do not attempt to service, repair, or remove the protective housing of the laser device.	

Fire and Explosion Hazards

The Marathon 2 (M2) provides no direct fire or explosion hazard.

 WARNING Fire Hazard	
Flammable cleaning products such as Isopropyl alcohol may cause fire if used on hot parts which may lead to death or personal injury. • Allow the product to completely cool before using flammable cleaning products for maintenance procedures.	

High Pressure Gas Hazards

 CAUTION High Pressure Refrigerant	
This product creates high pressure compressed gas. Internal pressure is monitored by sensing devices and is regulated by over pressure relief valves. Tampering with the relief valves may lead to moderate to serious injury. • Do not tamper with, disable, or replace internal sensor devices or over pressure relief valves with unauthorized devices. • Ensure that if gases are vented, the venting meets local regulations.	

 CAUTION High Pressure Gas	
Use of high pressure gas or compressed air during cleaning may cause flying debris. • When using high pressure gas for cleaning, wear personal protection equipment such as safety glasses. • Follow safety guidelines for cleaning with high pressure gas as specified by the facility.	

 CAUTION Extreme Cold	
Moving a cold refrigerant line may cause gas line to crimp and insulation to crack which may cause minor or moderate injury along with hazardous refrigerant discharge. • Do not attempt to move or position the refrigerant lines.	

Ergonomics Hazards

 CAUTION Two-Person Lift Recommended	
The Equipment Front End Module weighs at least 756.6 kg (1668 lb). The Vacuum Back End weighs at least 580.6 kg (1280 lb). Failure to take the proper precautions before moving any modules could result in personal injury. Do not attempt to move M2 System EFEM and VBE without the use of a fork lift or a hoist. Roll on smooth floors only.	

Tip Hazard

 WARNING Tip Hazard	
Moving this product without a hoist could cause a tip hazard which may cause death or serious injury. • Do not attempt to move the Product without the use of a fork lift or a hoist. • Roll on smooth floors only.	

Trip Hazard

 CAUTION Trip Hazard	
Cables for power and communication and facilities create trip hazards which may cause serious injury. • Always route the cables where they are not in the way of traffic.	

Environmental Information

Recycling and Hazardous Materials

NOTICE



Hazardous lubrication material is used in the arm bearings and the drive linear rails and ball screw.

If the armset or the drive is removed or replaced, it must be handled following all Federal, State, Local, and Facility procedures for the disposal of hazardous materials.

NOTICE

Lithium Battery Disposal



A lithium battery is located in the controller.

If the controller is being removed or replaced, it must be handled following all Federal, State, Local, and Facility procedures for the disposal of hazardous material.

Follow all facility and government regulations regarding recycling and disposal when discarding product components that have been replaced.

Safety Data Sheets

Hazardous materials may be present during the operation or maintenance of the M2 system. Read and understand the Material Safety Data Sheet (MSDS) for each material. These sheets provide crucial information pertaining to the hazardous material used in the equipment. The facility where the M2 system is to be used is responsible for the maintenance and distribution of each MSDS. Ensure that there is a copy in each workplace for all hazardous materials involved in the operation and maintenance of the M2 system.

Other gases, cleaners, and lubricants may be recommended for use with the M2 system. Obtain the MSDS for these materials from their supplier.

3. Specifications and Site Requirements

This chapter details the specifications of the M2 system and the requirements for installation.

Specifications

The Brooks Automation M2 system Vacuum Transport System is a high reliability platform supporting up to six Process Modules and four Load Port Modules based on the configuration. The specifications for the M2 system and its subsystems are detailed below.

NOTICE

All drawings within this manual are generic and may not reflect specific builds of the M2 system. To obtain a complete and current set of drawings and documents contact Brooks Technical Support.

Mechanical Specifications

Table 3-1: Equipment Front End Module

Parameter	Specification
Dimensions	Refer to the Equipment Front End Module's User Manual for typical physical dimensions, for the actual dimensions of the specific system, including foot and seismic tie-down locations refer to the Mechanical Layout Drawing supplied with this manual.
Weight	Refer to the Equipment Front End Module's User Manual for typical system weights, for the actual weight of the specific system, including Floor Loading and Center of Gravity refer to the Mechanical Layout Drawing supplied with this manual.

Parameter	Specification
Exposed Materials	Refer to the Equipment Front End Module's User Manual for detailed information on exposed materials. Typical exposed materials include: 6061 T6 Aluminum, 5080R Aluminum, Anodized Aluminum, Stainless Steel, Cold Rolled Steel, Baked Powder Coated Epoxy, Lexan®, PEEK™, Viton®
LPM Interface	Per SEMI E63 BOLTS interface
Leveling Provision	Adjustable feet to meet Material Transport Plane -0.4/+1.0 inch range
Rolling Provision	4 casters (minimum)
Lifting Provision	2 removable forking brackets provided under the frame
Hold-Down Provision	User supplied and installed brackets
Ground Clearance	19.1 mm (0.75 in) minimum 50.8 mm (2.00 in) maximum
Vacuum Port	6 mm Quick Connect if required
Pneumatic Port	6 mm Quick Connect if required
Exhaust Port	6 mm Quick Connect if required

Table 3-2: Vacuum Back End

Parameter	Specification
Dimensions	Refer to Figure 3-1 , Figure 3-3 , and Figure 3-4 for typical physical dimensions, for the actual dimensions of the specific system, including foot and seismic tie-down locations refer to the Mechanical Layout Drawing supplied with this manual.
Weight	M2 Compact: Approximately 580.6 kg (1280 lb) M2 Quad: Approximately 1047.8 kg (2310 lb) For the actual weight of the specific system, including Floor Loading and Center of Gravity refer to the CG and Foot Loading Layout Drawing supplied with this manual.
Exposed Materials (Atmosphere)	6061 T6 Aluminum, 5080R Aluminum, Anodized Aluminum, Stainless Steel, Cold Rolled Steel, Baked Powder Coated Epoxy, Lexan®, Pyrex®, Viton®
Exposed Materials	6061 T6 Aluminum, 5080R Aluminum, 316L Stainless Steel, Sintered (Vacuum)Nickel, Pyrex, Viton®, Kalrez®, Teflon®, Silicon Nitride (cool lock option) Alumina
Internal Volume	M2 Compact chmbr: Approximately 92 liter (5,623 in ³) M2 Quad chamber: Approximately 251 liter (15,294 in ³) M2 6 chamber: Approximately 119 liter (7,253 in ³) Straight LL chmbr: Approximately 6 liter (366 in ³) Angled LL chmbr: Approximately 7 liter (427 in ³)

Parameter	Specification
Leveling Provision	Adjustable feet to meet Material Transport Plane -0.4/+1.0 inch range
Rolling Provision	4 casters (minimum), removable
Lifting Provision	Removable forking brackets provided at each caster
Hold-Down Provision	User supplied and installed brackets
Ground Clearance	71.20 mm (2.8 in)
Vacuum Ports	KF 50
Nitrogen Port	Main: 1/4 in. HVCR PM Facet: 1/4 in. HVCR
Hi-Purity Gas Port	Main: 1/4 in. HVCR PM Facet: 1/4 in. HVCR
CDA Supply	Main: 1/2 in. Quick Connect PM Facet: 8 mm Quick Connect To EFEM: 8 mm Quick Connect
CDA Exhaust	Main: 1/2 in. Quick Connect PM Facet: 10 mm Quick Connect To EFEM: 10 mm Quick Connect
Over Pressure Exhaust	1/2 in. Quick Connect
PCW Supply	Main: 3/4 in NPT Quick Connect Coupler PM Facet: 3/4 in NPT Quick Connect Coupler
PCW Return	Main: 3/4 in NPT Quick Connect Nipple PM Facet: 3/4 in NPT Quick Connect Nipple

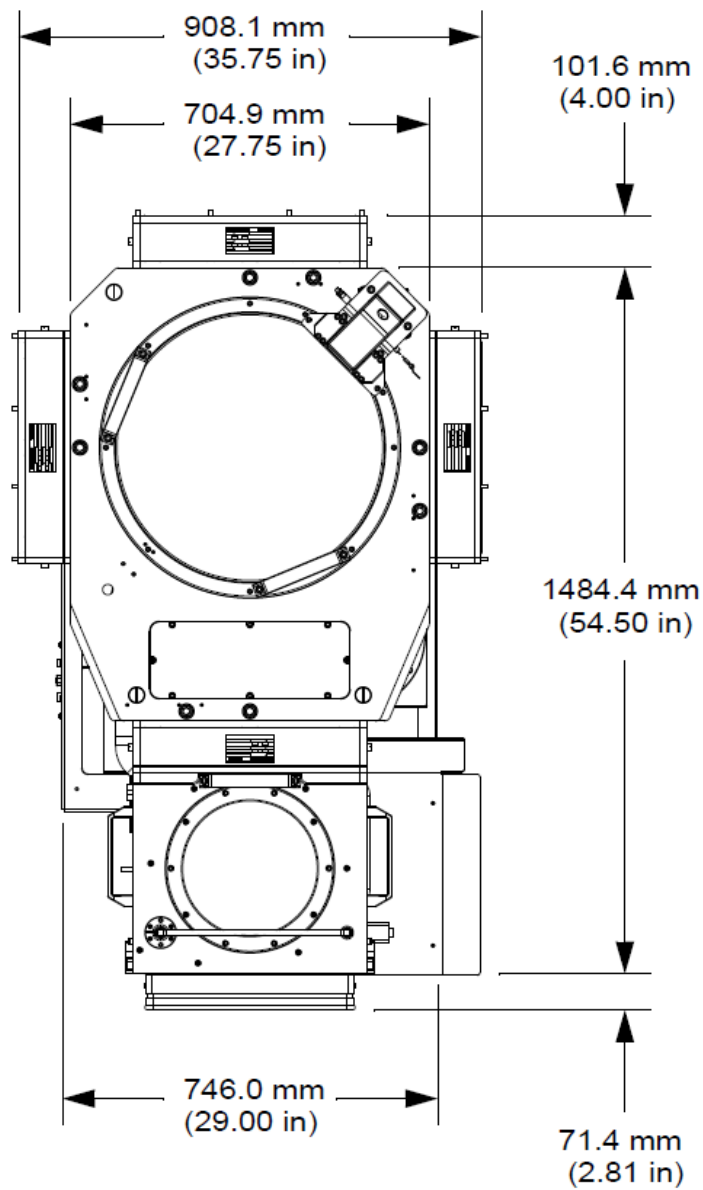


Figure 3-1: M2 Compact Vacuum Back End Dimensions - Typical

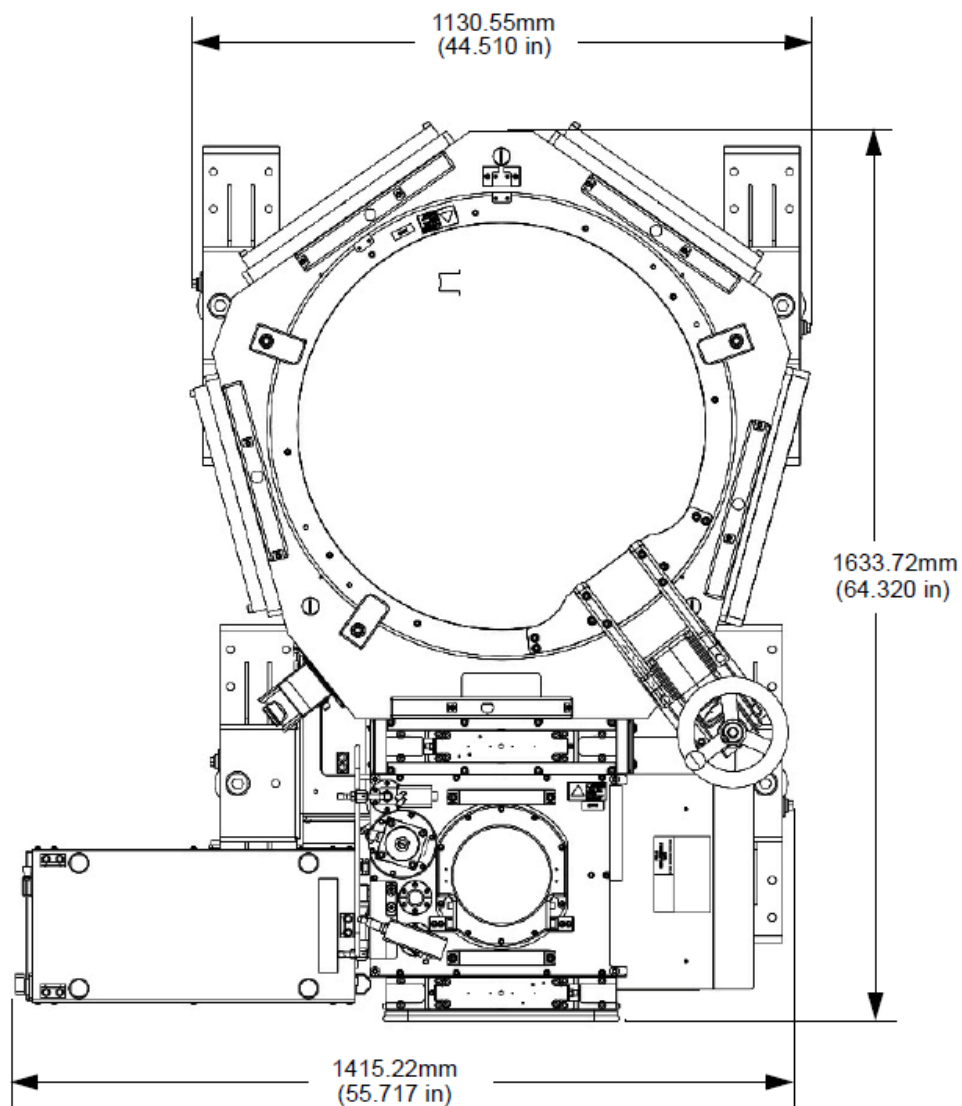


Figure 3-2: M2-C5 Vacuum Back End Dimensions-Typical

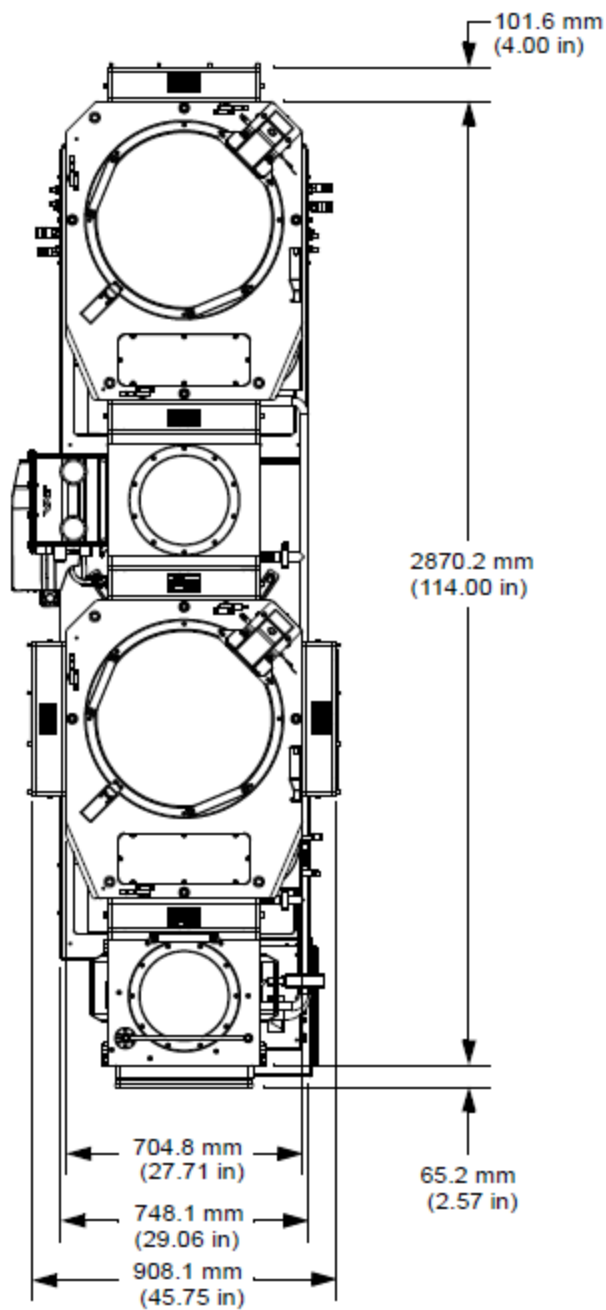


Figure 3-3: M2 Tandem Vacuum Back End Dimensions - Typical

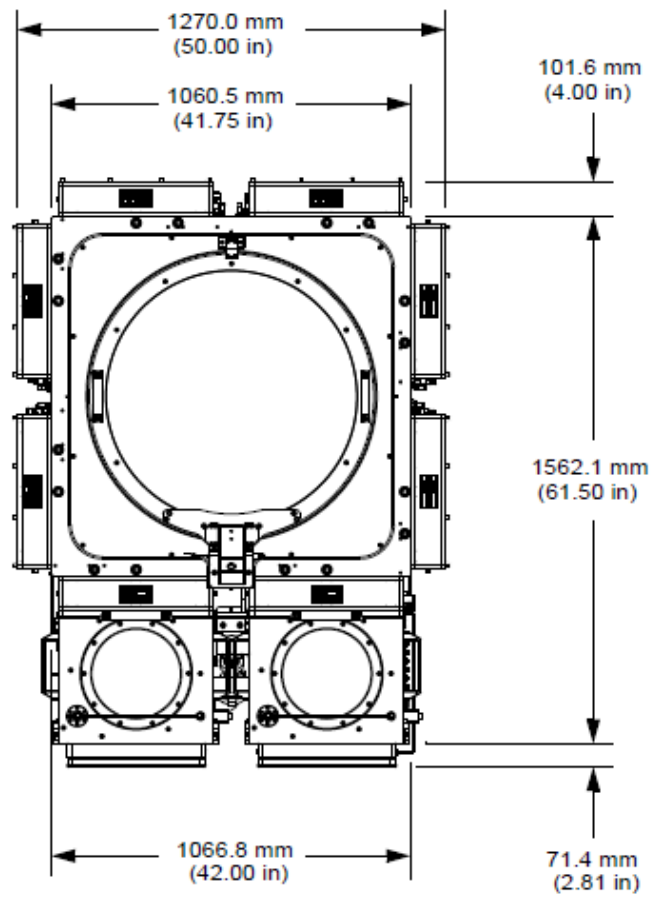


Figure 3-4: M2 Quad Vacuum Back End Dimensions - Typical

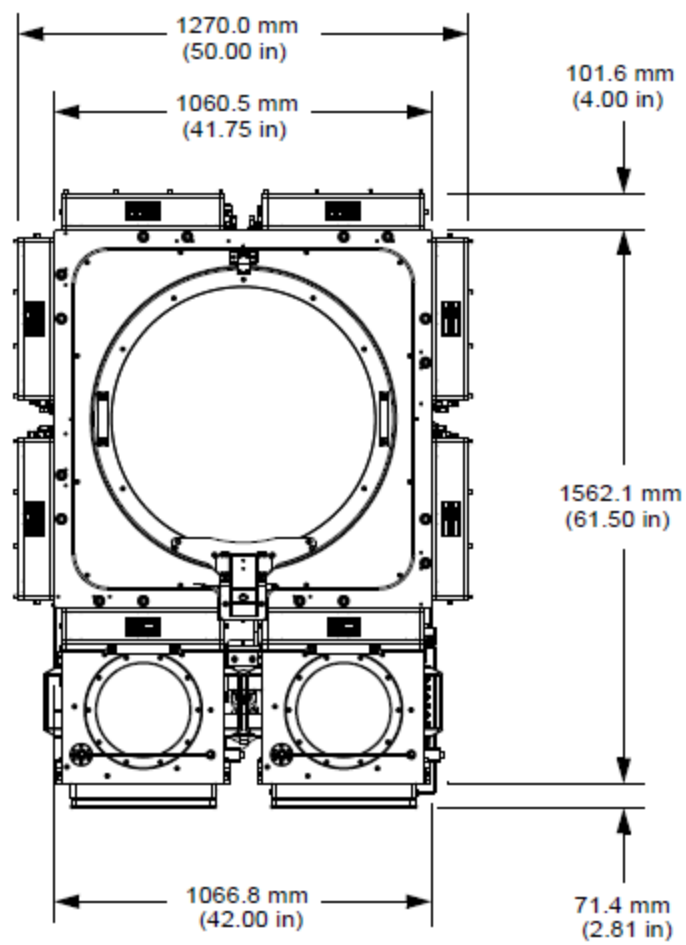


Figure 3-5: M2 Quad Vacuum Back End Dimensions - Typical

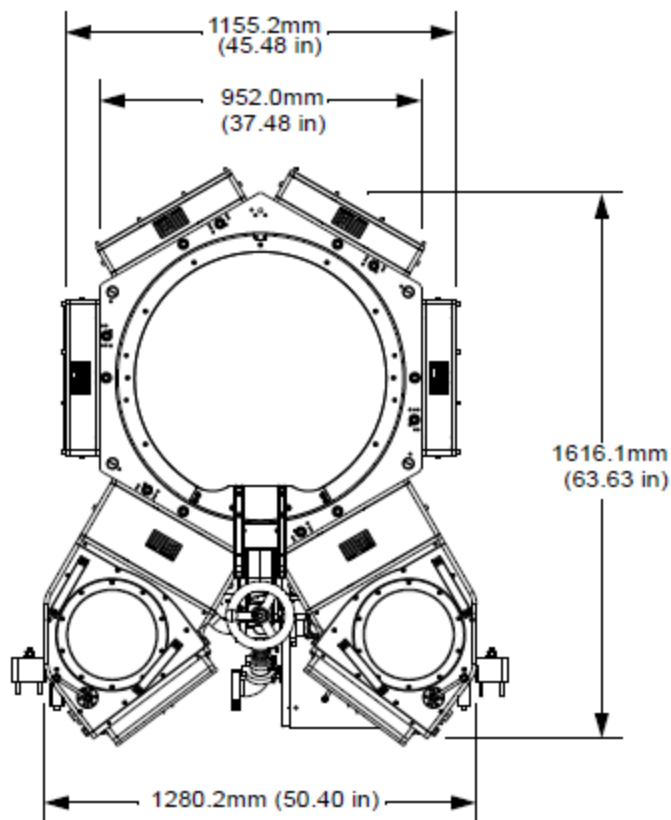


Figure 3-6: M2-6 Vacuum Back End Dimensions - Typical

Center of Gravity and Floor Loading

Center Of Gravity and Floor Loading information for the M2 system varies based on the configuration of the EFEM and VBE and the options installed on the M2 system. For the Center of Gravity and Floor Loading of the specific M2 system refer to the CG and Foot Loading Layout Drawing supplied with this manual.

Overturning Moment: Contact Brooks Automation for details on specific systems.

PM Weight Supported: Contact Brooks Automation for details on specific systems.

Brooks recommends that the Process Modules be designed such that they are capable of supporting their own weight.

AC Power Distribution

The Marathon 2 (M2) uses an AC Power Distribution Unit (ACPDU) to distribute AC power throughout the tool. The ACPDU also provides circuit protection. [Figure 3-7](#) shows the location of all connections found on the ACPDU. [Table 3-3](#) lists the connections, and shows which type of connectors are used.

NOTE: The ACPDU is not intended to supply power to user installed modules.

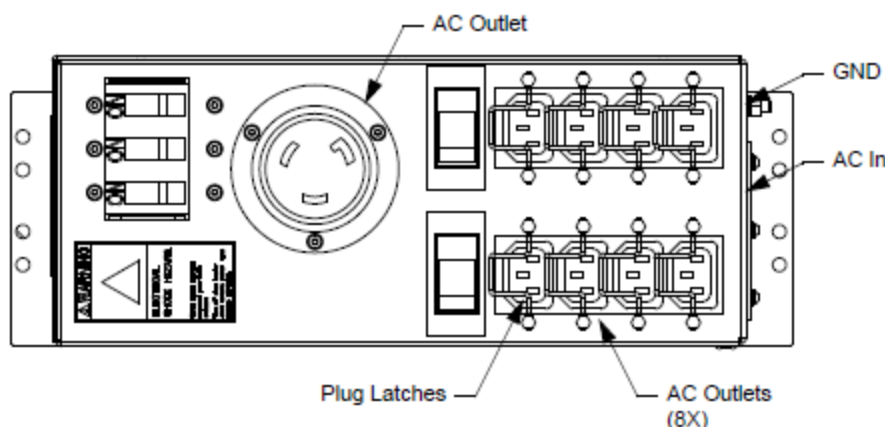


Figure 3-7: AC Power Distribution Unit - Connections

Table 3-3: AC Power Distribution Unit - Connections

Label	Description	Connector Type
RECPT 1	200 - 240 VAC @ 20 A, In	NEMA L15-30P
Earth Ground	Earth Ground	Stud, M5
RECPT 2	200 - 240 VAC @ 20 A, Outlet	NEMA L6-20R
J1.1, J1.2, J1.3, J1.4 J2.1, J2.2, J2.3, J2.4	200 - 240 VAC, 4 Total 10 A (max) Outlets (2X)	Female IEC 320

NOTE: The facility is responsible for the main disconnect devices between the M2 system and the facility's power source, ensuring it complies with the correct electric codes. Service to the M2 system should have the appropriate fuse or circuit breaker rating. The main user installed disconnect devices must meet, or exceed, the minimum AIC rating specified by SEMI S2. All current requirements shown are

maximum values, the actual current drawn will depend upon the use of the M2 system.

Power Cable

NOTICE

Before connecting or disconnecting the main power to the M2, be sure that all circuit breakers on the M2 and any related equipment are in the OFF position. Damage to internal components may result if the circuit breakers are left in the ON position.

The pin-out for the power cable is provided in .

Note that pins not identified with a signal name are to be left unconnected.

NOTICE

Do not connect or disconnect the power cable to the M2 system with the power on. Damage to internal components may result.

Power Connections

The M2 requires 200 - 240 VAC at 15 Amps (max) 50-60 Hz single phase (phase-to-phase or phase-to-neutral) for standard operation. The electric chamber heating option requires 200 - 240 VAC at 15 Amps (max) 50-60 Hz (phase-to-phase or phase-to-neutral). The actual power being drawn will depend upon operations being performed, however all power wiring must be capable of carrying the full load, refer to "[Facilities Specifications](#)" on page 58.

See the Controls Manual and System Block Diagram for more information.

NOTE: The facility is responsible for the main disconnect device between the M2 system and the facility's power source, ensuring it complies with the correct electric codes. Service to the M2 system should have the appropriate fuse or circuit breaker rating. The main user-installed disconnect device must be rated at 10,000 AIC minimum. All current requirements shown are maximum values, the actual current drawn will depend upon the use of the M2 system.

The proper distribution of power is determined by the user. Brooks Automation recommends circuit breakers, ground-fault protection, contactors, and/or EMO circuitry for equipment and personal safety.

The facility is responsible for the main disconnect device between the M2 system and the facility's power source, ensuring it complies with the correct electric codes. Service to the M2 system should have the appropriate fuse or circuit breaker rating. All current requirements shown are maximum values, the actual current drawn will depend upon the use of the M2 system. Refer to the ["Facilities Specifications" on page 58](#) for power requirements.

NOTE: Before connecting or disconnecting main power to the M2 system, ensure all circuit breakers on the M2 system and any related equipment are in the OFF position. Damage to internal components may result if circuit breakers are left in the ON position.

AC Power Distribution Cable

For Gen 5 systems the user must fabricate the power cable carrying facilities power to the AC Power Distribution Unit (ACPDU). The ACPDU is typically mounted on the M2 system's frame and provides power to the M2 system's modules. The pin-out for the ACPDU's 200 - 240 VAC cable is provided in [Table 3-4](#). The power cable connectors are shown in [Table 3-5](#).

Table 3-4: AC Power Distribution Unit Cable

AC INPUT, 200-240 VAC @ 20 A		
Pin ID	2 Phase	3 Phase
X	-	L3
Y	L2/N	L2/N
Z	L1	L1
G	GND	GND

Table 3-5: AC Power Distribution Unit Connectors

Connector Located on AC Power Distribution Unit	Connector Bagged for Facilities Power Cable
Hubbell 2425 Flanged inlet connector 250 VAC, 20A, 3 Phase, male Brooks P/N 211-0063-16	Hubbell 2423 Connector body 250 VAC, 20A, 3 Phase, male Brooks P/N 211-0068-14

Electrical Specifications

Overvoltage Category

The following table describes electrical overvoltage categories. Brooks Automation has designed the M2 system as an Overvoltage Category II device.

Table 3-6: Overvoltage Category

Category	Description
Category I	Signal level (special equipment or parts of equipment, telecommunications, etc.) with smaller transient overvoltages than Overvoltage Category II.
Category II	Local level (appliances, portable equipment, etc.) with smaller transient overvoltages than Overvoltage Category III.
Category III	Distribution level (fixed installation, building wiring, etc.) with smaller transient overvoltages than Overvoltage Category IV.
Category IV	Primary supply level (overhead lines, cable systems, etc.).

Facilities Specifications

Table 3-7: Facilities Specifications

Parameter	Specification
Pneumatic	Typical configurations require the following supply of clean, dry (unfiltered), oil free air: 90 psig $\pm$ 10 psig at 50 slm nominal, 200 slm max.
Nitrogen	200 - 240 VAC, 50 - 60 Hz, 10 A, single phase (phase to phase or phase to neutral), 10 A max, based on configuration and operating mode. In those installations where the JET is powering the M2 Vacuum Back End, the JET could consume an additional 3 Amps.
Process Gas	200 - 240 VAC, 50 - 60 Hz, 40 A, single phase (phase to phase or phase to neutral), 3 A max, supplied by a UPS, based on configuration and operating mode.
Exhaust	200 - 240 VAC, 50 - 60 Hz, 60 A, three phase (phase to phase), 30 A max, based on configuration and operating mode.
Vacuum, Backing	Typical configurations require the following supply: 610 mm Hg at 50 cc/sec (24 in Hg at 3.05 ci/sec). Note that only configurations of the M2 system using a FOUP Load Port Module, active grip end effector, or the AcuLine (AWA 8) will require an external backing vacuum supply.

Parameter	Specification
Vacuum, Rough	Pumping speed, 1500 lpm (53 cfm) minimum Ultimate pressure, 23 mTorr
Vacuum, Foreline	Pumping speed, 1500 lpm (53 cfm) minimum Ultimate pressure, 23 mTorr
Water (PCW)	Facilities chilled water must be supplied for cool modules and some pumps. Supply Pressure: 50 psig nominal, 100 psig maximum 30 psig minimum delta p between inlet and outlet Flow Rate: 15 l/m (4 gpm) Filtration: 200 um (0.5 mm Filter pre-installed) Temperature: 15° C ± 5° C (59° F ± 9° F) Acidity: 6.0 to 8.0 Ph Conductivity: 2000 µmhos/cm Dissolved Solids: < 75 ppm as calcium carbonate Corrosion Inhibitor: 300 - 600 ppm nitrite borate, 450 - 900 ppm sodium nitrite Organics, Intermittent Chlorination or Biocide application as required Open Systems: based on visual inspection (Do Not use algicides containing ethyl alcohol as it may degrade any seals it contacts) Organics, Standard filter test count < 100
Return (PCW)	Process Chilled Water return must be sufficient to handle water flow. Nominal 20 psi, 70 psi max.

Network Interface Connections

Ethernet: 10/100 Mbps

Network communications using the Ethernet communications protocol provides the ability to connect a number of different devices to a host controller using a single communications cable, which simplifies wiring. Each device connected to the network has a unique network device address. Only communications addressed to a specific device through the network will be received by that device. The configuration for the various devices using Ethernet is described in ["Operation" on page 110](#).

Network communications allows the Host Controller to communicate with the M2 system using the commands detailed in the associated robot manuals. In situations where the Teach Pendant and the Host Controller are unavailable, a personal computer running a network communications application may be connected to a network port on the Ethernet Switch using a standard Ethernet cable.

The connection to the M2 system from the host controller uses standard Ethernet network communications protocols and wiring. The configuration for the M2 system's network communications protocol is described in [Table 3-8](#). Note that if more than one M2 system will be connected to the same network the IP Address of each additional system must be changed to avoid IP conflicts.

Table 3-8: Ethernet Network Communications Protocol

Setting	Atmospheric Robot	Vacuum Robot
IP Address	20.20.249.20	20.20.249.10
Mask	255.255.255.0	255.255.255.0

The Ethernet cables used are standard network cable (UTP-Cat5) with an 8-pin RJ-45 connector that plugs into the Ethernet Switch at any of the Ethernet ports. The pin-out for this connection is provided in [Table 3-9](#). Note that pins not identified with a signal name are to be left unconnected. Refer to [Figure 4-3](#) and [Figure 4-5](#) for the location of these connections. To establish a direct communications link to the M2 system from a service computer (i.e., laptop) using Ethernet either a crossover cable or a hub is needed.

Table 3-9: Standard Ethernet Network Connector Pin Assignments

Pin	Signal
1	TX+
2	TX-
3	RX+
4	
5	
6	RX-
7	
8	

Serial Interface Connection

Serial I/O:

RS-232

RS-422

RS-485

Serial communications provides the ability to connect devices within the M2 system to a Host Controller through the Ethernet connection using an Ethernet to Serial Gateway. Each device within a system must have its own serial communications cable. The Baud Rate indicates the speed of the connection in bits-per-second.

The serial communications cable uses a standard 9-pin “D” connector. The pin-out for this connection is provided in [Table 3-10](#). Note that pins not identified with a signal name are to be left unconnected. Refer to [Figure 4-3](#) and [Figure 4-5](#) for the location of this connection.

Table 3-10: Standard Serial I/O Connector Pin Assignments

Pin	RS-232 Signal Name	RS-422 Signal Name
1		
2	TXD	RXD-
3	RXD	RXD+
4		
5	GND	TXD-
6		RX-
7		
8		TXD+
9		

Operating Specifications

Table 3-11: Operating Specifications

Parameter	Specification
Transport Plane	900 mm at LPM (SEMI std) 1100 mm/1200 mm (43.31 in/47.24 in) per SEMI E21 at PM (3.78 mm (0.15 in) above slot centerline)
Material Sizes	200 mm or 300 mm wafers notched fiducial per SEMI M1.15 and 300 mm flat SEMI M1.15 wafers
Material Thickness	775 ± 20 µm per SEMI M1.15
Laser Light	Class 1 Laser (used in wafer mappers) Class 2 Laser (used in Automatic Wafer Centering system)
Maximum Noise Level	NC55

Equipment Front End Module

Minienvironment:

- Classification: Exceeds ISO 14644-1 Class ISO 2 above the material transport plane
- Air Flow: 0.2 - 0.45 m/sec (40 - 90 ft/min)
- Air Volume: 13 cmm (460 cfm) maximum

Service Access: Removable side panels on minienvironment with safety interlock switches and viewports. Refer to ["Service Access" on page 63](#) for space requirements.

Vacuum Back End

Working Pressure:

- -15 psi (vacuum)
- +1 psi (overpressure)

Base Pressure:

- Rough Vacuum: < 100 mTorr
- Relief Pressure: 1/4 psi above ambient
- Leak Rate: <1.0x10⁻⁷ cc/sec He

Material Sensing: Polar-reflective beam break, bottom mount

Wafer Cooler LL: Cool Time: 20 - 25 seconds depending on material and initial and final temperatures

Service Access: Refer to ["Service Access" on page 63](#) for space requirements.

Site Requirements

Process Module Space Requirements

The M2 system accepts SEMI Standard compatible Process Modules as defined by SEMI E26. The M2 system is also capable of accepting non-standard Process Modules, contact Brooks Automation for details.

Environmental Requirements

ISO 14644-1 Class ISO 6 or better cleanroom ambient.

Table 3-12: Environmental Requirements

Parameter	Specification
Temperature	Operating: 20° C to 30° C (68° F to 86° F) Shipping: -25° C to 55° C (-13° F to 131° F), up to 65° C (149° F) for 24 hrs. max Storage: -25° C to 55° C (-13° F to 131° F), up to 65° C (149° F) for 24 hrs. max
Humidity	35% to 55% (relative, non-condensing)
Lighting	Standard lighting provided in the cleanroom environment where the M2 system is installed is sufficient for proper operation. Maintenance may require a user supplied service light (i.e., flashlight).

Service Access

The M2 system requires adequate space for service access as specified in SEMI E26 and for proper operation. Refer to the Mechanical Layout Drawing supplied with this manual for system dimensions.

Ensure that installation of the M2 system is such that it provides access to items required for service after installation, such as the lid lifter and connection panels.

Refer to the User manual for the Equipment Front End Module for its service space requirements.

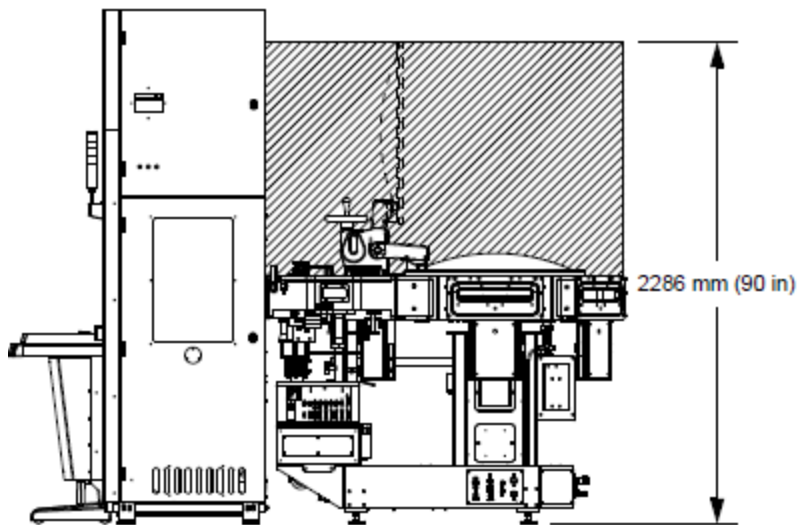


Figure 3-8: Typical Service and Exclusion Zones - Vertical

Moving the M2 System

Various locations within the site where the M2 system will be installed must meet the following minimum requirements to ensure proper handling of the M2 system:

Door Openings: The M2 system has been designed to separate into modules that fit through standard door openings. Note that for some doors it may be necessary to remove the Overhead Storage on the Jet ATS.

People: A minimum of two people are required for moving the Load Port modules and a minimum of four people are required to move the Vacuum Back End or Equipment Front End Module within the facility.

Floor: The M2 system has been designed to roll easily across smooth interior floors only. The floor where the M2 system will be installed must be capable of supporting the weight of the M2 system. Refer to the Equipment Front End Module's User Manual and the CG and Foot Loading Layout Drawing supplied with this manual. The weight information provided is maximum system weight, including LPMs, specific systems may weigh less.

4. Installation

This chapter provides complete installation procedures for the Brooks Automation M2 system including: unpacking, assembly, facilities connections, initial setup, and initial check-out.

Unpacking and Inspection

The Brooks Automation M2 system is shipped in separate packages which are individually sealed to maintain cleanroom conformance. Unpack each crate carefully; inspect and verify its contents against the shipping documents. Report any damage immediately to the shipper and to Brooks Automation.

One set of shipping documents will be attached to the outside of the main shipping crate for easy access. An additional set of the same documents will be attached to the equipment inside the shipping crate.

The M2 system was assembled in a cleanroom environment. The system is double-bagged for shipping in an ISO 14644-1 ISO Class 4 cleanroom. Before bagging the modules of the M2 system, they are cleaned and then completely wrapped in plastic that covers the top and bottom of all modules to ensure cleanliness. The plastic wrap is then cleaned, and the first bag is placed around each module. The bag is then cleaned and a second bag is placed around it.

When the M2 system is being prepared for shipping, the outer bag is cleaned and a foil bag is placed around each module of the M2 System. The foil bag is then sealed and evacuated and the system is bolted to the crate bottom before the crate is closed and bolted together. Tip indicators, shock indicators, and moisture indicators are attached to each crate.

 CAUTION Two-Person Lift Recommended	
The Equipment Front End Module weighs at least 756.6 kg (1668 lb). The Vacuum Back End weighs at least 580.6 kg (1280 lb). Failure to take the proper precautions before moving any modules could result in personal injury. Do not attempt to move M2 System EFEM and VBE without the use of a fork lift or a hoist. Roll on smooth floors only.	

 WARNING Tip Hazard	
Moving this product without a hoist could cause a tip hazard which may cause death or serious injury. - Do not attempt to move the Product without the use of a fork lift or a hoist. - Roll on smooth floors only.	

 CAUTION Personal Protective Equipment	
This product contains heavy objects that may cause personal injury. - Use safety shoes and head protection when installing or maintaining the product. - Wear protective eyewear when setting up or testing the system.	

NOTICE	
When rolling the Vacuum Back End on its casters, place hands on the dummy process modules or on the process module blank-offs. Gauges and sensors are located in other areas of the module and could be damaged if pushed against.	

Tools and Materials

The following tools and materials are required during the unpacking of the M2 system.

- Fork truck or appropriate lift
- Open End Wrench, minimum length 16 in., adjustable or size 19 mm, 1/2 in, 3/4 in, and 1 1/8 in
- Metric Hex wrenches
- Phillips screwdriver
- 1/2 drive ratchet 16 in. minimum with a 19mm or 3/4 socket
- 1/8 in. open end wrench

Procedure

Step	Action
1.	Upon receiving the crate, inspect the indicators for disturbance. Also, visually verify that the crate is not damaged. Inform the freight carrier and Brooks Automation of any inspection discrepancy.
2.	Remove the cover of each shipping crate. Unpack, inspect, and verify the contents against the shipping documents. Do not remove any protective wrapping. NOTE: Save all shipping materials for possible future use. If the M2 system is returned to Brooks for service or shipped to another location, the original shipping materials must be used. If the original shipping materials have become lost or damaged, contact Brooks Automation for replacements. Refer to Appendix G: "Packing and Shipping Instructions" on page 204. The M2 system was assembled and bagged in plastic in a cleanroom environment. To ensure the cleanliness of the M2 system, only unbag it in a cleanroom environment. The contents of the shipping crates will depend on the items purchased. Refer to the shipping documents for the exact contents. Table 4-1, below, is provided for reference only.
3.	Uncrate and move the Equipment Front End Module into its final location in the cleanroom as specified in the EFEM's User Manual.
4.	Remove the crate walls of the Vacuum Back End.
5.	Unbolt the caster brackets from the pallet floor (4 places minimum).
6.	Using a fork lift, raise the VBE to clear the shipping skid.
7.	Slide out the shipping skid.
8.	Lower the VBE jacking casters. NOTE: Turning the casters requires up to 70 ft-lbs of torque. Do not turn more than 1 to 2 turns at a time and then move to the next caster. Do not raise the caster all the way up at one time.
9.	Lower the Vacuum Back End to the floor.

Step	Action
10.	Roll the Vacuum Back End into the Depack area.
11.	Move the contents of all other crates into the Depack area.
12.	Vacuum and wipe down the bags for all items while in Depack.
13.	Lower the system by raising the casters until the system is resting on the feet inside of the bag. NOTE: Always adjust each caster the same amount. Do not allow the frame of the chamber to twist.
14.	Remove the caster brackets.
15.	Remove all bags. NOTE: Recycle all packaging materials.
16.	Replace the caster brackets on the system and lower the casters to raise the feet off the floor.
17.	Move all items to their final location in the cleanroom (refer to the "Installation Procedure" on page 69). NOTE: When pushing the M2 system on its casters, place hands on the dummy process modules or on the process module blank-offs. Gauges and sensors are located in other areas of the M2 system and could be damaged.
18.	Remove any additional wrapping. NOTE: Recycle all packaging materials.
19.	Carefully inspect the M2 system and all additional items for signs of damage that may have occurred during shipping

Procedures for re-packaging the M2 system for shipment are provided in [Appendix G: "Packing and Shipping Instructions" on page 204](#).

Table 4-1: Packing Checklist Reference

Package	Contents
Equipment Front End Module	Minienvironment on wheels with installed options that may include, Fan/Filter Unit, Robot, Aligner, etc.
Vacuum Back End	Chamber mounted on frame with wheels with installed options that may include: Vacuum robot, custom end effector, vacuum Load Locks, vacuum aligner, etc.
Load Port Module(s)	Load Port Modules with stand/cart
Installation Kit	Copy of ATP (Certificate of Performance Testing) Connector for power cable System cables Mounting Hardware User Manuals

Installation Procedure

The M2 system is typically supplied in a standard configuration. The information required to install the standard configuration of the M2 system is provided in the following procedures:

- "Installation Procedure" on page 69
- "Installing the Equipment Front End Module" on page 71
- "Installing the Load Port Modules" on page 72
- "Installing the Vacuum Back End" on page 72
- "Mounting the Process Modules" on page 75
- "Removing Shipping Brackets" on page 76
- "Intermodule Connections" on page 78
- "Facilities Connections" on page 78
- "Installation Procedure" on page 69

 WARNING	
Tip Hazard	
Moving this product without a hoist could cause a tip hazard which may cause death or serious injury. • Do not attempt to move the Product without the use of a fork lift or a hoist. • Roll on smooth floors only.	

 CAUTION	
Personal Protective Equipment	
This product contains heavy objects that may cause personal injury. • Use safety shoes and head protection when installing or maintaining the product. • Wear protective eyewear when setting up or testing the system.	

Tools and Materials

The following tools and materials are required during the installation of the M2 system.

- Metric Hex wrenches
- Standard Hex wrenches
- 15/16 inch open end wrench
- Scale (ruler)
- I-beam level
- Small beam level
- Bubble level
- Torque wrench
- Electronic Wafer Level (MicroTool or equivalent)
- Adjustable wrench capable of 1 1/4 inch maximum

Remove Protective Packaging

The modules of the M2 system are shipped with their internal components (robot, aligner, etc.) covered in protective packaging. This packaging must be removed before installation can be started.

Equipment Front End Module

Step	Action
1.	Remove any bags or other protective wrapping from robot arm assembly and aligner.
2.	Remove any bags or other protective wrapping from any installed optional equipment.
3.	Remove protective wrapping from any loose cable ends or connectors.
4.	Remove film from all windows.

Vacuum Back End Module

Remove protective wrapping from any loose cable ends or connectors.

Load Port Module(s)

Remove protective wrapping from any loose cable ends or connectors.

Installing the Equipment Front End Module

The Equipment Front End Module (EFEM) must be properly located in the facility so that AGV or OHT systems can hand-off wafer carriers to the Load Port Modules attached to it. Once located, the EFEM must be leveled, then it may then be bolted to the floor using the tie-down points provided to prevent any movement. After the EFEM module is installed the Vacuum Back End is docked to the EFEM and secured Refer to the EFEM's User Manual for detailed installation information.

Positioning the Equipment Front End Module

To ensure proper hand-off of the wafer carriers, the Load Port Modules must be attached to the front of the Equipment Front End Module to determine the proper placement of the EFEM.

Step	Action
1.	Refer to the EFEM and LPM User Manuals and mount the LPMs to the EFEM's minienvironment. NOTE: <i>The mounting provisions for the LPMs on the EFEM are leveled at the factory. No leveling adjustments are required.</i>
2.	Position the Equipment Front End Module such that the Load Port Modules are in the proper position for carrier hand-off.

Leveling the EFEM and Setting the Material Transport Plane

Adjustable feet are provided on the Equipment Front End Module minienvironments.

These feet are used to support the EFEM, to set the Wafer Transport Plane (load/unload height for the Load Port Modules is 900.0 mm (45.36 in) and the standard WTP at the rear of the EFEM is 1100.0 mm (34.31 in) or 1200.0 mm (47.24 in) depending on the configuration of the VBE), to compensate for an uneven floor, and to relieve the wheels once the EFEM is properly located.

NOTICE

Do not raise the non-supporting feet more than 1 mm from the floor to ensure that the system is not allowed to "twist" as this could damage any components connected to the system and could cause a potentially unsafe operating environment.

Refer to the EFEM User Manual for all EFEM adjustments.

Mounting Floor Ties/Seismic Brackets

Floor tie-down points are provided to secure the Equipment Front End Module to the floor. The tie-down points provide seismic anchoring per SEMI S2 to eliminate movement and for earthquake protection. User supplied tie-down brackets may be used when seismic anchoring is not required, but bolting to the floor is desired. Refer to the EFEM's User Manual for the appropriate procedure for securing the EFEM to the floor.

Installing the Load Port Modules

The LPMs must be connected for proper operation once the Equipment Front End Module is properly located and secured within the facility. The Load Port Modules are kinematically mounted and should require no adjustment. Refer to the EFEM User Manual and the appropriate Load Port Module User Manual for detailed information.

NOTE: The mounting provisions for the LPMs on the EFEM are leveled at the factory. No leveling adjustments are required.

Installing the Vacuum Back End

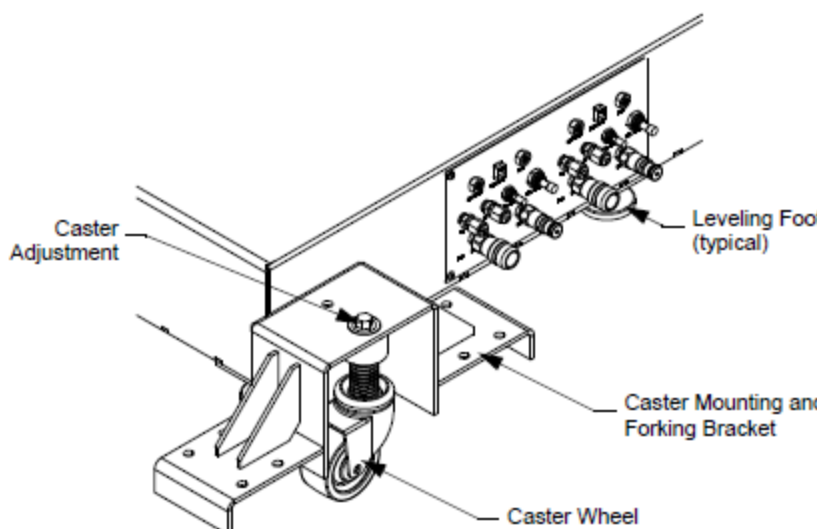
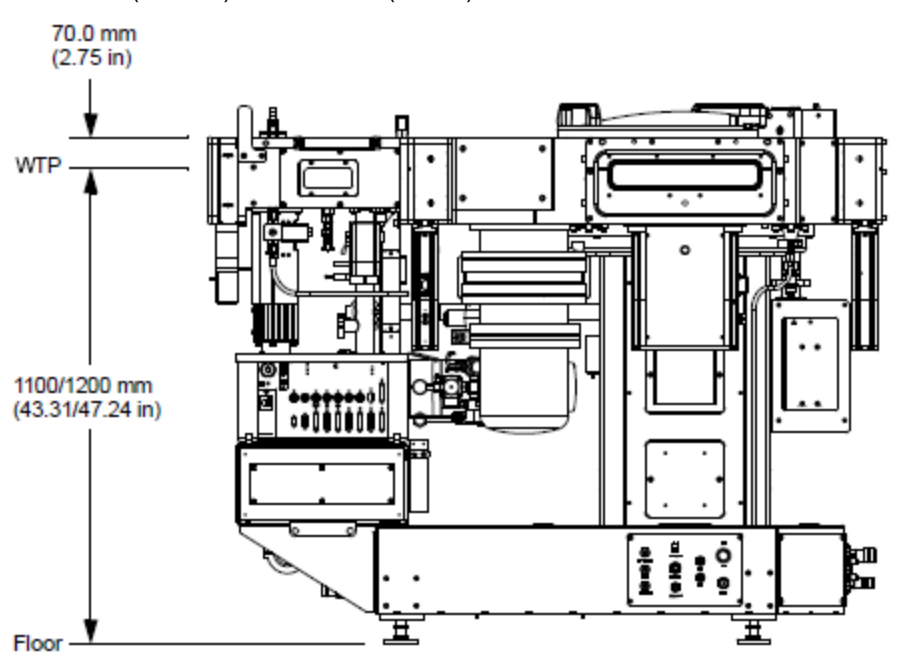
The Vacuum Back End must be set to the Material Transport Plane, leveled, and mated to the Equipment Front End Module. Once mated, the VBE may be bolted to the floor using the tie-down positions located on the VBE frame.

Leveling the Vacuum Back End and Setting the Wafer Transport Plane

Adjustable feet are provided on the frame of the Vacuum Back End. These feet are used to support the Transport Chamber, to set the Wafer Transport Plane, and to compensate for an uneven floor. This procedure assumes that the Process Module's conform to SEMI/MESC cluster tool specifications, and in particular that the station access port mating pins are located at the SEMI/MESC height.

NOTICE

Do not raise the non-supporting feet more than 1 mm from the floor to ensure that the system is not allowed to "twist" as this could damage any components connected to the system and could cause a potentially unsafe operating environment.

Step	Action
1.	Lower the leveling feet until the feet are fully supporting the module's weight. 
2.	Raise the wheels and remove the Caster Mounting Brackets and retain them for future use. NOTE: Turning the casters requires up to 70 ft-lbs of torque. Do not turn more than 1 to 2 turns at a time and then move to the next caster. Do not raise the caster all the way up at one time.
3.	The Wafer Transport Plane (WTP) can be established at either 1100 mm or 1200 mm depending on the system configuration by setting the distance from the top of the chamber to the floor at either 1170.0 mm (46.06 in) or 1270.0 mm (50.0 in). 
4.	Level the Vacuum Back End using a MicroTool Electronic Level placed on the inside surface of the chamber by adjusting each foot as necessary.

Mating the Vacuum Back End to the Equipment Front End Module

To ensure proper hand-off of material through the Load Locks the Vacuum Back End must be aligned to the Equipment Front End Module.

NOTICE

When pushing the M2 system on its casters, place hands on the dummy process modules or on the process module blank-offs. Gauges and sensors are located in other areas of the M2 system and could be damaged.

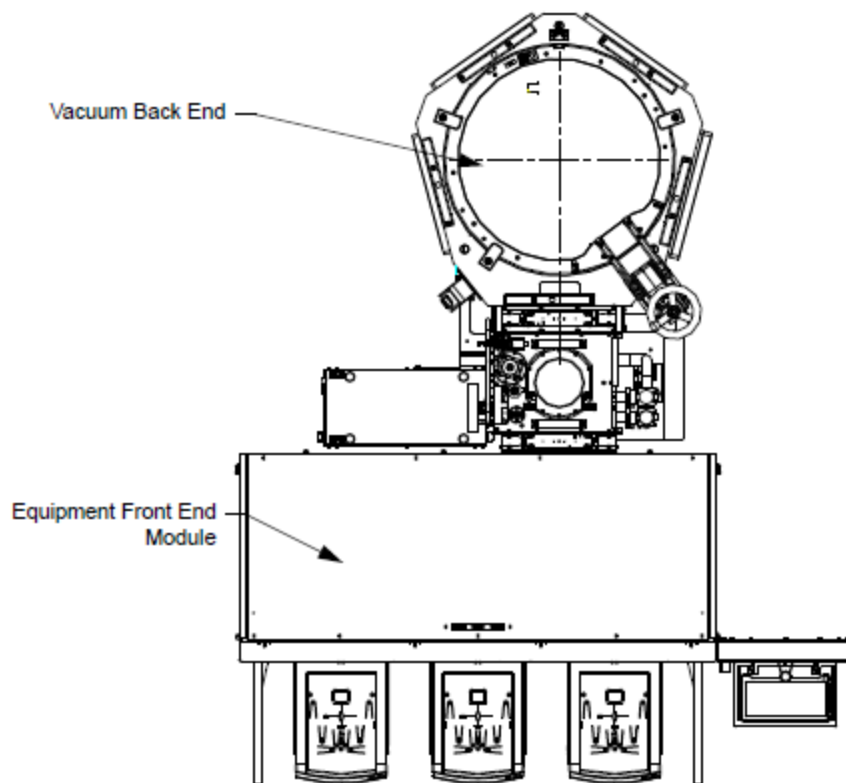


Figure 4-1: Mating the Equipment Front End Module and the Vacuum Back End

Step	Action
1.	Ensure the Equipment Front End Module is properly located and leveled.
2.	Position the Vacuum Back End such that the Load Locks align with the openings on the back of the Equipment Front End Module.

Installing Seismic or Tie-down Brackets

Seismic brackets may be installed to secure the Vacuum Back End to the floor to eliminate movement and for earthquake protection. The caster brackets must be removed from the system and the system secured with angle brackets (not supplied) using the tapped holes in the side of the frame as shown in [Figure 4-2](#).

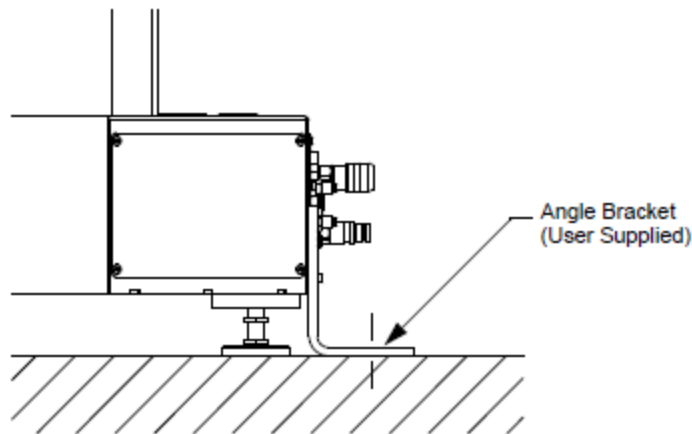


Figure 4-2: Seismic and Tie-down Bracket Mounting

Step	Action
1.	Remove the bolts with lock and flat washers securing the Jacking Caster Brackets to the lower beam of the frame.
2.	Locate the Seismic Brackets at the points the casters were attached to the frame as shown in Figure 4-2 .
3.	Position the brackets so that the seismic mounting holes are against the floor.
4.	Replace the four bolts and washers to secure the bracket to the frame.
5.	Install one M12 or equivalent size bolt (not supplied) through the bracket and into the floor. NOTE: Save the casters and brackets for future use in moving the M2 system.

Mounting the Process Modules

Any components that will be mounted to the Vacuum Back End are assumed to conform with the customer process module interface.

NOTE: It may be convenient to mount these components after initial installation and testing.

Step	Action
1.	Remove the blank-offs from the vacuum facets of the VBE Transport Chamber.
2.	Adjust the Process Module so that its Material Transport Plane is at the same height as the M2 systems MTP (refer to the Process Module User Manual). Ensure that the Process Module remains level while making any adjustments to the height.
3.	Mate the Process Module to the facet of the Vacuum Back End by inserting the pins on the Process Module into the holes on the FAP. NOTE: <i>It may be necessary to re-adjust the height of the module(s) to align them to the Transport Chamber. If a height re-adjustment is required, take care to ensure that the module remains level.</i>
4.	Once the Process Module is mated, bolt the flanges of the Process Module and the Vacuum Back End together using M10 bolts (not provided).

Removing Shipping Brackets

The modules of the M2 system are shipped with shipping brackets attached to them, which protect their moving parts and provide ease of movement of the modules.

These shipping brackets are red in color to easily distinguish them. All shipping brackets must be removed before the M2 system may be used.

NOTE: Save the shipping brackets for possible future use. If any of the modules of the M2 system are returned to Brooks for service or shipped to another location, the original shipping brackets must be used. Refer to [Appendix G: "Packing and Shipping Instructions"](#) on page 204.

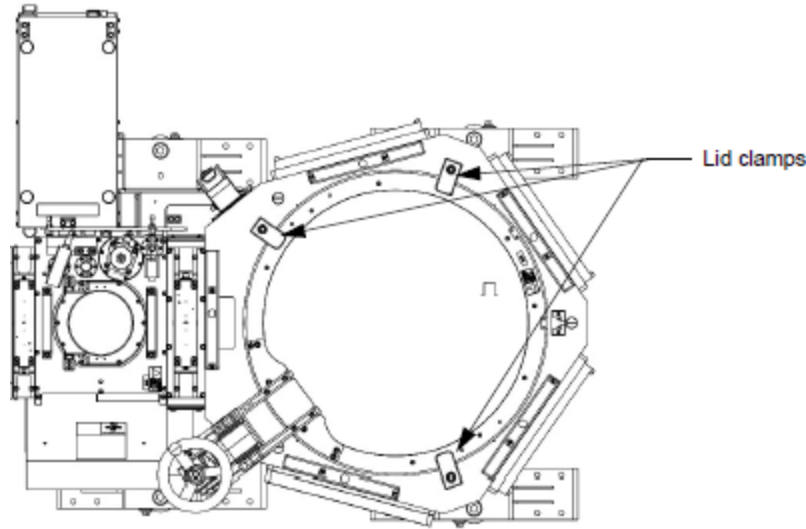
Equipment Front End Module

The robot arm is secured in place for protection during shipment. Refer to the EFEM User Manual for detailed information.

Shipping brackets are used to secure the robot arm to the robot flange. The type of brackets will vary based on the type of arm installed on the robot. Remove the brackets and save for future use. If the EFEM is shipped, the brackets must be replaced before shipping.

Vacuum Back End

The robot arm is secured in place within the Vacuum Back End's Transport Chamber for protection during shipment. These shipping brackets must be removed before attempting to operate the robot. The chamber is shipped under vacuum and the vacuum must be purged before lifting the lid.

Step	Action
1.	Manually open the slow vent valve, then the fast vent valve to purge the system.
2.	Loosen the lid clamps, but do not remove them. Turn them to the side to access the vacuum chamber lid. The lid clamps remain on the chamber to add additional security to the vacuum chamber.  The diagram shows a side view of the Vacuum Back End module. A large circular lid is visible. Several clamps are attached to the lid's perimeter. Arrows point to these clamps, and a label 'Lid clamps' is placed next to them. The clamps are shown in a position where they are being loosened or turned to the side.
3.	Raise the lid from the top of the vacuum chamber (refer to "Lid Lifter/Hinge" on page 136).
4.	Unscrew the arm shipping fixtures. Remove the fixtures and save for future use. If the Vacuum Back End module is shipped, the fixtures must be replaced before shipping.
5.	The end effectors were removed for shipping and must be re-installed (refer to the robot's User Manual).
6.	Lower the lid.
7.	Turn the lid clamps on the chamber and tighten the lid clamps.

Load Port Module(s)

The door opening paddle of the Load Port Module(s) is secured in place for protection during shipment. These shipping brackets must be removed before attempting to operate the LPMs. Refer to the appropriate Load Port Module User Manual for detailed information.

Step	Action
1.	Remove the brackets securing the paddle to the frame and save for future use.
2.	Refer to each LPM User Manual for instructions on the LPM installation and the removal of shipping brackets.
3.	If the Load Port module is shipped, the brackets must be replaced before shipping.

Intermodule Connections

The standard configuration of the M2 system requires several connections be made between the Equipment Front End Module and Vacuum Back End modules once they are physically connected together. The M2 system is shipped from the factory with all EFEM and VBE internal connections already made.

Wiring Diagrams are supplied with the System Manual. Refer to these diagrams while installing the system to verify correct connections. The configuration of the M2 system will determine which components may be included with the system. Use the following instructions as a reference for step order only. Some connections may have been installed at the factory. In this case, only verification of the connection is required.

Facilities Connections

The standard configuration of the M2 system requires compressed air, nitrogen (vent gas), vacuum, exhaust, electrical power, communications connections, and optionally cooling water, and cooling water return. Refer to the ["Facilities Specifications" on page 58](#) for detailed descriptions of the required user-supplied facilities and ["Mechanical Specifications" on page 46](#) for fitting specifications.

All facility lines connect to the M2 system via the facilities interfaces located under the chamber. All the connectors on the facilities interface panels are labeled for easy identification. Refer to the electrical and mechanical drawings supplied with the System Manual for more information.

The following procedures provide the information required to make all facilities connections to the M2 system. Connections to the Equipment Front End Module are shown in [Figure 4-3](#) and [Figure 4-](#)

4. Connections to the Vacuum Back End for the M2 Compact, M2 Tandem, M2 Quad, and M2 4 - 7 VBE modules are shown respectively in [Figure 4-5](#), [Figure 4-6](#), [Figure 4-7](#) and [Figure 4-8](#). Refer to "Operation" on page 110 for wiring pinouts.

 WARNING Lockout / Tagout	
Working with energized equipment may cause sudden movement or electrical shock and may result in death or serious injury. • All energy must be removed from the equipment per the facility's Lockout/Tagout procedure before servicing. • If local procedures are not available, follow the procedure for Lockout/Tagout in OSHA Standard 29CFR 1910.147.	 

 CAUTION Personal Protective Equipment	
This product contains heavy objects that may cause personal injury. • Use safety shoes and head protection when installing or maintaining the product. • Wear protective eyewear when setting up or testing the system.	

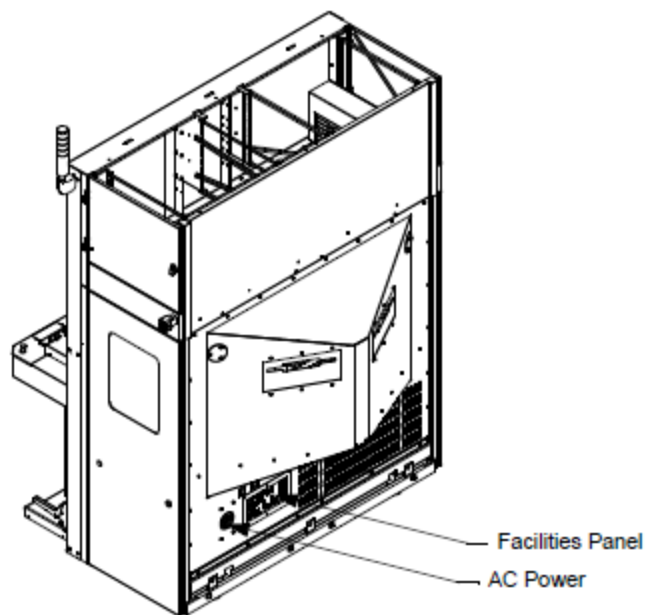


Figure 4-3: Typical Facilities Connections - Equipment Front End Module

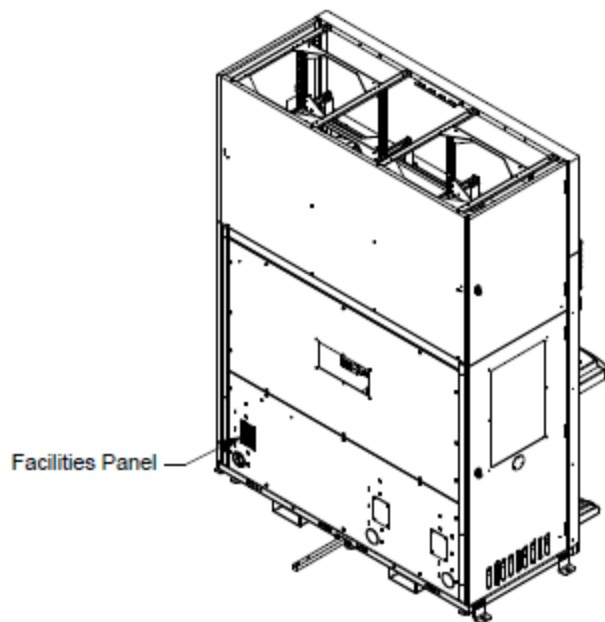


Figure 4-4: Typical Facilities Connections - Equipment Front End Module

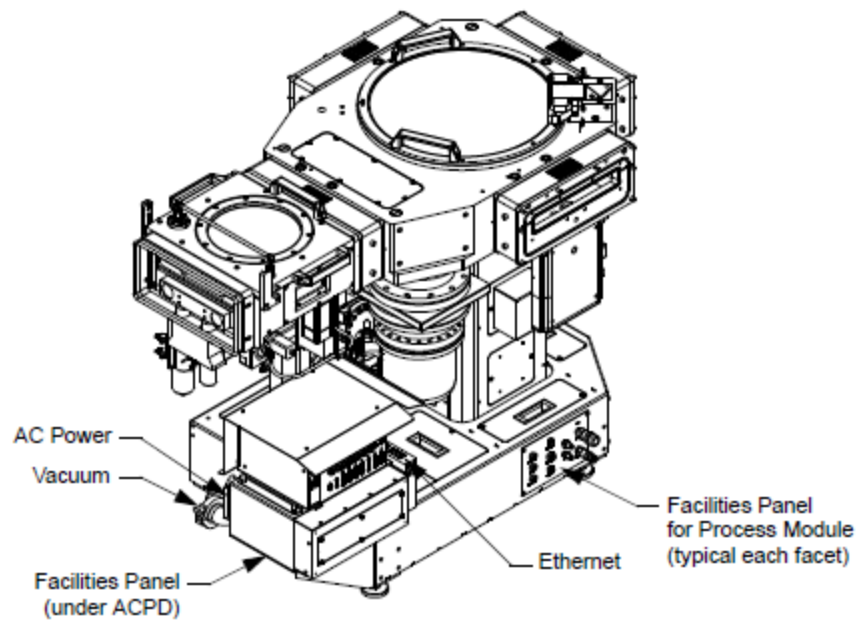


Figure 4-5: Typical Facilities Connections - M2 Compact, M2 C4, C5, C6 Vacuum Back End

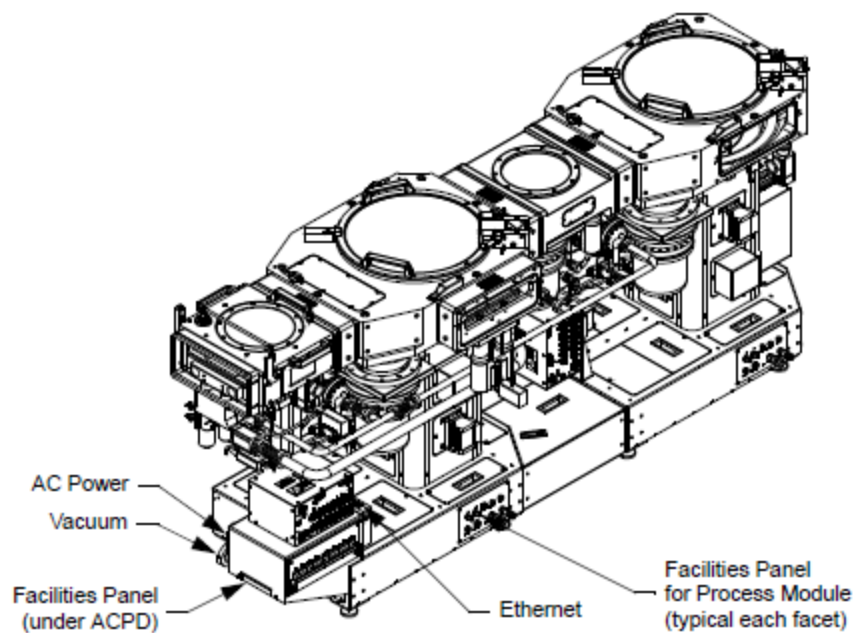


Figure 4-6: Typical Facilities Connections - M2 Tandem Vacuum Back End

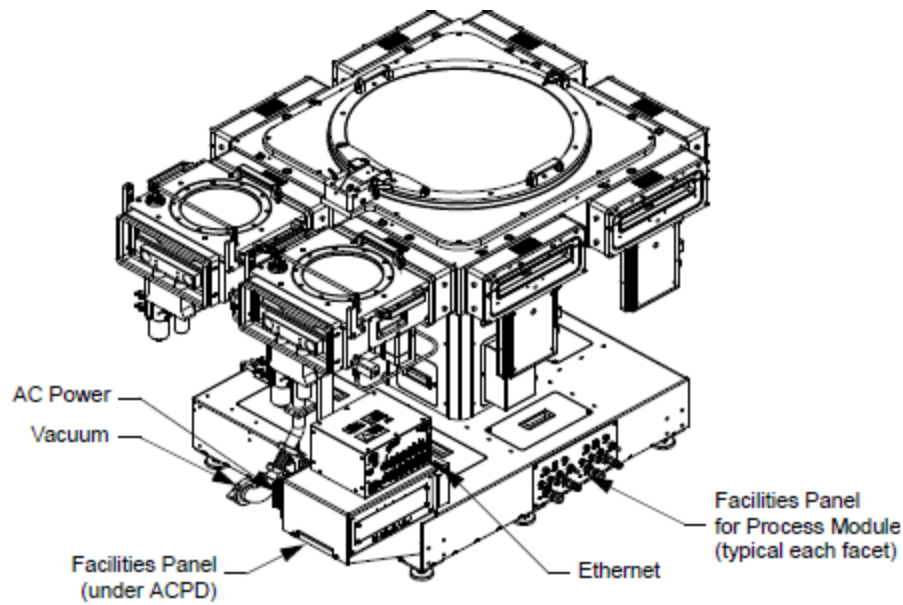


Figure 4-7: Typical Facilities Connections - M2 Quad Vacuum Back End

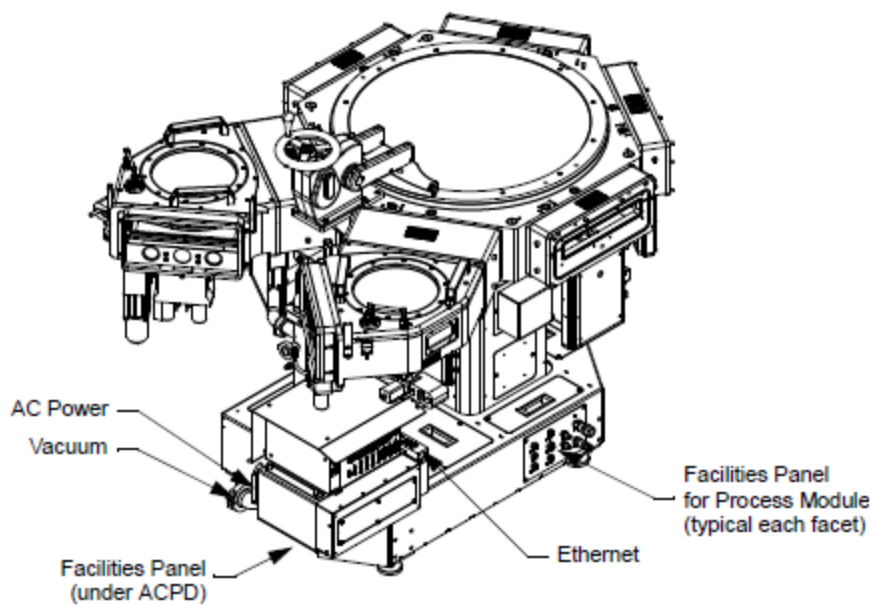


Figure 4-8: Typical Facilities Connections - M2 4, 5, 6, and 7 Vacuum Back End

Facilities Panels

The Equipment Front End Module is supplied with facilities connections, including power, and interface panels located as shown in [Figure 4-3](#) and [Figure 4-4](#). The standard configurations for both the Series 8 EFEM and the Jet ATS EFEM modules are shown respectively. The standard configurations for the Facilities Panels referenced in the figures are shown in [Figure 4-9](#).

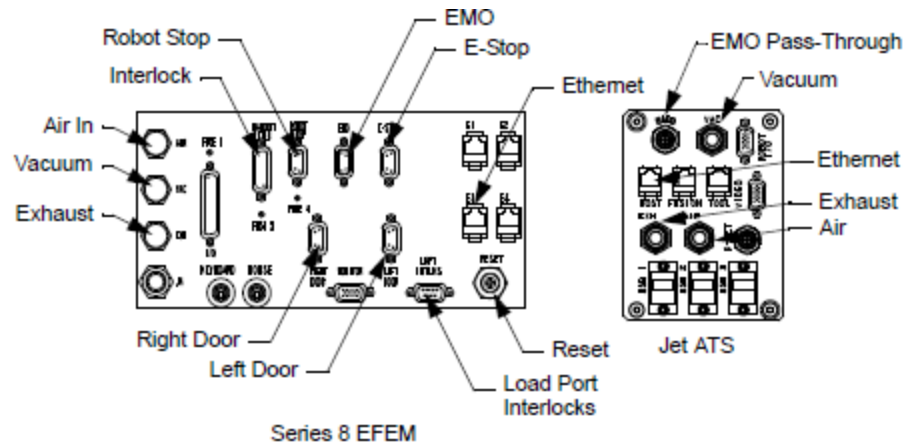


Figure 4-9: Typical Facilities Panel - Equipment Front End Module

The Vacuum Back End is supplied with facilities connections, including power and vacuum, located as shown in [Figure 4-5](#), [Figure 4-6](#), [Figure 4-7](#), and [Figure 4-8](#). The standard configurations for the Facilities Panel referenced in the figures is shown in [Figure 4-10](#).

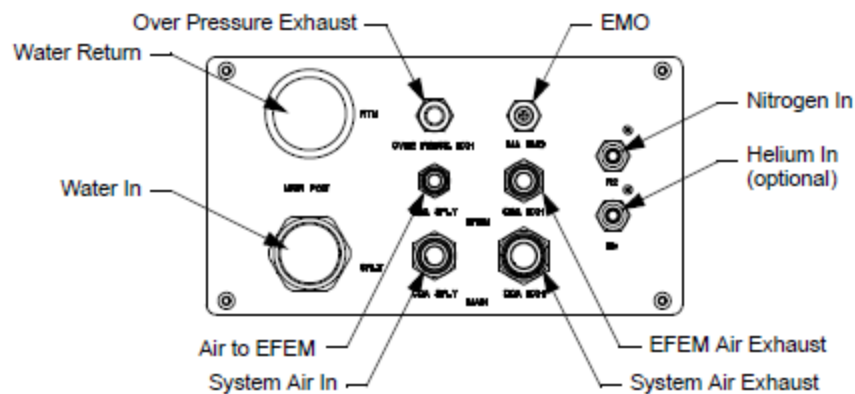


Figure 4-10: Typical Facilities Panel - Vacuum Back End

Electrical

Electrical power is connected to the M2 system for operation of the robots, sensors, and other subsystems. An AC electrical connection is provided on the ACPD mounted on the Vacuum back

End for facility power. Refer to the "[Facilities Specifications](#)" on page 58 for electrical requirements. Ensure that the electrical connection is for the appropriate voltage.

NOTICE

Do not turn on the electrical supply from the facility until all connections to the M2 system and all installation procedures have been completed.

EMO Circuit

The EMO button supplied with the M2 system is provided to allow the user to configure a single EMO button that removes power from all material handling and processing components in the M2 system and the Process Modules. A pass-through connection to the user's EMO circuit is provided at the Equipment Front End Module's Facilities Panel through an M-12 male connector, which connects to the EMO Junction Block is provided on the Vacuum Back End. The VBE EMO Junction Block provides a central connection point for all EMO switches in the tool including any switches provided on the Process Modules.

NOTE: If this circuit is used, the action caused by pressing the EMO button is determined by the user.

Nitrogen

Nitrogen is used in the M2 system as the vent gas to ensure that venting does not contaminate the chamber. A 1/4 in VCR connection is provided on the Vacuum Back End. Refer to the "[Facilities Specifications](#)" on page 58 for nitrogen gas requirements. Ensure that the nitrogen connection is for the appropriate pressure.

NOTICE

Do not turn on the nitrogen supply until all connections to the M2 system and all installation procedures have been completed.

Step	Action
1.	Run a 1/4 in. O.D. Nitrogen supply line to the N2 connection on the VBE Facilities Panel as shown in Figure 4-10 .

Step	Action
2.	Connect the nitrogen line from the facility to the nitrogen connection on the Vacuum Back End.

Process Gases

Process gas connections may be provided on the M2 system for the user's convenience. All connections to the process gas lines must be made as specified by the user.

NOTICE

Do not turn on the process gas supply until all connections to the M2 system and all installation procedures have been completed.

Pneumatic

Air is used in the M2 system for operation of the Load Port Modules, Slot Valves, Atmospheric Doors, and other devices. A 10 mm connection is provided on the Vacuum Back End. Refer to the ["Facilities Specifications" on page 58](#) for the pneumatic requirements. Ensure that the pneumatic connection is for the appropriate pressure.

NOTICE

Do not turn on the pneumatic supply until all connections to the M2 system and all installation procedures have been completed.

Step	Action
1.	Connect the compressed air line from the facility to the 10 mm quick connect CDA SPLY connection on the VBE Facilities Panel as shown in Figure 4-10 .

Exhaust

A line to receive exhaust from operation of the M2 system is connected to the Vacuum Back End. One 10 mm quick connect exhaust port is provided on the Vacuum Back End's Pneumatic Facilities Panel. Refer to the ["Facilities Specifications" on page 58](#) for exhaust requirements.

Step	Action
1.	Connect the line for clean exhaust from the facility to the 1/2 inch Swagelok quick connect CDA EXH connection on the VBE Facilities Panel as shown in Figure 4-10 .
2.	Connect the line for scrubbed exhaust from the facility to the OVER PRESS. EXH connection on the VBE Facilities Panel as shown in Figure 4-10 .
3.	Connect the exhaust from any vacuum roughing pumps supplied with the system to the facility's gas exhaust system.

Vacuum

An appropriate user supplied vacuum system must be connected to the M2 system for evacuating the Transport Chamber in the Vacuum Back End. Ensure the vacuum system is capable of providing the desired pump down times for the vacuum chamber. Refer to the "[Facilities Specifications](#)" on [page 58](#) for vacuum requirements.

Depending upon the configuration of the M2 system, differential vacuum may need to be supplied to various modules including the robot, aligner, and Load Port Modules in the Equipment Front End Module for proper operation of these units.

NOTICE

Do not turn on the vacuum connection until all connections to the M2 system and all installation procedures have been completed.

Step	Action
1.	Connect the facilities' rough vacuum line to the Rough Manifold on the VBE as shown in Figure 4-5 , Figure 4-6 , Figure 4-7 and Figure 4-8 .
2.	If required, connect the vacuum line from the facility to the 6 mm quick connect VAC connection on the EFEM's Facilities Interface Panel.

Water

Depending upon the configuration of the M2 system, water may need to be supplied for cooling of components attached to the Transport Chamber, such as turbo pumps, or for the cooling of material in the Load Lock. Refer to the "[Facilities Specifications](#)" on [page 58](#) for water supply and return requirements. Ensure that the water connection is for the appropriate pressure and temperature and is maintained to avoid corrosion.

NOTICE

Do not turn on the water connection until all connections to the M2 system and all installation procedures have been completed.

Step	Action
1.	Run an appropriate size Teflon line from the facility water supply to the SUPPLY connection on the VBE Facilities Panel as shown in Figure 4-10 .
2.	If required, connect the vacuum line from the facility to the 6 mm quick connect VAC connection on the EFEM's Facilities Interface Panel.

Water Return

Step	Action
1.	Run an appropriate size Teflon line from the facility water return to the RETURN connection on the VBE Facilities Panel as shown in Figure 4-10 .

Communication Connections

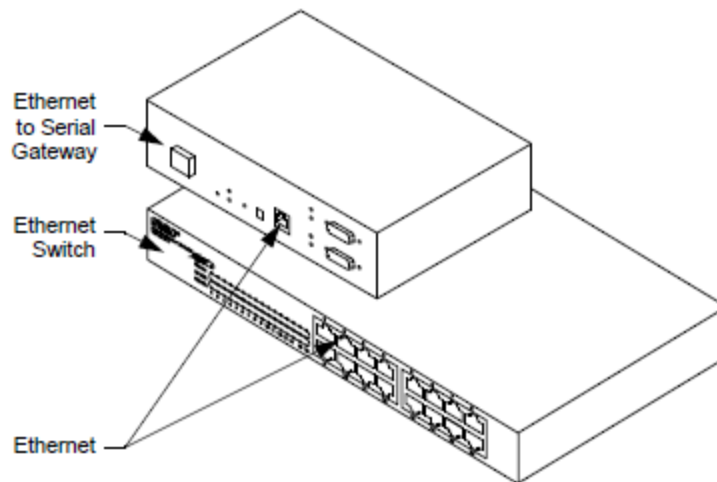
The modules within the M2 system use Ethernet, DeviceNet, and RS-242 for communications.

NOTICE

Never connect or disconnect the communications lines with power applied to the M2 system as damage to internal components or unexpected motion may result.

Ethernet

The standard configuration of the M2 system supports Ethernet communication between the host controller and the M2 system. Make the Ethernet communications connection to the M2 system as shown in [Figure 4-11](#).

**Figure 4-11: Typical Ethernet Communications Connection**

Step	Action
1.	Connect the Ethernet cable for communications from the host controller to any Ethernet port on the Ethernet Switch (refer to the Block Diagram supplied with this manual) on the VBE as shown in Figure 4-5 , Figure 4-6 , Figure 4-7 and Figure 4-8 .

DeviceNet

The standard configuration of the M2 system uses DeviceNet communication in the VBE. Refer the controls manual for more information.

Software Installation

The M2 system requires no software installation in any of its modules.

Upgrades to the software can be downloaded through the Ethernet connection. Refer to the Upgrade Procedure in the Release Notes supplied with any upgrades.

NOTE: Alterations or changes to the software should only be made by qualified Brooks Automation personnel.

Power-up Sequence

The following procedure describes the steps to safely apply power to the M2 system and verify that it is ready for operation.

 WARNING Automatic Movement / Crush Hazard	
If any interlocks are disabled the possibility exists of automatic movement of systems within the M2 system. The following systems have the possibility of automatic movement: - Atmospheric Robot - Atmospheric Aligner - Load Port Modules - Optional Wafer Inverter - Vacuum Robot Vacuum - Load Lock Z-lift - Atmospheric Doors - Vacuum Slot Valves - Isolation Valves - Pumps Moving mechanisms have no obstruction sensors and can cause serious personal injury or death. Do not operate the M2 system without the protective covers in place.	

Step	Action
1.	Check to ensure that all of the installation procedures previously described in this chapter have been completed.

Step	Action
2.	Operational Safety and Interlock Checks: - Ensure that the Equipment Front End Module minienvironment doors are closed and secured. - Ensure that the Vacuum Back End vacuum chamber and load lock lids are closed and secured.
3.	Mechanical Checks: - Verify all shipping brackets have been removed. - Ensure that the Equipment Front End Module is properly and securely installed in the facility. - Ensure that the Load Port modules are properly and securely mounted to the Equipment Front End Module. - Ensure that the Vacuum Back End has been properly secured within the facility. - Ensure that the Vacuum Back End is properly and securely mounted to the Equipment Front End Module. - Ensure that the OEM Process Module(s) are properly and securely mounted to the Vacuum Back End. - Ensure that all hardware is secure. - Ensure that the EMO button supplied on the Equipment Front End Module is functional and remove the Warning label from the EMO button.
4.	Facility Checks: - Ensure that all facilities are capable of meeting, or exceeding, the requirements as described in the "Facilities Specifications" on page 58. - Ensure that the power, communications, air, exhaust, nitrogen, vacuum, water, and any other connections have been completed. - Check all cables. Verify the connectors are fully seated and screws/locks are secured to ensure good continuity. - Verify all internal cables are routed in a safe place and away from any internal movement. - Verify all external cables are routed in a safe place and away from any travel areas. - Inspect all cables and tubing for restricting bend radii or excessive tension.
5.	Pre-operation Checks: Ensure that there are no obstructions in the travel path of the robots and their end effectors within the Equipment Front End Module and the Vacuum Back End. NOTE: Some of the internal components of the M2 system may present travel obstructions to the robot end effectors in certain cases. It is the user's responsibility to control the robots such that the robots, and any material in transport, do not come into contact with these components.
6.	Verify the AC power connection from the M2 system to the plant's electrical services. NOTE: High Voltage 200 - 240 VAC at 50 A. The AC circuit must be properly protected.
7.	Verify the AC power connection from the ACPD in the Vacuum Back End to the Equipment Front End Module. NOTE: High Voltage - 240 VAC at 15 A. The AC circuit must be properly protected.
8.	Turn on vacuum, air, nitrogen, and water supply if used.

Step	Action																
9.	Turn on the circuit breakers on the ACPD in the Vacuum Back End. The following sounds and indicators should be observed: - Audible sounds: fans in robot drive - The indicators listed in individual manuals will be lit as shown: <table><tr><th>Component</th><th>Indicator</th><th>Status</th></tr><tr><td>Vacuum Robot</td><td>Power</td><td>Green</td></tr><tr><td>Air Pressure Sensor</td><td>Pressure Sensor Status LED</td><td>Green</td></tr><tr><td>Nitrogen Pressure Sensor</td><td>Pressure Sensor Status LED</td><td>Green</td></tr></table>	Component	Indicator	Status	Vacuum Robot	Power	Green	Air Pressure Sensor	Pressure Sensor Status LED	Green	Nitrogen Pressure Sensor	Pressure Sensor Status LED	Green				
Component	Indicator	Status															
Vacuum Robot	Power	Green															
Air Pressure Sensor	Pressure Sensor Status LED	Green															
Nitrogen Pressure Sensor	Pressure Sensor Status LED	Green															
10.	Turn on the circuit breakers on the ACPD in the Equipment Front End Module. - Audible sounds: fans in robot drive, power supply, and Fan/Filter Unit - The indicators listed in individual manuals will be lit as shown: <table><tr><th>Component</th><th>Indicator</th><th>Status</th></tr><tr><td rowspan="3">Controller</td><td>POWER</td><td>Green</td></tr><tr><td>MOTORS</td><td>Green</td></tr><tr><td>24V</td><td>Green</td></tr><tr><td>Aligners</td><td>POWER</td><td>Green</td></tr><tr><td>Load Port Modules</td><td>Lights lit determined by user</td><td></td></tr></table>	Component	Indicator	Status	Controller	POWER	Green	MOTORS	Green	24V	Green	Aligners	POWER	Green	Load Port Modules	Lights lit determined by user	
Component	Indicator	Status															
Controller	POWER	Green															
	MOTORS	Green															
	24V	Green															
Aligners	POWER	Green															
Load Port Modules	Lights lit determined by user																
11.	Perform a Ground Continuity check from the surfaces of the Equipment Front End Module and the Vacuum Back End to a known good ground.																
12.	If a Reset switch is installed, engage it twice.																
13.	Verify proper operation of all interlocks.																
14.	If the initialization sequence executes without error, then the Brooks Automation M2 system has been properly installed, all the components are communicating successfully, and the system is ready for alignment. If start-up was successful, the M2 system is ready to accept commands. If, however, the start-up sequence was unsuccessful, refer to "Troubleshooting and Repair" on page 183. NOTE: The host controller initiates all motion control in the M2 system. It is the user's responsibility to initiate a safe start-up of the M2 system. NOTE: Do not attempt to operate the M2 system until all setup procedures described in this chapter have been completed.																

Step	Action
15.	Return M2 system to operation or teach the M2 system as required.

The Brooks Automation M2 system must be aligned with the system that it will be operating in to prevent misplacement of the material being moved through the system or collision of the robot with other parts of the system. Note that even a small misalignment can interfere with proper M2 system operation and may cause material breakage or M2 system damage.

The user must perform a complete alignment as part of installing the M2 system in a larger system. Refer to ["Alignment and Teaching" on page 93](#) for the alignment procedures.

NOTICE

Do not attempt to operate the M2 system until it has been properly aligned. The alignment procedure in this manual must be completed prior to commanding motion.

5. Alignment and Teaching

This chapter provides complete adjustment and calibration directions for the Brooks Automation M2 system and its integrated components.

 CAUTION Unauthorized Service	
Personal injury or damage to equipment may result if this product is operated or serviced by unauthorized personnel. • Only qualified personnel are allowed to transport, assemble, operate, or maintain the Product. • Properly qualified personnel are those who have received certified training and have the proper qualifications for their jobs.	

The components within the Brooks Automation M2 system must be aligned to each other to prevent misplacement of material or collision of the robot in the Equipment Front End Module or Vacuum Back End with other parts of the system. Note that even a small misalignment can interfere with proper system operation. The components of the system were aligned at the factory prior to shipment.

Typical system alignment starts with leveling the Equipment Front End Module (EFEM) and then aligning the Vacuum Back End to the EFEM. Once the VBE is aligned to the EFEM the Process Modules are then aligned to the M2 system.

The user must perform the following alignment procedure as part of installing the M2 system in a system, during routine maintenance, or whenever the robot end effector or one of the system modules requires replacement. Brooks Automation recommends an alignment check under the following circumstances:

- A complete alignment when the M2 system is first setup at the user's site.
- A complete check when any of the controllers or any of the material handling modules (aligner, load port, robot, robots' end effectors, etc.) are replaced.
- A complete check if the M2 system was involved in a material transfer error.
- A complete check if the M2 system was involved when an Emergency Off (EMO) occurred.
- A partial check at the appropriate station(s) whenever any component, such as a Load Lock or a Process Module, is replaced.
- A complete check of the robot if it was involved in a collision.

Before attempting to align the M2 system, be familiar with the subsystems attached to the system.

- Be prepared to use each robots' hand-held Teach Pendant (refer to the robots' User Manual).
- Understand the operation of the Equipment Front End Module (refer to the EFEM's User Manual).
- Understand the operation of the Load Port Modules (refer to the LPMs' User Manual).
- Understand the operation of the Load Lock Modules or other devices the system is interfacing with for material transfer.
- Read through the entire alignment procedure before beginning.
- Record the Station coordinates for each robot in the appropriate worksheet provided in [Appendix C: "Station Identification" on page 195](#).

NOTE: Even a small misalignment can interfere with proper system operation and cause unnecessary downtime. Follow all steps to ensure precise alignment.

Required Tools and Test Equipment

Performing the alignment procedure requires the following tools and materials:

- The parameter sheet for all robot stations from the System Acceptance Test (ATP) shipped with the system
- A computer running a terminal emulator or a dumb terminal with an RS-232 Serial or Ethernet communications connection
- The Teach Pendant (Control/Display Module (CDM)) for each robot
- A set of hex key wrenches in inch sizes
- A set of hex key wrenches in metric sizes
- A 150 mm (6 in) steel ruler graduated in hundredths
- 15/16" open end or socket wrench
- Small screwdriver
- A wafer carrier of the type used in normal processing
- MicroTool Dummy Wafers or test material of the type and size for which the system is being set up
- MicroTool Electronic Wafer Level (or bubble level with an accuracy of 0.10mm/m)
- Dial indicator and fixture (Brooks P/N JC-1262 or equivalent). See [Appendix F: "Tooling and Fixtures" on page 203](#).
- All teach fixtures
- The User Manuals for any devices the M2 system will interface with
- The User Manuals for all components within the Vacuum Back End
- The User Manuals for the EFEM and all components within the Equipment Front End Module

Alignment Strategy

The alignment procedure is performed to ensure mechanical integrity between the motion of the robot and the stations being served. The M2 system is an Atmospheric to Vacuum Equipment Front End System for Process Modules. To properly align the M2 system it must be attached to the Process Modules it will be used with. The alignment consists of adjusting and aligning mechanical components of the system to ensure proper operation and to prevent any accidental contact or interference between moving and static elements of the system during material transfer operations.

The mechanical alignment phase includes robot end effector adjustment, system component adjustment, and programming actual station values (R, T, and Z) into the robot. These procedures are generally performed using fixtures (available from Brooks) and measuring instruments (e.g., scales, dial indicators, etc.). Another very useful tool is the robots' Teach Pendant, which provides very precise local control of the robot.

The alignment is performed to ensure proper equipment operation and precise material transport within the user's system. The Teach Pendants or a computer running a Terminal Emulator, and the command set described in the WAVE II User Manual and the Fusion Controls User Manuals will be used during the performance of the Alignment Procedure.

NOTICE

A thorough alignment protects against equipment damage and misaligned or sliding material.

It is crucial that the alignment is performed in the given sequence for maximum operating performance of the M2 system. Brooks recommends reading the entire Alignment procedure prior to performing it.

The following elements will be addressed in the Alignment Procedure:

- a. Verify that all components are properly installed and leveled.
- b. Adjust station locations as required.
- c. Final system check-out.

NOTICE

Safety interlocks may be overridden while using the M2 system's Teach Pendants. The user is responsible for any damage to the M2 system or their system as a result of using the Teach Pendants incorrectly.

The vacuum robot within the Vacuum Back End does not have leveling adjustments. The robot is mounted directly to the chamber of the VBE. Adjustment of the Vacuum Back End is part of the alignment of the M2 system during installation. Adjustment of the EFEM is part of the alignment of the M2 system during installation. All components of the M2 system must be leveled prior to operation.

Alignment Overview

Typical system alignment starts with locating and setting the height and leveling the Equipment Front End Module then setting the height and leveling the Vacuum Back End and then docking the Vacuum Back End to the EFEM, and then docking the Process Module(s) to the M2 system VBE.

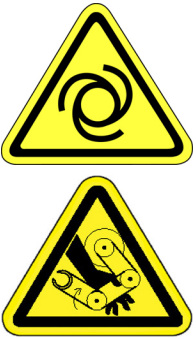
The major steps of the alignment process are detailed below. Detailed descriptions of each step are provided below in ["Alignment Process" on page 97](#).

Step	Action
1.	Ensure that the end effectors of all robots in the system are set up properly.
2.	Level the Equipment Front End Module per relevant manuals and instructions.
3.	Configure the atmospheric robot's stations (aligner, load ports, load locks, etc.) and teach the handoff positions.
4.	Level the Vacuum Back End and verify that the Material Transport Plane is set to 1100 mm (43.307 in) or 1200 mm (47.25 in) according to customer requirements.
5.	Configure the vacuum robot for operation within the Vacuum Back End.
6.	Teach the handoff positions in the Vacuum Back End for the atmospheric and vacuum robots.
7.	Level the Process Module(s) ensuring the material stage is parallel to the reference plane of the M2 system and that the Material Transport Plane is set to 1100 mm (43.307 in) or 1200 mm (47.25 in) according to customer requirements and attach to the M2 system.
8.	Test the system alignment by running a series of test material to ensure proper material transport throughout the M2 system.

Alignment Process

A complete and accurate alignment ensures that no part of the robots or of any material being transported contacts any of the system's interior surfaces and that no sliding motions occur between any material and any support surfaces. The alignment will be done using the robots' Teach Pendants and a computer running a terminal emulator with an Ethernet communications connection.

NOTE: The following procedures are provided as a reference to the alignment of a full cluster tool system. Special alignment procedures in the actual components User Manuals will take priority over the procedures supplied in this manual.

 WARNING Automatic Movement / Crush Hazard	
If any interlocks are disabled the possibility exists of automatic movement of systems within the M2 system. The following systems have the possibility of automatic movement: - Atmospheric Robot - Atmospheric Aligner - Load Port Modules - Optional Wafer Inverter - Vacuum Robot Vacuum - Load Lock Z-lift - Atmospheric Doors - Vacuum Slot Valves - Isolation Valves - Pumps Moving mechanisms have no obstruction sensors and can cause serious personal injury or death. Do not operate the M2 system without the protective covers in place.	

 WARNING Tip Hazard	
Moving this product without a hoist could cause a tip hazard which may cause death or serious injury. - Do not attempt to move the Product without the use of a fork lift or a hoist. - Roll on smooth floors only.	

It is crucial that the alignment is performed in the sequence shown in this section for maximum operating performance of the M2 system. Many of the adjustments will be made using the robots'

Teach Pendant or a computer. Prior to beginning the alignment procedure, ensure the following steps have been completed.

Step	Action
1.	Read the "Alignment Overview" on page 95 and the Alignment Procedures contained in the EFEM and Robot Manuals.
2.	Read and understand "Safety" on page 18 .
3.	Become familiar with the safety warnings and the procedures to ensure safety while performing the procedure.
4.	Become familiar with all attached subsystems, including the Teach Pendants, and the command sets to be used.
5.	Ensure the Vacuum Back End, the Equipment Front End Module, the Process Module(s), and all associated components are at room temperature.
6.	Power up and initialize the M2 system and all devices that interface with the M2 system. The system must be in the following state: • All vacuum chambers must be at atmosphere • All vacuum chamber slot valves and atmospheric doors must be open • Load Lock Z-Lifts are in the UP position
7.	Follow the alignment procedures provided in this section in the order presented. Note that this section provides a detailed overview of the alignment process, which will reference the actual procedures as required.

Locate and Level the Minienvironment

Adjustable feet are provided on the frame of the minienvironment. These feet are used to support the EFEM, to compensate for an uneven floor, and to relieve the wheels. The EFEM must be located such that the Load Port modules attached to the front are properly positioned for carrier hand-off with the facility's automated material carrier equipment. Refer to ["Installing the Equipment Front End Module" on page 71](#) for complete installation information.

NOTE: It should not be necessary to level the Equipment Front End Module unless this is a new installation.

Locate and Level the Vacuum Back End

Adjustable feet are provided on the frame of the Vacuum Back End. These feet are used to support the Vacuum Transport Chamber, to compensate for an uneven floor, and to relieve the wheels. The

Vacuum Back End must be located to ensure proper hand-off of the material with the EFEM. Refer to ["Mating the Vacuum Back End to the Equipment Front End Module" on page 74](#).

NOTE: It should not be necessary to level the M2 system unless this is a new installation.

Level the Process Modules and Dock to the Vacuum Back End

Follow the manufacturers directions for leveling the Process Modules that are connected to the M2 system. Ensure that the Material Transport Plane is set to 1100 mm (43.307 in) or 1200 mm (47.25 in) according to customer requirements. Refer to ["Mounting the Process Modules" on page 75](#).

NOTE: It should not be necessary to level the Process Modules unless it is a new module or significant changes have been made to it.

Adjust the Robot's End Effectors

The condition of all end effectors must be verified to ensure proper material handoff.

NOTE: It should not be necessary to adjust the end effectors.

Step	Action
1.	Verify that all end effectors are flat. Refer to "Verifying Flatness of Robot's End Effector" on page 179 .
2.	Verify the dip and twist of all end effectors is within specifications and make any necessary corrections or adjustments. Refer to "Adjusting the Robot's End Effector(s)" on page 180 .

Teach the Atmospheric Robot the Stations for all Atmospheric Material Transfer Points

The robot's software uses a station coordinate system for identifying specific locations within the EFEM. By identifying physical locations in this manner, it is only necessary to provide the robot with the station name instead of the complete coordinate set each time a command is issued to the robot. Multiple station names may be assigned to a single physical location.

The teaching procedures assume that the atmospheric robot has been configured with the appropriate software. The procedures then cover setting up the robot. For detailed information on teaching refer to the Equipment Front End Module User Manual.

Teach the Robot the Atmospheric Aligner Location

The aligner acts as the center point of wafer transfers through the EFEM. It is used to orient the fiducial of all wafers, and it may be used to assist in centering the wafer on the robot's end effector. To ensure proper handoff of the wafer between the robot and the aligner, the aligner station must be taught to the robot. Refer to the Equipment Front End Module User Manual for instructions on teaching the aligner station.

Teach the Robot the LPM Locations

The Load Port Modules provide the interface for wafer transfer from the facility. To ensure proper handoff of the wafer between the robot and the Load Port Modules the LPM stations must be taught to the robot. Refer to the Equipment Front End Module User Manual for instructions on teaching the LPM stations.

Teach the Robot the Load Lock Locations

The Load Locks provide the interface for material transfer to the vacuum environment. To ensure proper handoff of the material between the robot and the Load Locks, the LL stations must be taught to the atmospheric robot. Refer to the Equipment Front End Module User Manual for instructions on teaching the LL stations.

Teach the Vacuum Robot the Stations for all Vacuum Material Transfer Points

The MagnaTran robots' software uses a station coordinate system for identifying specific locations. By identifying physical locations in this manner, it is only necessary to provide the robots with the station number instead of the complete coordinate set each time a command is issued to the robot. Multiple station numbers may be assigned to a single physical location for logistical purposes.

Teach the Robot the Load Lock Locations

The Load Locks provide the interface for material transfer to the atmospheric environment. To ensure proper handoff of the material between the robot and the Load Locks, the LL stations must be taught to the vacuum robot. Refer to ["Teach the Vacuum Robots the Load Locks " on page 103](#) for instructions on teaching the LL stations.

Teach the Robot the Process Module Locations

The Process Modules attached to the Vacuum Back End provide the actual processing of the material and require precise placement of the material within them. To ensure proper handoff of the material between the vacuum robot and the Process Modules the PM stations must be taught to the robot. Refer to ["Teach the Vacuum Robot the Process Modules " on page 106](#) for instructions on teaching the PM stations.

Verify Proper Operation of the Material Presence Sensors

Once the modules of the M2 system have been properly aligned the sensors within the system must be aligned for proper operation.

Step	Action
1.	Verify proper operation of the Material Presence Sensors. Refer to "Material Presence Sensor Adjustment" on page 177 .

Verify Proper Operation of the M2 System

Once the modules of the M2 system have been properly aligned the operation of the system must be verified.

Step	Action
1.	Verify proper material transfer between all stations within the M2 system. Refer to "System Alignment Check-out" on page 108 .

Teaching Procedures

The following alignment procedures will provide the information required for standard user alignment of the Brooks Automation M2 system. For a full system alignment, follow the ["Alignment Process" on page 97](#).

System Preparation

The system must be properly prepared before starting the Alignment and Teaching Procedure to ensure the procedure can be completed in a quick and safe manner.

Procedure Category

Type 2 Procedure: Equipment is energized and all energized circuits are covered or insulated. All work is performed remotely using the CDM or service computer. Refer to ["Environmental Information" on page 45](#).

Safety

- Read, understand, and follow the safety advise in ["Safety" on page 18](#).
- During the teaching procedure, the system is at a Type 2 Electrical Hazard Category. Refer to ["Laser Hazards" on page 41](#).

- Breaking material can cause flying shards. Always wear eye protection when teaching the robot and using a test material.

Preparation

If preparing for alignment after installation, power up and initialize the M2 system as specified in ["Power-up Sequence" on page 89](#).

If preparing for an alignment after replacing a component or performing an alignment check, first ensure that the Transport Chamber, the Load Locks, and any Process Module chambers are vented.

NOTICE

Do not proceed to the next step until all vacuum chambers within the system are at atmospheric pressure. Damage to the system could result from opening unequal ized slot valves.

Step	Action
1.	Open each slot valve and each atmospheric door.
2.	Shut off the vacuum and venting subsystems and perform lockout/tagout procedures to ensure that the Slot Valves and other associated valves do not move unexpectedly.

Initiating the CDM

Verify that all installation procedures in the robot's User Manual including arm installation have been completed. Some steps may have been performed at the factory prior to shipment.

Performing a system alignment on the M2 system requires moving the robot arm and entering station coordinates or other robot parameters into the robot's memory. This is most conveniently done using the robot's hand-held Control/Display Module (CDM) supplied with the robot. Before the robot's CDM can be used, it must be connected to the robot. Follow the procedure for connecting and initiating the CDM in the robot User Manual.

Opening the Chamber Lid

If the vacuum robot has not been taught, the Transfer Chamber Lid and Load Lock Lids may be opened to allow access to the end effectors and allow visual verification of the station assignments. To open the Transfer Chamber Lid, refer to ["Using the Lid Lifter " on page 136](#).

 WARNING Potential Robot Movement	
The product has the potential for automatic motion that may cause death or serious injury. • Avoid working inside the movement path or under extended components. • Use physical barriers to prevent injury when working in the movement path.	

Teach the Vacuum Robots the Load Locks

The following procedure teaches the vacuum robot in the Vacuum Back End the Load Lock stations. Note that this procedure is for use with M2 systems running WAVE II Software. Refer to the WAVE II Software User Manual for information on determining the version of software being used.

NOTE: The stations referenced in this procedure are for a standard configuration (refer to ["Station Coordinate System" on page 114](#)). Actual station assignments may vary based on the system configuration.

Changing station assignments may cause interlocks to be ignored. Changing the station numbers requires reconfiguration of all station options.

Procedure Category

Type 2 Procedure: Equipment is energized and all energized circuits are covered or insulated. All work is performed remotely using the service computer. Refer to ["Environmental Information" on page 45](#).

Required Tools and Test Equipment

- Teach Fixture Kit
- Calipers, 150 mm (6 in)
- Control/Display Module
- The vacuum robot User Manual
- PC running a terminal emulator or a communications program such as Procomm™ or RSU™ (available from Brooks)
- MicroTool Dummy Wafer or test material of the appropriate type and size

Adjustment/Calibration Strategy

This procedure consists of several steps. Each step must be completed before proceeding to the next step. This sequence assumes the vacuum robot uses passive backside material contact.

For the procedure provided below, the following configuration is assumed:

- Load Lock B (on the right-hand side) is Station 1 for the vacuum robot
- Load Lock A (on the left-hand side) is Station 2 for the vacuum robot

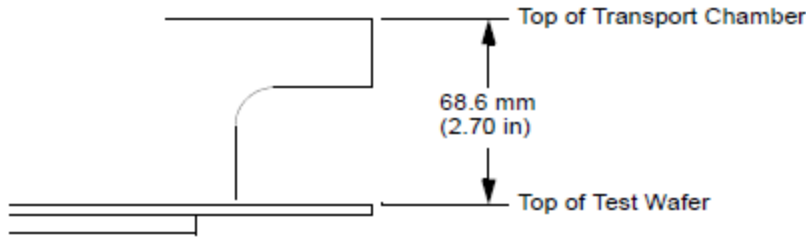
For dual and/or stacked Load Locks, check and use the station assignments according to the configuration of the Load Locks on your tool.

Teaching the Load Lock Values for the Vacuum Robot

NOTICE

All slot valves and doors must be open before teaching the robots.

Step	Action
1.	Using the robot's CDM, teach the robot the R and T values for Load Lock B. SETUP -> STATIONS -> 1 -> CR -> LEARN R, T, BTO -> HAND LOCATE - Using the CDM, move the Z axis until the end effector can enter the Load Lock and manually move the robot's end effector into the Load Lock. - Position the arm so the hole in the end effector lines up with the hole in the base of the Load Lock. - Insert the 1/8 inch diameter pin through the hole in the end effector and into the hole in the Load Lock base (adjust the EE as necessary to ensure the pin is fully seated). - Once the end effector is positioned correctly save the R and T values for the vacuum robot using the CDM. ESCAPE -> STORE -> R -> T -> QUIT

Step	Action
2.	Using the robot's CDM, teach the robot the BTO value for Load Lock B. SETUP -> STATIONS -> 1 -> CR -> LEARN R, T, BTO -> HAND LOCATE - Remove the pin from the end effector. - Move the robot's end effector out of the Load Lock. - Place the MicroTool test wafer on the end effector. - Move the end effector up or down until it is positioned 68.6 mm (2.70 in) from the top of the chamber to the top of the test wafer, as shown. Note that if material other than a MicroTool Test Wafer is used the dimension specified must be adjusted to account for the differences.  - Once the end effector is positioned correctly save the BTO value for the vacuum robot using the CDM. ESCAPE -> STORE -> BTO -> QUIT
3.	Using the robot's CDM, move the robot's arm out of the Load Lock. SETUP -> STATIONS -> 1 -> CR -> LEARN R, T, BTO -> HAND LOCATE
4.	Move the robot's arm with the material out of the Load Lock and exit use of the vacuum robot using the CDM. QUIT
5.	Assign the Lower value for Station 1 (Standard Load Lock/Cool Load Lock). SETUP -> STATIONS -> 1 -> CR -> ASSIGN LOCATION -> L -> 14000 -> CR -> QUIT
6.	Record the Station coordinates in the appropriate worksheet provided in Appendix C: "Station Identification" on page 195.
7.	If the robot has dual end effectors, repeat the procedure for End Effector B.
8.	Repeat the procedure for Load Lock A using the appropriate station number (Station 2).

Teaching the vacuum robot the coordinates of the Load Locks is now complete. Return control of the robot to the host controller and shut off the CDM.

Teach the Vacuum Robot the Process Modules

The following procedure teaches the vacuum robot the Process Module stations. Note that this procedure is for use with M2 systems running WAVE II Software. Refer to the WAVE II Software User Manual for information on determining the version of software being used.

NOTE: The stations referenced in this procedure are for a standard configuration (refer to ["Station Coordinate System" on page 114](#)). Actual station assignments may vary based on the system configuration.

Changing station assignments may cause interlocks to be ignored. Changing the station numbers requires reconfiguration of all station options.

Procedure Category

Type 2 Procedure: Equipment is energized and all energized circuits are covered or insulated. All work is performed remotely using the service computer. Refer to ["Environmental Information" on page 45](#).

Required Tools and Test Equipment

- Teach Fixture Kit
- Control/Display Module
- The vacuum robot User Manual
- PC running a terminal emulator or a communications program such as Procomm™ or RSU™ (available from Brooks)
- MicroTool Dummy Wafer or test material of the appropriate type and size

Adjustment/Calibration Strategy

This procedure consists of several steps. Each step must be completed before proceeding to the next step. This sequence assumes the vacuum robot uses passive backside material contact.

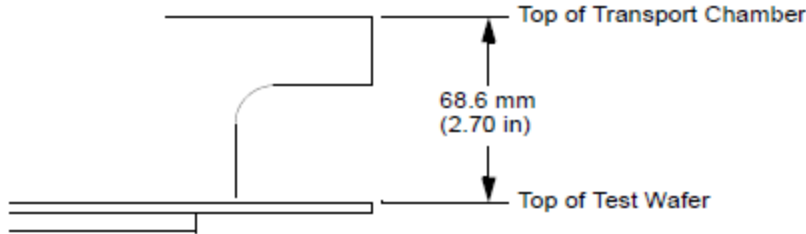
For the procedure provided below, the following configuration is assumed:

- The first Process Module on the left-hand side is Station 3 for the vacuum robot

NOTE: It may be helpful to use a glass wafer with cross-hairs scribed into it to locate the centers of the Process Module stations.

Teaching Procedure

Refer to ["Station Coordinate System" on page 114](#) for an illustration of station assignments.

Step	Action
1.	Using the robot's CDM, teach the robot the R and T values for the Process Module. SETUP -> STATIONS -> 3 -> CR -> LEARN R, T, BTO -> HAND LOCATE - If the Process Module does not have a hole for the locating pin install the PM Teach Fixture. - Using the CDM, move the Z axis until the end effector can enter the Process Module and manually move the robot's end effector into the Process Module. - Position the arm so the hole in the end effector lines up with the hole in the base of the Process Module or in the Teach Fixture. - Insert the 1/8 inch diameter pin through the hole in the end effector and into the hole in the Process Module/Teach Fixture base (adjust the EE as necessary to ensure the pin is fully seated). - Once the end effector is positioned correctly save the R and T values for the vacuum robot using the CDM. ESCAPE -> STORE -> R -> T -> QUIT
2.	Using the robot's CDM, teach the robot the BTO value for the Process Module. SETUP -> STATIONS -> 3 -> CR -> LEARN R, T, BTO -> HAND LOCATE - Remove the pin from the end effector. - Move the robot's end effector out of the Process Module. - Place the MicroTool test wafer on the end effector. - Move the end effector up or down until it is positioned 68.6 mm (2.70 in) from the top of the chamber to the top of the test wafer, as shown. Note that if material other than a MicroTool Test Wafer is used the dimension specified must be adjusted to account for the differences.  - Once the end effector is positioned correctly save the BTO value for the vacuum robot using the CDM. ESCAPE -> STORE -> BTO -> QUIT
3.	Assign the Lower value for the Process Module. SETUP -> STATIONS -> 3 -> CR -> ASSIGN LOCATION -> L -> 12000 (or as required) -> CR -> QUIT
4.	Record the Station coordinates in the appropriate worksheet provided in Appendix C: "Station Identification" on page 195.

Step	Action
5.	If the robot has dual end effectors, repeat the procedure for End Effector B.
6.	Repeat the procedure for Load Lock A using the appropriate station number (Station 2).

Teaching the vacuum robot the coordinates of the Process Modules is now complete. Return control of the robot to the host controller and shut off the CDM.

System Alignment Check-out

To verify that the alignment has been completed successfully, use the system's controller. Otherwise, use a PC and the CDM's material transfer functions to move material from each cassette through the system. Perform the entire check-out using the robot's pan 'A'; if a dual end effector arm set is being used, perform the entire check-out for pan 'B' also.

Once all robot's R, T, and Z axes have been set up for all transfers, it is necessary to verify proper transfer of material to and from all modules within the system.

NOTE: This procedure must be performed during initial setup and at any time that the robot's arms or end effector(s) are damaged, removed and replaced, or changed.

Procedure Category

Type 2 Procedure: Equipment is energized and all energized circuits are covered or insulated. All work is performed remotely using the service computer. Refer to ["Environmental Information" on page 45](#).

Required Tools and Test Equipment

- The robot's Control/Display Module (CDM)
- PC running a terminal emulator or a communications program such as Procomm™ or RSU™ (available from Brooks)
- MicroTool Dummy Wafers or test material of the appropriate type and size
- FOUP of the type that will be used in production

Limits and Tolerances

- All FOUPs/cassettes used with the M2 systems must meet SEMI/MESC standards.

Adjustment/Calibration Strategy

This procedure verifies proper operation of material transfer between all modules by observing system operation during material transfers. The material should not slide on the end effectors or on any material transfer points. There should be no bumping of material against cassette walls or other system components.

Procedure

Using the PC and the robot's CDM, position material for transfer within the modules and PICK the material from one module and PLACE it into another module. During the PICK and PLACE procedures, observe the system to verify proper operation. Repeat the procedure to transfer the material back to its original location.

NOTE: Observe material transfer from each Process Module, from each shelf of each Load Lock, from the Aligners, and from each slot in each Load Port Module. When using a dual arm set, repeat the above procedure to check system alignment using pan 'B'.

6. Operation

This chapter provides complete operation directions for the Brooks Automation M2 system. The operation of the M2 system is covered for both normal conditions and emergency conditions. This chapter provides operation instructions for the M2 system only. For operation instructions related to the major components of the system (i.e., pumps, valves, etc.), reference the appropriate user manuals.

Theory of Operation

System Overview

The M2 system consists of an integrated Equipment Front End Module (EFEM), vacuum Load Locks (LL), and a Vacuum Back End (VBE) to provide a controlled, ultra-clean environment for material transfer between the factory and the process equipment. The M2 system is composed of Brooks Automation components and additional subsystems creating a complete system. The system is divided into 3 main groups or subsystems: the Atmospheric Front End, the Vacuum Load Locks, and the Vacuum Back End (Compact, C4, C5, C6, C7, Quad, Tandem, or 4, 5, 6, or 7). Each subsystem is discussed in this chapter.

The EFEM provides a clean environment for the transfer of material from their carriers to the vacuum environment. The Equipment Front End Module (EFEM) consists of a minienvironment that houses a material transfer robot, wafer aligner, and FFU and provides BOLTS compatible interfaces to accept the docking of various types of Load Port Modules and provides support for a User Interface.

The EFEM is connected to the Vacuum Back End, which protects the Process Modules and the material in process from exposure to atmosphere and contamination through vacuum Load Locks. These Load Locks provide support for up to two wafers and may optionally provide cooling for processed wafers. The environmental controls and z-lift mechanism for the cooling option are controlled through the Vacuum Back End.

The Vacuum Back End consists of an aluminum vacuum chamber, material-handling robot, material sensors for each station, and environmental controls. The M2 system is designed to transfer material among standard SEMI/MESC compatible material-handling or processing modules in an ultra clean, vacuum environment. These modules include all Brooks supplied modules and all customer supplied Process Modules. The vacuum environment within the Vacuum Transport System is maintained by a controller in conjunction with the Load Locks and the user's Process Modules connected to the chamber.

Material transfer between these modules occurs across a single horizontal plane called the Wafer Transport Plane (WTP). The robot end effector and all access ports in the chamber walls are aligned to the WTP. This configuration permits attachment of material-handling or processing modules to each facet of the chamber.

The M2 system provides an Ethernet interface to allow connecting the system to the facility's network. Within the M2 system several communications protocols are used for data transfer and control including Ethernet, DeviceNet, and Serial I/O.

Depending on system configuration (refer to ["Configuration" on page 15](#)), some components discussed in this section may not be present on a particular system.

NOTE: This manual is intended to provide information about a wide variety of M2 Transport Vacuum Transport Systems and may contain references to items not installed on a specific system.

Operation

The M2 system is designed to transport material between various processing stations with minimal contamination of the material. Transport of the material is accomplished using Brooks Automation's atmospheric and vacuum robots. This chapter is intended to give users of M2 systems information on how to operate the M2 system. It is not intended to be a complete reference for developing the associated software and hardware necessary for M2 system operation.

The M2 system uses the controller supplied with the Atmospheric Robot to control all functions within the Atmospheric Front End and the controller supplied as part of the vacuum robot to control the functions of the M2 Vacuum Back End. The controllers are connected together to provide system monitoring and interlocks. Each of the robots in the M2 EFEM and VBE are independently controlled by the host controller.

Material is introduced into the M2 system through Load Port Modules (LPM) attached to the EFEM. These modules allow up to 25 substrates to be loaded at one time using SEMI-standard wafer carriers, ready for single-wafer processing through the M2 system.

The LPM maps the wafers in the carrier and provides the information to the host. This ensures picking of properly placed wafers only. The atmospheric robot then takes one wafer from an LPM and places it on the atmospheric aligner. The wafer is scanned and the fiducial is positioned. The robot then picks the wafer from the aligner using the offset data obtained during the scan to ensure the wafer is properly centered. Once the Load Lock on the Vacuum Back End is vented, the atmospheric door is opened and the robot places the wafer on the top shelf of the LL. If a processed wafer is present on the bottom shelf, the robot then picks the processed wafer, the atmospheric door is closed, and the processed wafer is placed into a wafer carrier on an LPM.

The user's host controller initiates pump-down of the Load Lock. When the vacuum in the Load Lock chamber reaches the vacuum setpoint, the vacuum slot valve is opened and the host controller instructs the vacuum robot to remove the processed wafer from the Process Module and places it on the bottom shelf of the LL. The vacuum robot then picks the new wafer from the top shelf of the Load Lock and transfers it to the Process Module for processing.

While the wafers are being processed the atmospheric robot transfers wafers as described above. Once the wafer processing is completed the vacuum robot transfers wafers as described above. This cycle continues until all material is processed. Refer to ["Operation Overview" on page 112](#) and ["Determining Material Locations" on page 122](#) for a detailed description of the system's operation.

Operation Overview

Configuration and operation of the M2 system is through the user's host controller. Refer to the controller's documentation for information on its setup and operation.

This operation section provides unique information in relation to these components as part of a M2 system. In the case of any contradiction, this manual will take precedence.

The following sequence demonstrates the normal material transfer operation of the M2 system.

Step	Action
1.	Load material to be processed into the system. - A wafer carrier is placed in one of the Load Port Modules attached to the EFEM. - Once the LPM is open the host controller initiates a mapping of the wafers in the carrier and retrieves the wafer map when it is completed.
2.	Pick a wafer from the carrier and align. - The host controller vents the Load Lock. - The host controller instructs the atmospheric robot to pick a wafer from the carrier on the LPM and place it on the aligner within the EFEM.
3.	Align the wafer and place it into the Load Lock. - The host controller instructs the aligner to orient the fiducial of the wafer and the atmospheric robot to pick the wafer from the aligner. The aligner measures the eccentricity if required and communicates the position of the wafer to the robot controller. - Once the Load Lock chamber is at atmospheric pressure the host controller opens the Atmospheric Door. - The host controller instructs the atmospheric robot to transfer the centered and oriented wafer to the incoming wafer shelf (top shelf) in the Load Lock. - The host controller closes the atmospheric door to the Load Lock. - The host controller initiates a pump down of the Load Lock.
4.	Place the wafer into the first Process Module. Pick the next wafer from the carrier and align. - Once the Load Lock chamber is at the vacuum setpoint the host controller opens the Vacuum Slot Valve. - The host controller instructs the vacuum robot within the Vacuum Back End to transfer the incoming wafer into the first Process Module. - The host controller closes the Vacuum Slot Valve. - The host controller vents the Load Lock. - While the first wafer is in process, the host controller instructs the atmospheric robot to remove the next wafer from the LPM and place it on the aligner within the EFEM.
5.	Align the wafer and place it into the Load Lock. Move the processed wafer to the next processing stage. - The host controller instructs the aligner to orient the fiducial of the next wafer and the atmospheric robot to pick the wafer from the aligner. The aligner measures the eccentricity if required and communicates the position of the wafer to the robot controller. - Once the Load Lock chamber is at atmospheric pressure the host controller opens the Atmospheric Door. - The host controller instructs the atmospheric robot to transfer the centered and oriented wafer to the incoming wafer shelf in the Load Lock. - The host controller closes the atmospheric door to the Load Lock. - The host controller initiates a pump down of the Load Lock. - The host controller instructs the vacuum robot to transfer the wafer from the first Process Module to the Second Process Module, or the Load Lock depending upon the process's recipe.

Step	Action
6.	Pick the next wafer from the carrier and align. Place the wafer into the first Process Module, place the fully processed wafer into the Load Lock. - Once the Load Lock chamber is at the vacuum setpoint the host controller opens the Vacuum Slot Valve. - The host controller instructs the vacuum robot to transfer the incoming wafer into the first Process Module. The host controller instructs the vacuum robot to transfer the incoming wafer into the first Process Module. - The host controller instructs the vacuum robot to transfer the processed wafer from the second Process Module to the outgoing wafer shelf (bottom shelf) in the Load Lock. - The host controller closes the Vacuum Slot Valve. - The host controller vents the Load Lock. - The host controller instructs the atmospheric robot to remove the next wafer from the LPM and place it on the aligner within the EFEM.
7.	Align the wafer and place it into the Load Lock. Move the processed wafer to the next processing stage, and place the fully processed wafer into the carrier. - The host controller instructs the aligner to orient the fiducial of the next wafer and the atmospheric robot to pick the wafer from the aligner. The aligner measures the eccentricity if required and communicates the position of the wafer to the robot controller. - Once the Load Lock chamber is at atmospheric pressure the host controller opens the Atmospheric Door. - The host controller instructs the atmospheric robot to transfer the centered and oriented wafer to the incoming wafer shelf in the Load Lock. - The host controller instructs the atmospheric robot to remove the processed wafer from the outgoing wafer shelf of the Load Lock and place it into the LPM. - The host controller closes the atmospheric door to the Load Lock. - The host controller initiates a pump down of the Load Lock. - The host controller instructs the vacuum robot to transfer the wafer from the first Process Module to the Second Process Module, or the Load Lock depending upon the process's recipe.
8.	The cycle (Step 6 and Step 7) repeats until all wafers in the carrier have been processed.
9.	Once all of the wafers within the wafer carrier have been processed, the wafer carrier is removed and replaced with the next carrier to be processed.

Station Coordinate System

The robot software uses a station coordinate system for identifying specific locations within the M2 system as shown in [Figure 6-1](#). Each station is identified by its Theta position, its Radial position (amount of arm extension), and its Z position (vertical distance from Home). Some M2 systems may have additional parameters specified for a station, based on additional functions provided by the robot, such as Wrist position and VIA point position.

Station numbers are assigned to represent each module connected to the M2 system and each material transfer point within the M2 system. All station number assignments are dependent upon the specific system configuration. By identifying the stations in this manner, it is only necessary to provide the robot with the station number instead of the complete coordinate set each time a command is issued to the robot. Multiple station numbers may be given to a single physical location,

or the same location may be referenced as different station numbers by different robots as shown in [Figure 6-1](#).

Brooks Automation will configure the stations on the M2 system as shown unless different station assignments are specifically requested. All references to setting stations in this manual will reflect the standard Brooks M2 system station assignments shown in [Figure 6-1](#).

NOTE: The stations referenced here are for the M2 system configuration.

If the station numbers were assigned at the factory, changing the station numbers may cause interlocks to be ignored.

Changing the station numbers requires reconfiguration of all station options.

All numbering of stations within the Transport Chamber for the vacuum robot is done in a clockwise direction starting with the Load Lock on the right when looking at the M2 system from the top, see [Figure 6-1](#). Any intermodule stations are numbered on a second clockwise circuit of the Transport Chamber. All numbering of stations within the Minienvironment is done in a counter-clockwise direction starting with the Load Lock on the right when looking at the M2 system from the top, see [Figure 6-1](#).

The R (radial extension), T (rotational), and Z (vertical) values for each station should be recorded for each type of material that will be used with the system. Note that these values will be different for different size wafers and for different systems.

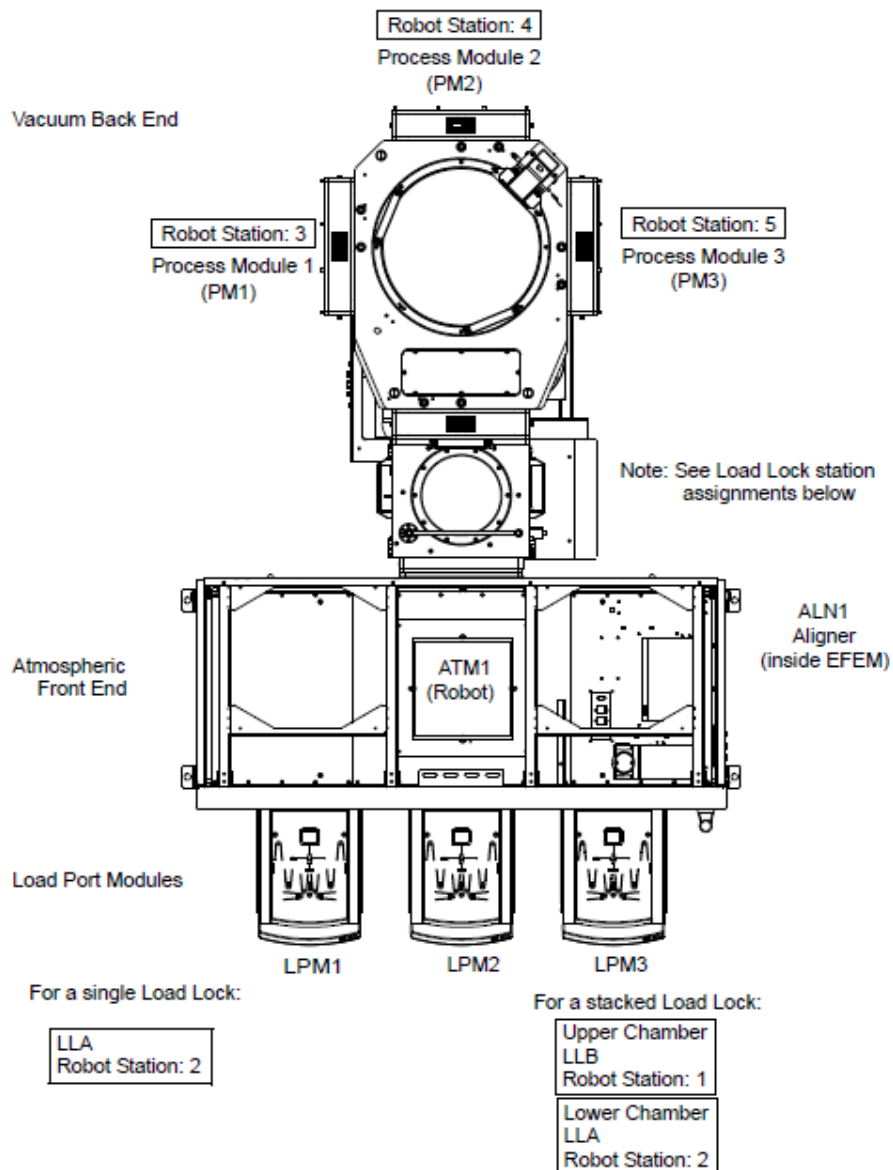


Figure 6-1: Station Assignment Example M2 Compact

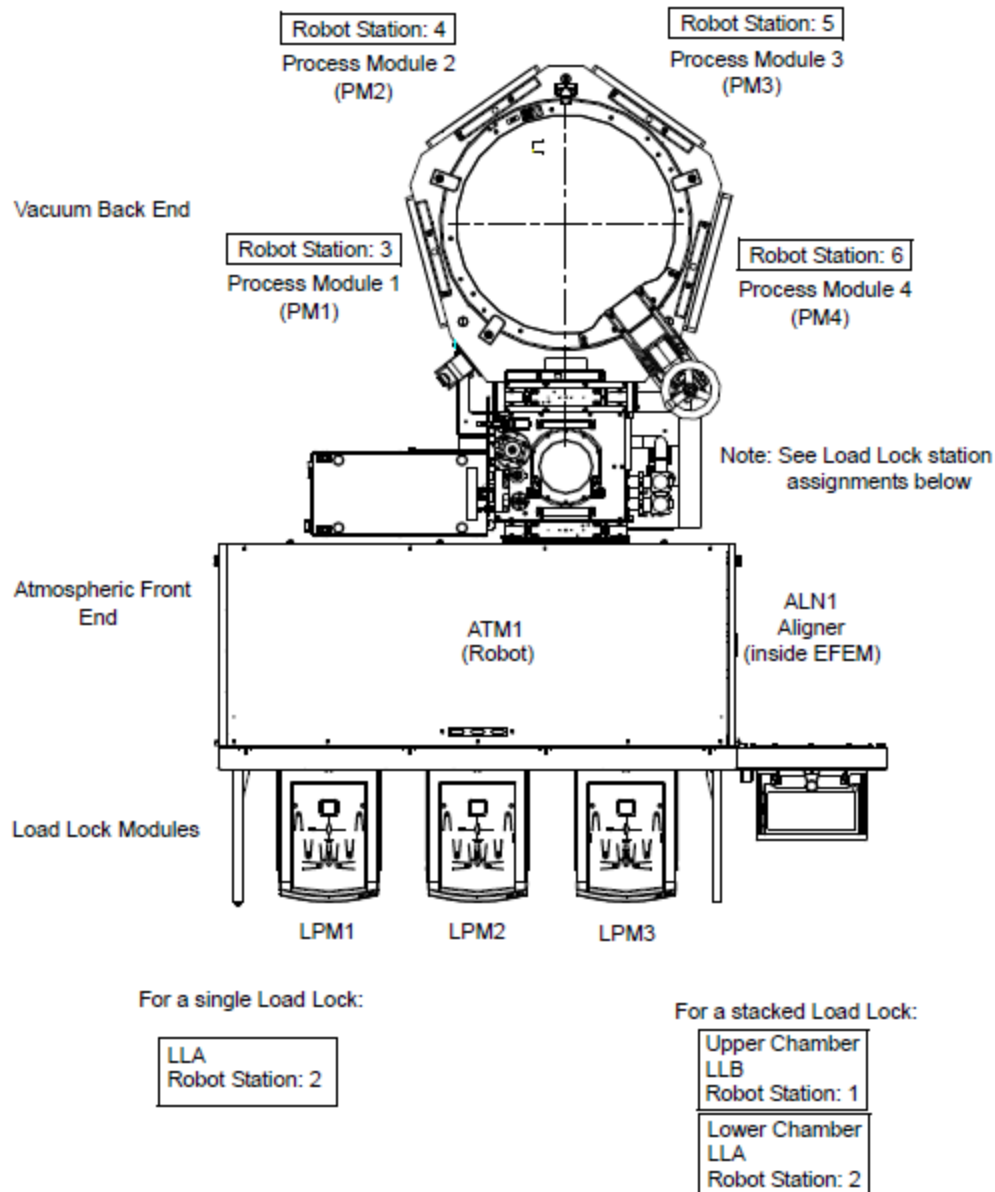


Figure 6-2: Station Assignments Examples M2C 5 (Similar for C4, C6 and C7)

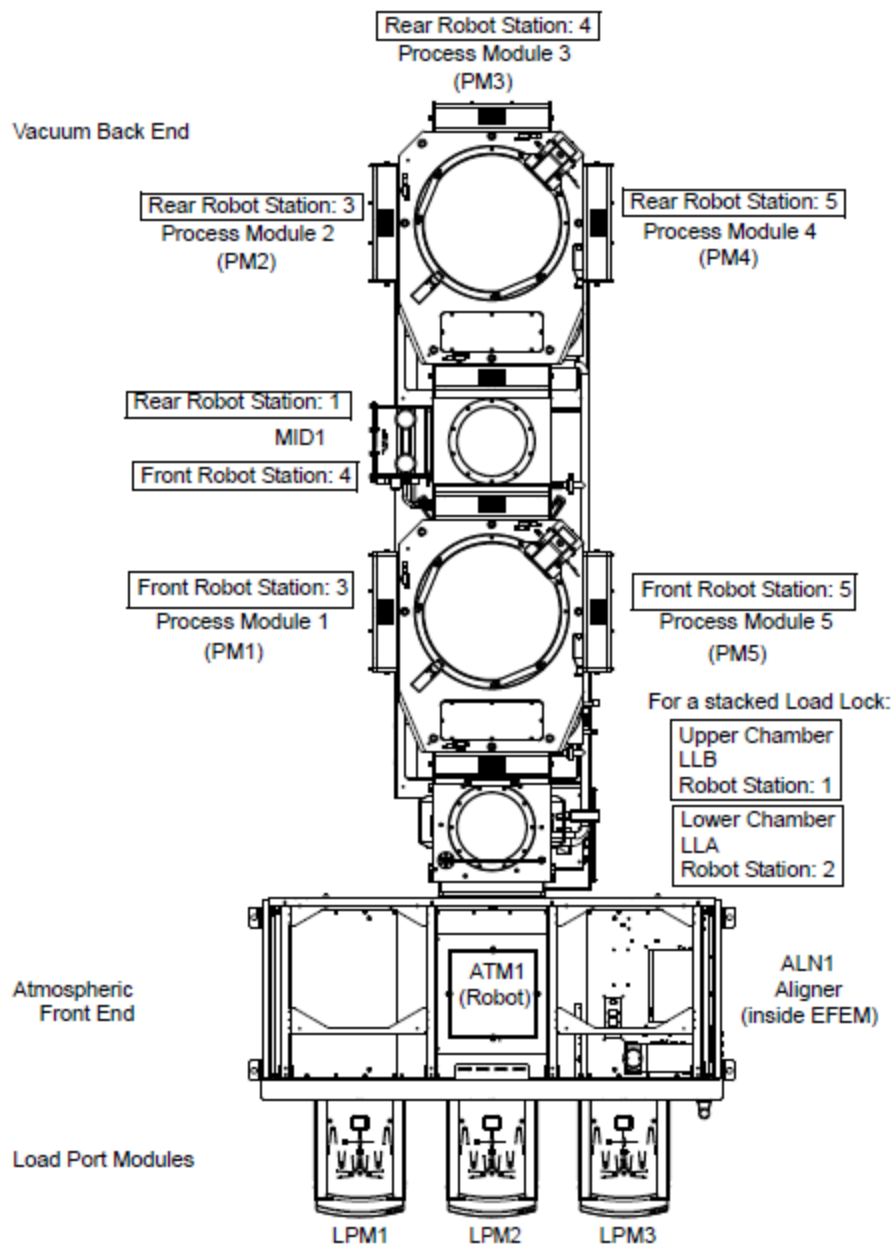


Figure 6-3: Station Assignment Examples M2 Tandem

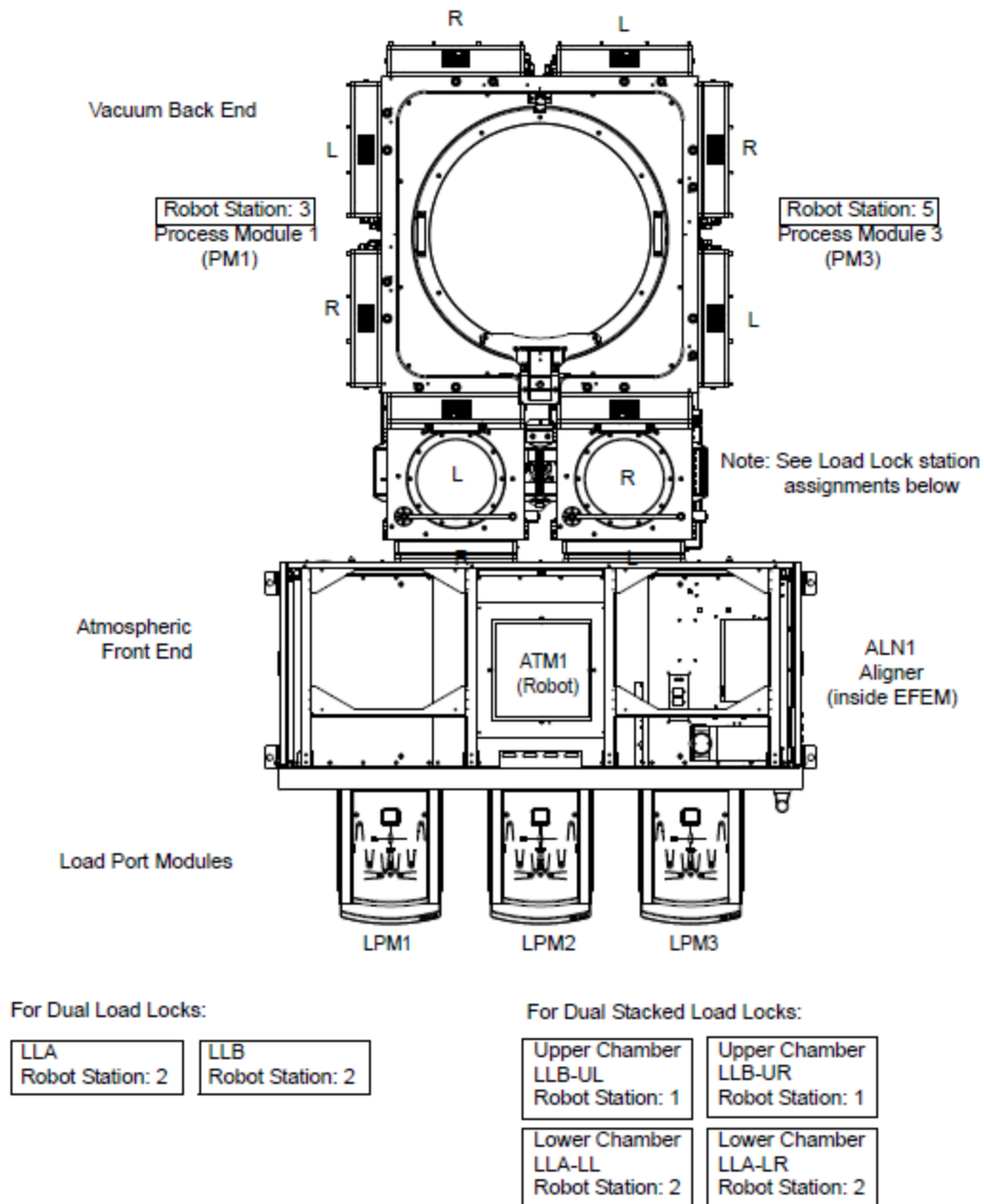
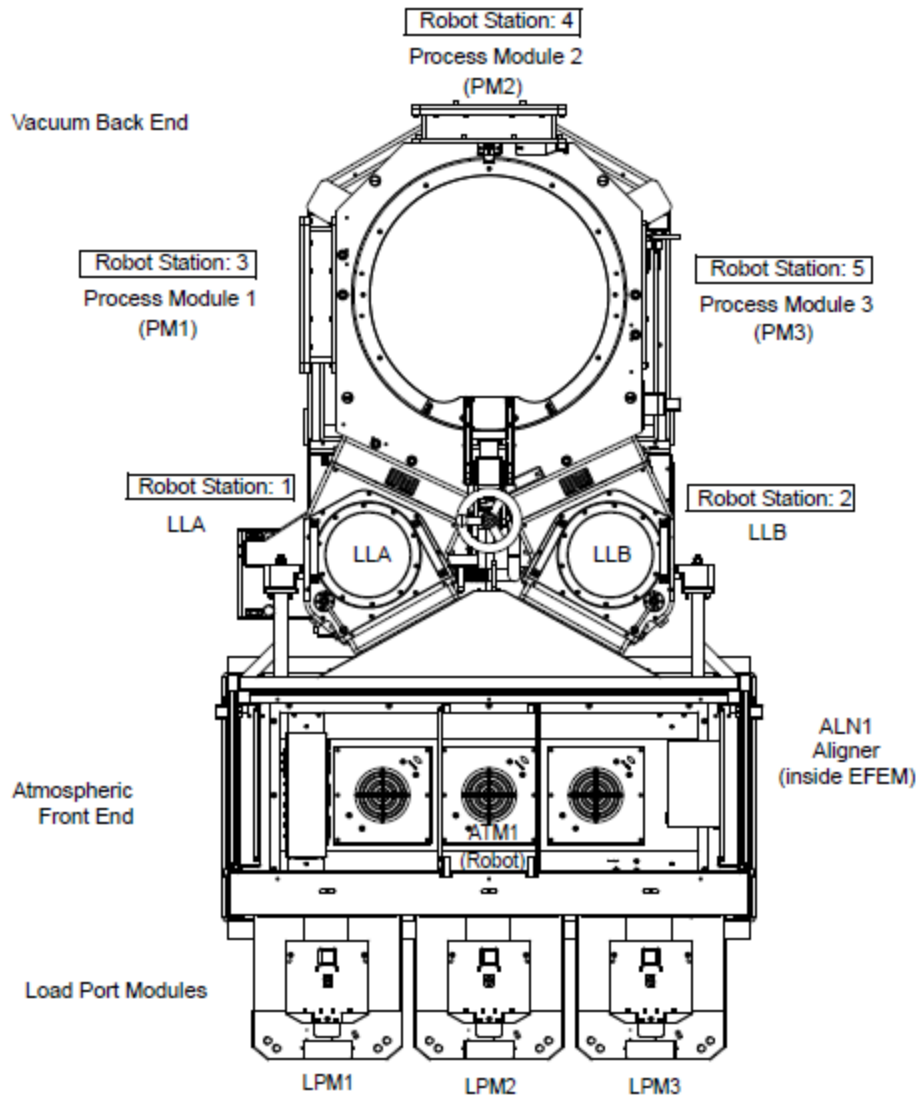


Figure 6-4: Station Assignment Examples M2 Quad



M2 - 5 Shown

Figure 6-5: Station Assignment Examples M2 4 - 7

When the Z-axis is being used, there are a number of user definable parameters that must be provided for proper operation. The Base Transfer Offset (BTO) provides the distance from the robot's Home position to the systems Wafer Transfer Plane (WTP). The Lower parameter provides the distance from the WTP that the robot must move down to deposit the material, which also defines the height that the robot must enter a module to pick up the material.

The Slot parameter is used to define the number of slots in a station (the default is one) and to specify the slot the robot's operation will be performed on (if none is specified the default is assumed). The Pitch parameter is used to define the distance between slots. When using the Slot and Pitch parameters, the total number of slots may not exceed the vertical distance that the robot is capable of traveling.

NOTE: Any or all of these values can differ from station to station.

Table 6-1: Station Parameters

Station Parameter	Description
R	The full radial extension in increments of 0.001 mm.
T	The rotational position, Theta, in increments of 0.001 ° over a range of 360 °.
W WA/WB FastSwap	The end effector flipping position in increments of 0.001 ° over a range of +10° to -190°.
Z	The vertical position in increments of 0.001mm.
S	The horizontal axis of the traverser in microns.
BTO	The Z-axis location, in microns, of the Wafer Transport Plane, which is also the Up position of the robot arm in Station 1.
LOWER	The distance in microns below the Wafer Transport Plane at which the Down position of the robot arm is located.
NSLOTS	The number of slots at the station.
PITCH	The uniform distance, in microns, between the slots.

NOTE: Any or all of these values can differ from station to station.

Frames of Reference

Before setting stations or using the M2 Vacuum Transport System, it is important to understand the Frames of Reference used within the system.

Material is transported to specific locations, or stations, within the system by the robots. Each location is defined by its T and R polar coordinates and its Z position within the system's Frame of Reference. Station definition is the process of defining each of these locations, which are then stored in the robot's memory for future reference by the robot. It is important to note that the system's frame of reference is defined by the robot as described below and that each station is defined by the R, T, Z, and other station values programmed into the robot.

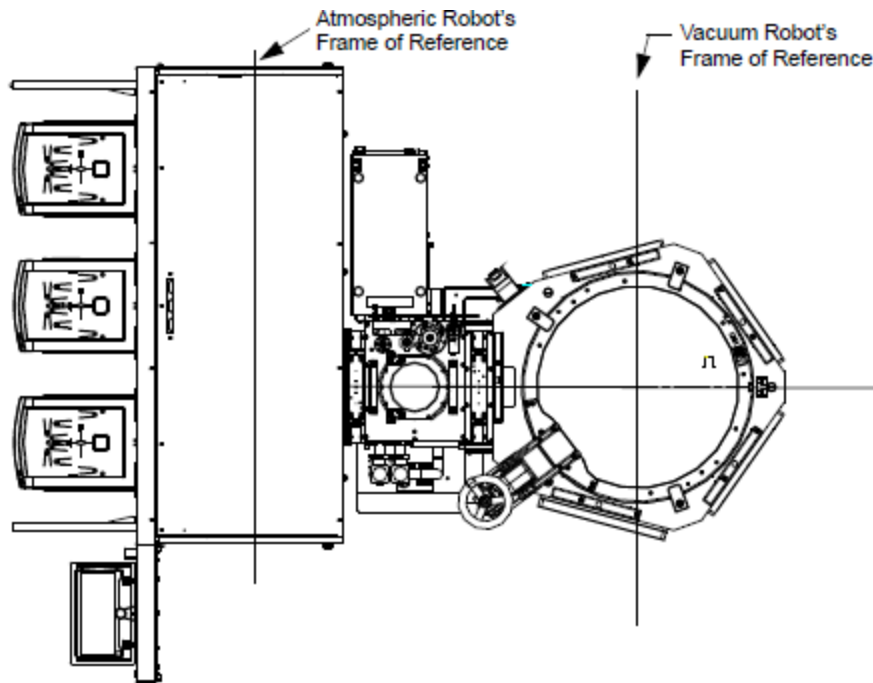


Figure 6-6: Frames of Reference (In a typical system)

Robot's Frame of Reference

The typical frame of reference for the Transport Chamber is defined by the robot's coordinate system. The top view shown in [Figure 6-6](#) is a horizontal x-y plane, and each position within this plane is defined using a polar coordinate notation for each robot.

NOTE: The system's 0° axis is defined by the robot's 0° position, which is typically the robot's rotational Home position.

Looking at the top view of the system, the robot's rotational, or T (theta), position value increases from 0° at the Home position to 360° in a clockwise direction. The robot's radial, or R, axis is measured from the center line of the robot radially outward in millimeters.

The third axis in the Transport Chamber's Frame of Reference is the vertical, or Z, axis. The zero position for the Z-axis is defined by the robot's vertical Home position.

Determining Material Locations

There are several ways to determine material presence within the M2 system as described below.

Robot Pick and Place Commands

Each robot will assume it has material after power-up. The robot will assume it has material after a PICK command at a station without sensors. The robot will assume it does not have material after a PLACE command at a station without sensors. For stations with sensors the robot will check the station sensor to verify that the PICK/PLACE was successful.

Material Presence Sensing

The vacuum grip on the atmospheric robots and aligner can be used to determine the presence of material.

The end effector on the atmospheric robots has a sensor to detect material presence. The aligner can also use the CCD to determine wafer presence by looking for the shadow of a wafer on the chuck.

Material Mapping

The atmospheric robots and Load Ports may have Optical Wafer Mappers that are used to map wafer carriers and report the presence of wafers in particular slots. The robot mounted mapper is capable of identifying present, missing, and cross-slotted wafers. The LPM mounted mapper is also capable of identifying double-slotted wafers.

Transport Chamber Material Sensors

There are material sensors in the Vacuum Back End, positioned according to the vacuum robot User Manual as R_MT (Radial Motion) material sensors that are configured as either EXtend or REtract type sensors (refer to the Robot Software Manual). The vacuum robot can be commanded to do a CHECK LOAD to determine material presence. This command causes the robot to move the material such that the edge of material present on the end effector would trigger the sensor.

The vacuum robot automatically checks the R_MT sensor before and after a Pick or a Place. If the material present state does not match the expected state the robot will generate an error.

Safety Interlocks

The M2 system is provided with safety interlocks to ensure the safety of the operators and service personnel.

NOTE: The Door Panel/Robot Motion Interlock on the minienvironment will halt motion of the robot. Power to the robot or other components in the system is ON.

For more information, refer to the appropriate controls manual.

 WARNING Automatic Movement / Crush Hazard	
If any interlocks are disabled the possibility exists of automatic movement of systems within the M2 system. The following systems have the possibility of automatic movement: - Atmospheric Robot - Atmospheric Aligner - Load Port Modules - Optional Wafer Inverter - Vacuum Robot Vacuum - Load Lock Z-lift - Atmospheric Doors - Vacuum Slot Valves - Isolation Valves - Pumps Moving mechanisms have no obstruction sensors and can cause serious personal injury or death. Do not operate the M2 system without the protective covers in place.	

Identification

All user safety interlocks are located as shown in [Figure 6-7](#).

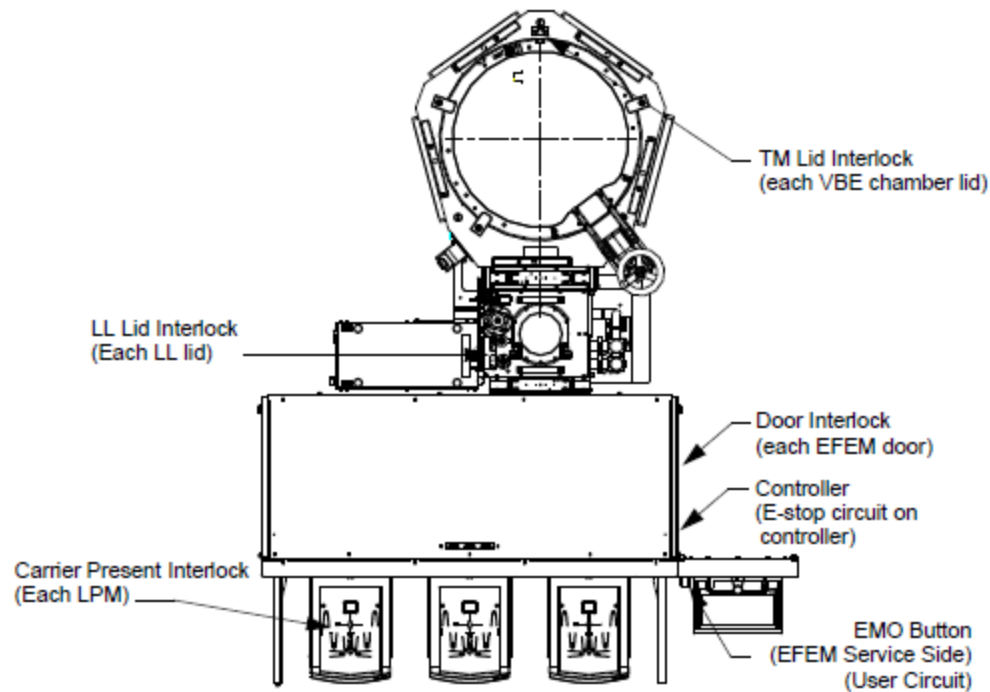


Figure 6-7: Safety Interlocks, Typical

Function

The interlocks shown in [Figure 6-7](#) are detailed in [Table 6-2](#).

Table 6-2: Safety Interlocks

Name	Type	Function
"Safety Interlocks" on page 124	2 position switch (Off, On)	Inhibits robot and load port motion if EFEM door is open
"Carrier Present Interlock" on page 126	2 position switch (Off, On)	Inhibits LPM motion if FOUP/cassette is not present
"Safety Interlocks" on page 124	Locking Button	User Defined
"Safety Interlocks" on page 124	User Defined (typically a push button or a momentary contact key switch)	Resets Safety Node after an Interlock is activated
Chamber "Safety Interlocks" on page 124	Keyed Magnetic Switch	Inhibits vacuum robot motion and slot valve controls
LL "Safety Interlocks" on page 124	Keyed magnetic switch	Inhibits slot valve and load lock door controls, and atmospheric and vacuum robot motion

Door Interlock

Access into the EFEM minienvironment is through the side doors. These doors contact an actuator switch that will signal the controller that an unsafe condition is in effect if the door is open. This safety interlock prevents motion of the robot and Load Port Modules while the door is open.

For M2 systems with an EFEM, when the door is opened the safety interlock switch state is detected by the Safety System which deservos the robot by breaking its interlock loop. The Z-axis brake is applied.

Carrier Present Interlock

Inhibits Load and Unload motion of the Load Port Module.

Emergency Off (EMO) Circuit

Typically, a user supplied EMO button will be configured such that pressing it will remove all power from the M2 system and all attached components. Once the emergency is resolved, which can include determining the reason for the emergency and checking the station involved during the emergency, power can be restored to the M2 system and all attached components. With power restored the robot and all attached components should be re-initialized, then processing can be restarted.

The EMO button supplied with the M2 system is provided to allow the user to configure a single EMO button that removes power from all material handling and processing components within the M2 system. A pass-through connection for the user's EMO circuit is provided at the Atmospheric Front End's Facilities Interface Panel through an M-12 male connector.

E-stop for EFEM Option

Refer to the appropriate user manual for details about the E-stop and interlock circuits.

Reset Circuit

The M2 system provides the ability for a user supplied Reset button to be installed on the tool where the M2 system is installed by connecting it to the Safety Node. The Reset Circuit is used to reset the Safety Node to return it to service after clearing an activated interlock (refer to the appropriate controls manual for interlock descriptions and conditions).

Lid Open Interlock

The Lid Open Interlock uses coded magnetic switches to detect the presence of the Transport Chamber and Load Lock lids in the closed position. The Lid Open Interlock may be bypassed by

using a service key with a matching coded magnet. The key is designed to prevent the lid from being closed while it is installed. Ensure the service key is removed and the lid is properly closed before returning the M2 system to operation.

NOTICE

Attempting to pump down the transport chamber while the lid is open and the service key is installed may damage the pumps or other vacuum components.

Atmospheric Front End

The Atmospheric Front End consists of Load Port Modules connected to an EFEM. The EFEM can be either the Brooks Automation EFEM or the Brooks Automation Jet ATS.

The EFEM includes:

- ["Minienvironment" on page 127](#)
- ["Atmospheric Front End Features" on page 128](#)
- ["Atmospheric Front End Options" on page 130](#)
- ["Atmospheric Robots and Controllers" on page 131](#)

Operation

The Atmospheric Front End includes a minienvironment that provides a controlled area for clean transfer of material from the factory interface to the vacuum chamber. The minienvironment provides mounting for the atmospheric robot, aligner, and EFEM controller and BOLTS interfaces for mounting Load Port Modules, which provide the factory interface. A number of options are available for the EFEM as detailed in ["Atmospheric Front End Options" on page 130](#).

Operation of the minienvironment includes the control of air flow through the unit and monitoring the door switches for safety. Any type of supported wafer carrier is placed on one of the LPMs. The robot in the EFEM removes the wafers from the carrier, passes them to the aligner where the fiducial is positioned as desired, and then passes them on to the Vacuum Back End. After processing, the atmospheric robot removes the wafers from the VBE, re-aligns them if needed, and places them back into the wafer carrier. For complete operation information refer to the EFEM User Manual.

Minienvironment

The minienvironment enclosure provides the housing and mounting for the components of the EFEM. The standard minienvironment configuration for the M2 system provides 3-bays, however 2-bay and 4-bay models are available. In all models it is possible to use bays as equipment racks, user interfaces, or any other user defined function. The minienvironments are also available with wing panels for use with user interfaces.

The Atmospheric Front End provides a simple, easy to use, integrated Equipment Front End Module (EFEM) with next generation controls. The EFEM consists of a minienvironment enclosure that supports a fan/filter unit and houses an atmospheric material transfer robot, a wafer aligner, and control electronics. The minienvironment has BOLTS compatible interfaces to accept the docking of various types of load ports and provides a mechanical connection to the process tool. All standard factory interfaces for material transfer such as Carrier ID (including OCR) and E84 are supported. Refer to the Atmospheric Front End User Manual for complete information on the EFEM including all components, locations and types of connections, and options.

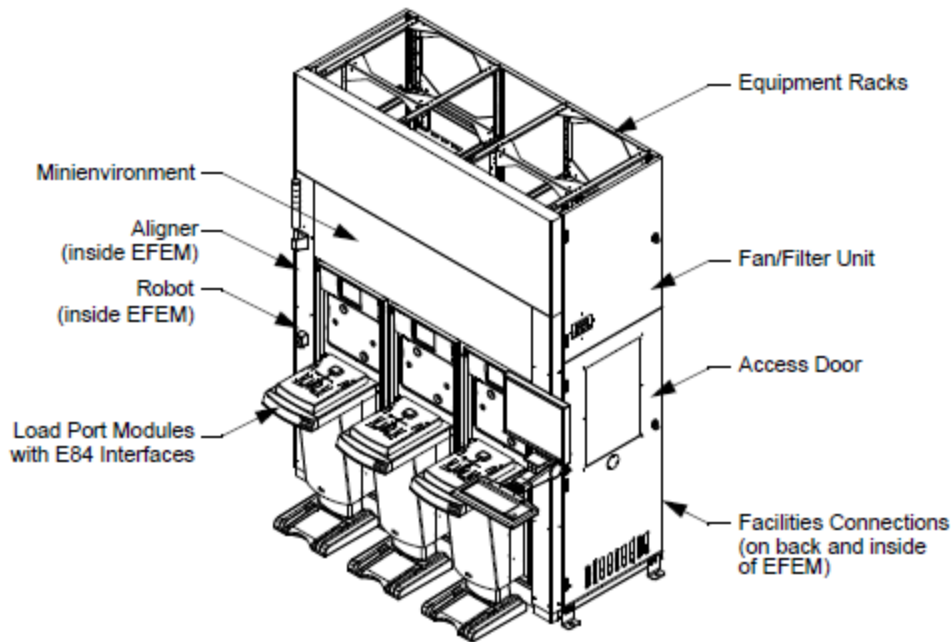


Figure 6-8: Typical Atmospheric Front End (Subsystem Identification)

Atmospheric Front End Features

Fan/Filter Unit

The Fan/Filter Unit (FFU) provides airflow and filtering to maintain an ISO 14644-1 ISO Class 2 or better material handling environment within the EFEM while maintaining positive internal pressure.

Door Safety Switches

Access into the minienvironment for service is through the two side doors. These doors actuate a switch, which prevents operation of the atmospheric robot and load ports when either door is open. The door open signal is also connected to the Controller to prevent closing of the atmospheric doors on the Load Locks.

Facilities Panel

The Facilities Panel is the user's interface to the Atmospheric Front End. It provides a centralized point for the communication and control connections between the EFEM, the Vacuum Back End, any other modules of the M2 system, and the plant.

Depending upon the configuration of the EFEM, the panel may also provide pneumatic (vacuum, air, and vent) and other connections for the EFEM.

EFEM Service Light

The internal lighting fixtures provide lighting within the material handling zone of the minienvironment. This lighting supplements the facility lighting making visual observation of operation easier and improving service access.

EMO Button

An Emergency Off (EMO) button may be supplied with the M2 system for the user's convenience. The M2 system is not provided with an Emergency Off (EMO) circuit. The user is accountable for the EMO circuit and the wiring of the EMO button.

Typically, the EMO circuit will be configured such that pressing it removes all power from the M2 system and all attached components. Once the emergency is resolved, which can include determining the reason for the emergency and checking the station involved during the emergency, power can be restored to the M2 system and all attached components.

NOTE: The user is responsible for all EMO circuitry.

Typically, depressing the EMO button causes power to be deactivated for the entire tool. Main switching is the responsibility of the tool integrator.

NOTE: If the Atmospheric Front End is equipped with a PC running control software, power must not be removed from the PC without first powering it down. Failure to provide a controlled shutdown of the PC may cause loss of data within the PC.

NOTICE

The EMO circuit is the responsibility of the user. The Warning Label should not be removed from the EMO Button until the EMO circuit has been wired and tested.

Atmospheric Front End Options

Teach Pendant

The optional teach pendants for the Brooks Automation atmospheric robots are used as a general maintenance interface for the EFEM. This interface can be used for component testing, calibration (aligners, robots, load ports, etc.), and station teaching. The teach pendant's have an integral Emergency Stop button for safety.

Ionizer

For those fabs that require higher performance, per SEMI E78, optional ionization units are mounted in the top of the minienvironment below the air filter and are designed to eliminate electrostatic discharge (ESD) and particle contamination caused by electrostatic attraction within the minienvironment. The system guarantees intrinsically balanced ionization without the need for complicated feedback circuits, and adjustment is never needed. One ionizer is centered in the air flow for each bay. The ionizers feature a unique aerodynamic design that ionizes a local area without disrupting laminar flow.

Light Tower

The optional light tower provides instant visual and audio status of the system or any user defined events. The standard light tower provides four colored lights and an alarm that may be independently and/or simultaneously activated in either continuous or flashing mode. They may also be externally controlled allowing many possibilities for flasher timing.

Each light module consists of a LED array in one of four colors: RED, AMBER, BLUE, and GREEN. Each individual light module is removable and replaceable. The light tower has one separate audible alarm signal, ALARM1.

Light Curtain

The optional Light Curtain is installed on the front of the Atmospheric Front End and provides operator safety when manually accessing the Load Port Modules attached to the front of the EFEM. The user accessible areas of the LPs are separated from the general facility area by a "curtain" of light. The top of the light curtain is open allowing access by OHT system.

The Light Curtain provides an interlock with the E84 system. When any beam of light within the Light Curtain is broken, the interlock disables communication to the E84 transponders and notifies the system controller of the change in status. When the obstruction in the Light Curtain is removed, the interlock enables communication to the E84 transponders and notifies the system controller of the change in status.

User Interface

The optional User Interface (UI), consisting of a flat panel display with touchscreen and a keyboard with trackball, provides the user with a convenient, and easy to use, method of local control and monitoring of the M2 system. The UI is mounted on an adjustable arm that may be positioned as desired by the operator.

Wafer Mapping

Wafer Mapping is available in several different options. For the Reliance ATR reflective or through-beam wafer mappers mounted on the robot's end effector are available. For the Razor ATR through-beam wafer mappers mounted on the robot's end effector are available. These wafer mappers are used to map wafers being presented to the EFEM on the Load Ports. The robot mounted mappers are capable of identifying present, missing, and cross-slotted wafers.

The Load Port Modules may be supplied with an optional through-beam wafer mapper which eliminates the need for a mapper mounted on the robot's end effector. The load port mounted mapper is capable of identifying present, missing, cross-slotted, and double-slotted wafers.

NOTE: Detection of double-slotted wafers is not guaranteed using the robot for mapping. The recommended configuration to detect double slotted wafers is using a FixLoad 6M or Vision LPM with load port mapping.

E84 Interface

Optional E84 devices are available to support AGV and OHT systems. For AGV system the E84 module and transponder are mounted in the LPM. For OHT systems the E84 module mounts inside the EFEM and the transponders are mounted in the appropriate relation to the Load Port Modules.

Atmospheric Robots and Controllers

The Brooks Automation atmospheric robots are compact, direct drive, continuous rotation material handlers designed for atmospheric environments. The unique design of the robots allows unlimited motion in the T (rotational) axis. The robots are supplied with a SCARA type arm capable of supporting one or two end effectors depending upon the configuration. For each type of robot, the controller for the robot also provides control of the atmospheric aligner. Within certain configurations of the EFEM the robot is mounted on a track to provide the robot access to additional LPMs.

Refer to the Brooks Automation EFEM manuals for complete information on the robots.

End Effectors

The atmospheric robots offer both edge contact and back side contact end effectors for substrate support during movement in, and through, the Atmospheric Front End.

Passive Edge Contact End Effectors

Passive edge contact end effectors for wafers provide a passive support of the wafer and material presence detection. These end effectors are all fork-style and provide a minimum of three points of contact for wafer support.

Active Edge Grip End Effectors

Active edge grip end effectors for wafers provide an active grip support of the wafer and material presence detection allowing faster throughput without wafer slippage. These end effectors are all fork-style and provide three points of contact for wafer gripping.

Back Side Contact End Effectors

Back side contact end effectors for wafers provide a vacuum grip and material presence detection allowing faster throughput without wafer slippage. Back side contact end effectors are available as both paddle-style and fork-style depending on the user's requirements.

Optional Wafer Mappers

The ATM robot offers either reflective or through-beam wafer mappers mounted on the robot's end effector, the mapper style is determined by the end effector type. The Razor ATR offers through-beam wafer mappers mounted on the robot's end effector. These wafer mappers are used to map wafers being presented to the EFEM on the Load Ports. The robot mounted mapper is capable of identifying present, missing, and cross-slotted wafers.

NOTE: Detection of double-slotted wafers is not guaranteed using the robot for mapping. The recommended configuration to detect double slotted wafers is using a FixLoad 6M with load port mapping.

Atmospheric Aligners

The Brooks Automation atmospheric aligners are compact wafer aligners designed for atmospheric environments. The aligners provide fiducial identification and placement and identification of the wafer's eccentricity direction and offset allowing the robot to perform an offset pick of the wafer from the aligner, which centers the wafer on the robot's end effector. The aligners can also provide rotational positioning of the wafer for scanning by an OCR system. For each type of aligner, the controller for the robot also provides control of the aligner.

Refer to the Brooks Automation EFEM manuals for more information.

Vacuum Back End

The Vacuum Back End includes:

- Transport Chamber and Frame
- Load Locks
- Vacuum/Venting Systems
- Pneumatic System
- Gas System
- Cooling System
- Electrical System
- Facet Adapter Plates
- Material Presence Sensors
- Automatic Wafer Centering
- Pressure Switch
- Vacuum Robots
- Ethernet
- DeviceNet

Operation

The Vacuum Back End includes a vacuum transport chamber that provides a controlled environment for transfer of material from the EFEM to the Process Modules. The VBE provides mounting for the load locks, vacuum robot, controls electronics, pumps, valves, and gauges. The transport chamber is maintained at vacuum while the load locks are pumped and vented to transfer material between atmosphere and vacuum.

Operation of the VBE includes the control of vacuum and vent systems, transfer isolation valves, and the lid switches for safety. Any type of supported material is placed into one of the Load Locks. The robot in the VBE removes the material from the load lock once the LL is pumped down and then passes it on to the Process Module. After processing, the robot removes the material from the PM and returns them to the LL where they are retrieved by the atmospheric robot once the LL is vented.

Transport Chamber and Frame

There are several different chamber designs used in the Brooks Automation M2 Vacuum Back End. These designs provide from two to six Process Module facets with different footprint configurations to maximize floor space usage (refer to [Figure 1-2: "Marathon 2 Configurations" on page 16](#)). A central vacuum robot is used for material transfer within each chamber. This design provides the ability to select the smallest footprint available for processes requiring multi-step processing without removing the material from the vacuum environment.

Multi-Faceted Chamber

All multi-faceted Transport Chambers for the M2 system are designed to provide an ultra-clean, high-vacuum environment for transfer of material among Process Modules. Each external vacuum facet is designed to accept a slot valve which, when installed, provides a custom interface for connecting with a Process Module. Slot valves are also located between the main vacuum chamber and the modular Load Locks, which have atmospheric doors on their external facets.

The Vacuum Back End chamber provides for installation of the material handling robot and includes ISO compatible ports for vacuum system components such as gauges and pumps associated with the chamber, and support for the Material Sensor system. Each facet of the chamber provides mounting for slot valves to isolate the chamber from the Process Modules and Load Locks. There is one material sensor at each Process Module and Load Lock station. All seals on the chamber are preprocessed elastomer seals.

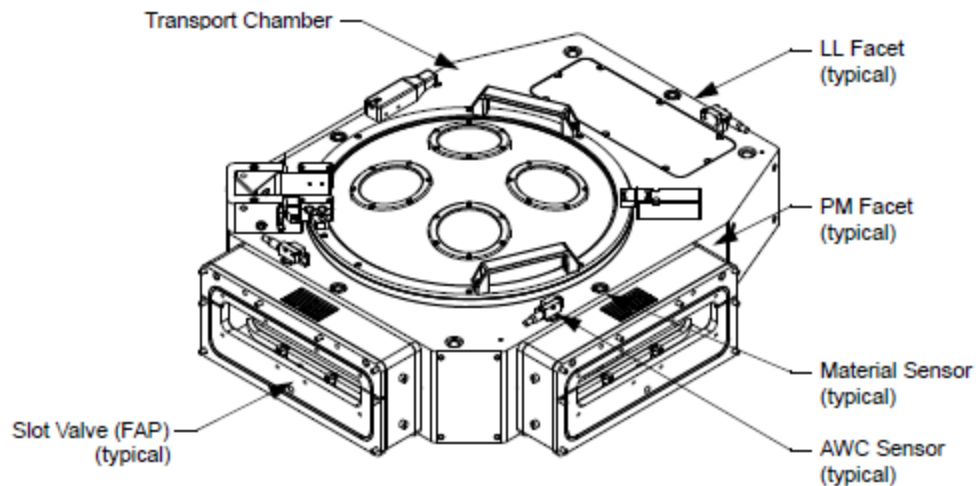


Figure 6-9: Typical Chamber Overview

Transport Chamber Lid Assembly

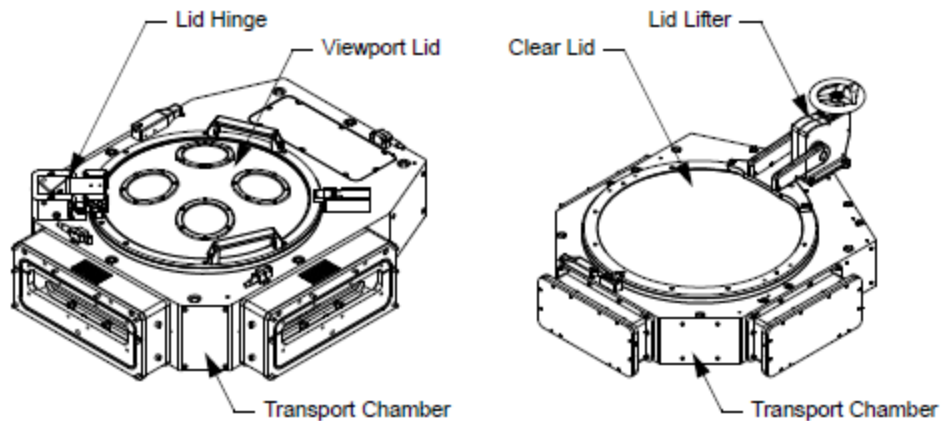


Figure 6-10: Typical Chamber Lid Overview

The Vacuum Back End lid is located on the top of the Transport Chamber, sealing the chamber and providing access into the chamber. The lid meets all SEMI S2 and EU safety standards. There are two different lid options, the InSight™ clear domed lid for rough vacuum applications and a domed aluminum lid with viewports for high vacuum applications.

The clear InSight lid is fabricated from aluminum and Lexan® and weighs 15 kg (33 lb) for the small lid and 21 kg (46 lb) for the large lid. The viewport lid is fabricated from aluminum and weighs 30 kg (67 lb) for the small lid. The aluminum lid provides Pyrex® viewport windows with o-ring seals. The vacuum sealing surface on the bottom edge of the lid mates with the vacuum chamber. No locking provisions are required.

The Lid Lifter or Lid Hinge mounts to the top of the Transport Chamber and has an arm bolted to the chamber lid. These mechanisms are used to safely raise and lower the lid when service is required.

NOTICE

Do not attempt to open the lid if the chamber is under vacuum.

Lid Lifter/Hinge

The lid may be raised to clean the inside of the chamber and the robot or to remove the robot, the robot arms, or the robot end effector(s). The lid may be provided with either a hinge or a manually operated, gear-driven lifter to allow easy opening and closing. Both the Lid Lifter and Lid Hinge provide a 90° opening angle in the vertical plane.

Using the Lid Lifter

The Lid Lifter is accessed from between the Load Locks. The lid lifter components are shown in [Figure 6-11](#).

 CAUTION Heavy Object	
The chamber lid can weigh up to 30 kg (67 lb). Personal injury could result in the squeezing or compression of head or arms when performing any service inside of the chamber during the lid is raised. Do not lean inside, or place hands or arms into the chamber unless the lid is in the full upright position and secured. The Lid Lifter mechanism is designed not to backdrive, however, the lid must never be left in an intermediate position. The only two acceptable positions for the lid are fully lowered, or fully raised (90°). Personnel should not place their head or arms into the chamber without providing an additional brace to the lid in case of lifter failure.	

NOTICE

Do not attempt to operate the lid lifter if the chamber is under vacuum, or the O-ring seal has not been released. Damage to the lifter will occur.

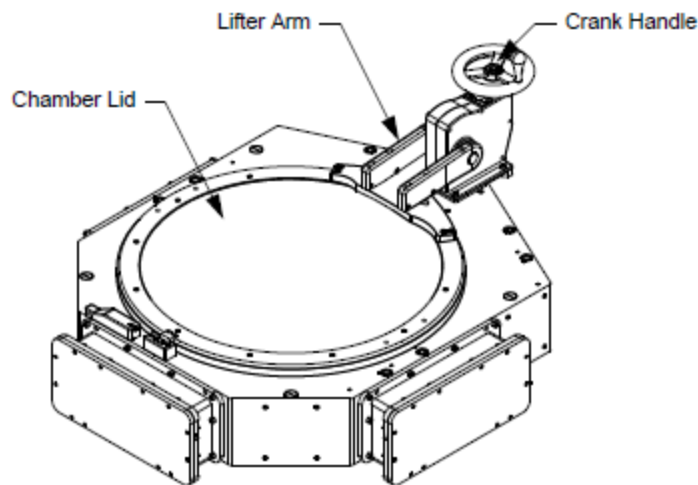
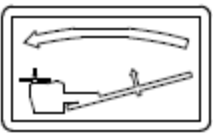


Figure 6-11: Lid Lifter Operation

Step	Action
1.	Vent the chamber to atmosphere.
2.	To raise the lid, turn the crank handle on top of the Lifter in a counter- clockwise direction.
3.	Using the handle, turn the hand wheel in the direction of the arrow on the label. Continue turning until the lid is in a 90° position (approximately 75 turns).  If turning the crank in the proper direction does not cause the lid to raise, stop immediately and recheck that the system is not in vacuum, the seal has been released, and nothing is obstructing the lid.
4.	Before closing the lid, inspect the o-ring for any sign of damage. Replace the o-ring if necessary. Turn the handle on the hand wheel in the opposite direction of the arrow to lower the lid.

Using the Lid Hinge

The Lid Hinge is located so that the lid can be easily opened. The lid hinge components are shown in Figure 6-12.

 CAUTION Heavy Object	
The chamber lid can weigh up to 30 kg (67 lb). Personal injury could result in the squeezing or compression of head or arms when performing any service inside of the chamber during the lid is raised. Do not lean inside, or place hands or arms into the chamber unless the lid is in the full upright position and secured. The Lid Lifter mechanism is designed not to backdrive, however, the lid must never be left in an intermediate position. The only two acceptable positions for the lid are fully lowered, or fully raised (90°). Personnel should not place their head or arms into the chamber without providing an additional brace to the lid in case of lifter failure.	

NOTICE

Do not attempt to operate the lid lifter if the chamber is under vacuum, or the O-ring seal has not been released. Damage to the lifter will occur.

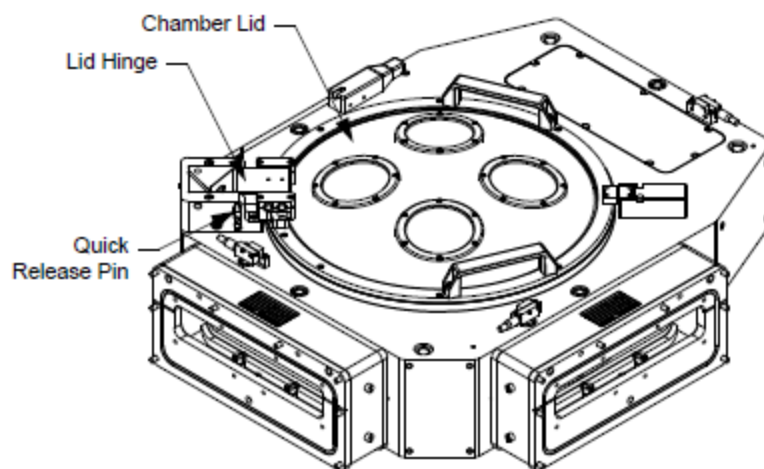


Figure 6-12: Lid Hinge Operation

Step	Action
1.	Vent the chamber to atmosphere.
2.	To raise the lid, remove the quick release pin from the hinge. Lift up on the handles on the lid and raise the lid to the fully upright position. Insert the quick release pin into the hinge.
3.	Before closing the lid, inspect the o-ring for any sign of damage. Replace the o-ring if necessary. Remove the quick release pin and lower the lid onto the chamber. Replace the quick release pin in the hinge.
4.	Before closing the lid, inspect the o-ring for any sign of damage. Replace the o-ring if necessary. Turn the handle on the hand wheel in the opposite direction of the arrow to lower the lid.

Frame Assembly

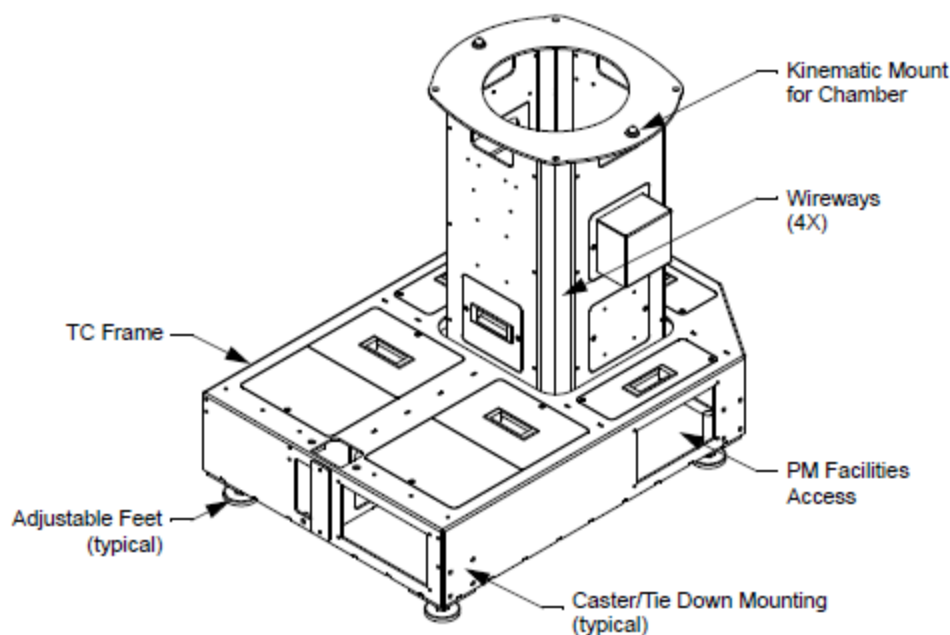


Figure 6-13: Typical M2 Frame Assembly

The Vacuum Back End frame is used to support the Vacuum Transport Chamber, the peripheral modules, various vacuum system components (e.g., gauges, and valves) and facilities interfaces associated with it. The frame consists of a welded steel structure.

The height of the frame is such that the height of the chamber's MTP above the facility floor when mounted on the frame is either 1100.0 mm (43.31 in) or 1200.0 mm (47.24 in) as specified by the user. Refer to ["Installation Procedure" on page 69](#).

The Vacuum Back End frame is provided with removable casters for rolling the chamber and frame to its destination. The frame is also equipped with adjustable feet allowing adjusting and leveling of the Vacuum Back End. Seismic hold-down locations are provided for user supplied brackets for facilities requiring earthquake protection. Refer to ["Installation Procedure" on page 69](#). Service access is provided under the chamber behind the Minienvironment and between the Process Modules, see ["Service Access" on page 63](#).

Load Locks

Single Load Locks

The basic single Load Lock is available and consists of an aluminum blank-off plate that is mounted in the floor of the Load Lock chamber supporting a two-level shelf system. The shelves are created by aluminum tabs attached horizontally to two support blocks mounted on the perimeter of the plate. Both the straight and angled LL can accept the Cooler option, which provides a z-lift mechanism that lowers the bottom shelf to deposit the wafer onto a cool tray.

The Load Lock mounts to the slot valve (FAP) on the Vacuum Back End at Station 2 for M2 Compact and M2 Tandem systems and at Station 1 and Station 2 for M2 Quad systems. The angled Load Lock mounts to the slot valves (FAPs) on the Vacuum Back End at Station 1 and Station 2 for M2 4, 5, 6, and 7 systems. The lid is fabricated from aluminum and Pyrex® and weighs 15 kg (33 lb). All Load Locks provide an atmospheric door at the interface to the Atmospheric Front End.

Stacked Load Locks

The Stacked Load Lock consists of two Straight Load Locks mounted vertically. The bottom Load Lock is inverted as compared to the top LoadLock. The shelves for the top and the bottom are created by aluminum tabs attached horizontally to two support blocks mounted on the perimeter of the plate for each of the two Load Locks.

The Stacked Load Lock can accept the Cooler option, which provides a Z-lift mechanism that lowers the bottom shelf of the Load Lock to expose the wafer to a cool tray. The Z-lift mechanism also moves the shelves to a position for access by the robots. The M2 may be configured with 2 (dual) stacked Load Locks.

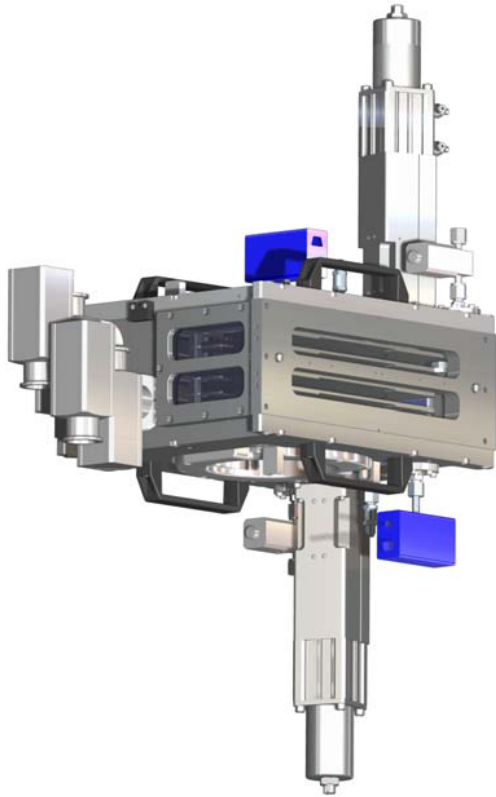


Figure 6-14: Typical Dual Load Lock

Operation

The Load Locks are located between the EFEM and the VBE and support two wafers each on shelves within the load lock during vacuum pumping and venting. When the Load Lock is vented, the atmospheric door can be opened for the atmospheric robot to place unprocessed wafers on the top shelf and pick processed wafers from the bottom shelf. When the LL is at vacuum, the vacuum slot valve can be opened for the vacuum robot to pick unprocessed wafers from the top shelf and place processed wafers on the bottom shelf. Refer to [Figure 6-15](#) for a diagram showing a typical Load Lock operation cycle.

NOTE: There are no wafer sensors in use for the Load Lock.

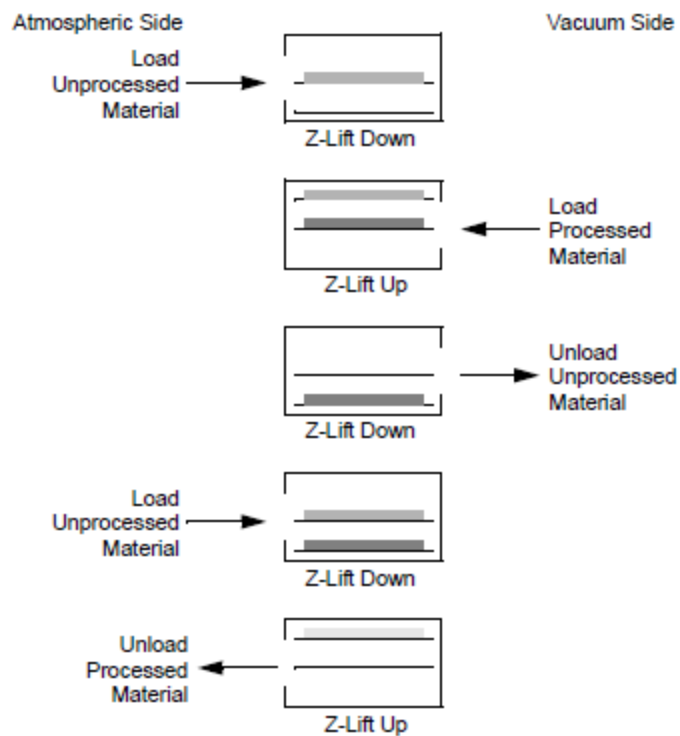


Figure 6-15: Load Lock Operation Diagram

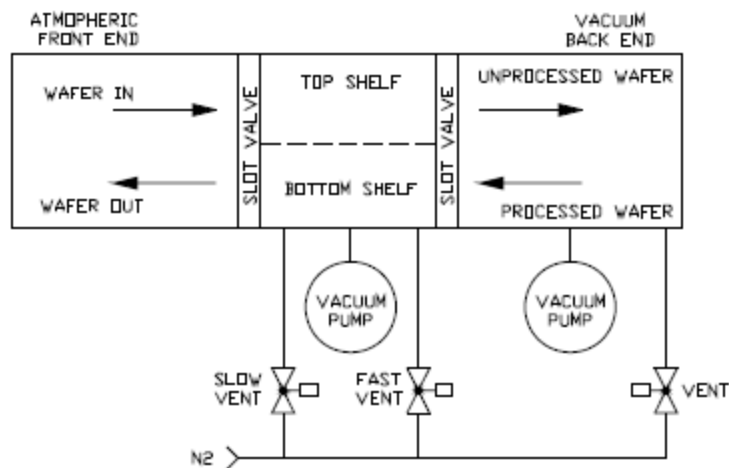


Figure 6-16: Load Lock Cycle Diagram

If the wafers coming out of the Process Module are hot, they can be cooled down within the LL. The "Load Locks" allows the hot wafer to be lowered, which deposits the wafer onto the cool tray. Once the wafer cools, the z-lift mechanism returns the wafer to the transfer position.

Cooling Option

The Load Lock with Cooler is a high reliability wafer cooler. This option is used when wafer cooling is required for processed wafers on the way out of the vacuum environment prior to insertion into a plastic cassette to prevent damage to the cassette.

The cooler consists of an aluminum cool platen with water cooled channels mounted in the floor of the Load Lock chamber that provides heat dissipation and a z-lift mechanism for moving the wafer down to the cool platen and up for handoff with the robots' end effectors. The cooler is easy to service with a removable cover providing easy access to the cool plate for cleaning.

Once the vacuum robot retracts after placing a wafer on the shelf of the lift mechanism it is lowered to the Cool Plate to facilitate wafer cooling. After the cool cycle is complete the wafer is raised for handoff to the atmospheric robot. The z-lift mechanism moves from fully up to fully down within 2 seconds.

A second shelf above the cool platen is utilized for passing unprocessed wafers through the LL from the atmospheric side into the vacuum side for processing.

Operation

The basic operation of the Load Lock with Cooler is the same as the standard Load Lock. The cooling option provides cooling for the hot processed wafer placed on the bottom shelf by the vacuum robot.

NOTE: The time and temperature requirements for cooling must be determined by the user for their specific application.

The vacuum slot valve is opened and the vacuum robot places a hot processed wafer on the bottom shelf of the Load Lock. The vacuum robot then picks the unprocessed wafer from the top shelf and retracts. The vacuum slot valve is then closed and the z-lift mechanism lowers the hot wafer on the bottom shelf depositing it on the cool platen. The Load Lock is vented to atmospheric pressure with nitrogen using a two-stage profiled vent process.

After venting is complete the atmospheric door is opened. The atmospheric robot places a new unprocessed wafer on the top shelf and retracts. The z-lift raises the cooled wafer off of the cool platen back to the transfer position. The atmospheric robot then picks the cooled wafer from the bottom shelf. The atmospheric door is closed and the Load Lock is pumped down to the vacuum setpoint. Refer to [Figure 6-16](#) for a diagram showing a typical Load Lock operation cycle.

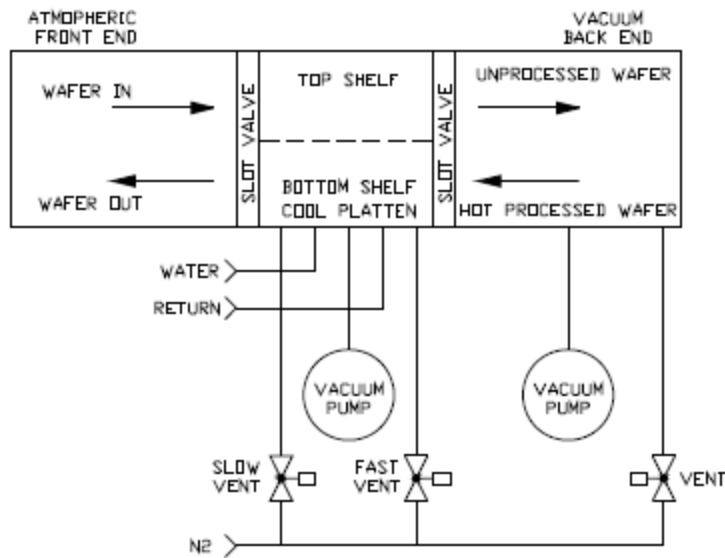


Figure 6-17: Load Lock with Cooler Cycle Diagram

Vacuum/Venting Systems

The modular design of the M2 Vacuum Back End allows for configuration changes to support different vacuum system packages. To the extent possible, the individual vacuum system packages feature the same components to reduce the number of required spare parts and to simplify maintenance and repair.

The M2 systems are supplied with vacuum system packages to provide environmental control for the Transport Chamber, the Load Locks, and any other peripheral items, as requested. Vacuum system packages are designed to minimize the introduction of contaminants into the chambers during evacuation and vent processes by using profiled pump downs and profiled vent ups. The complete M2 system provides integrated management of all vacuum system packages supplied with the M2 system.

Each vacuum system package has five elements: a "[Vacuum Pumping System](#)", "[Chamber Isolation Valves](#)", a "[Venting System](#)", a "[Vacuum Measurement System](#)", and "[Vacuum System Control](#)".

Vacuum Pumping System

The pumping system is designed to bring the modules of the M2 system from atmospheric pressure to vacuum with minimum introduction of contaminants and turbulence. Each module to be evacuated generally incorporates a main pump, a backing pump, a pump vent valve, and a pump controller. Roughing vacuum is required and can be provided by a Brooks Automation supplied backing pump or from a customer provided source.

High Vacuum Pump(s)

Optional high vacuum pumps, which are normally turbomolecular (turbo) pumps or cryogenic (cryo) pumps, are used to evacuate the Transport Chamber and Load Lock chambers. Turbomolecular pumps require backing vacuum pumps to operate properly.

Integrated Point of Use Pump

The M2 systems use a single mechanical dry pump in conjunction with staging valves to support two rough pumping processes. This is a pump with dry working chambers, i.e., the gases being pumped from the pump chamber do not come into contact with any lubricant. A single mechanical pump (Alcatel A100 or equivalent) is used in the M2 systems to evacuate the Transport Chamber and the Load Locks. The mechanical pump is powered by three phase 208 VAC, routed through the ACPD, and is controlled via a serial I/O connection.

A two-stage, slow/fast roughing process is used on the Load Lock, and a single-stage fast rough process is used in the Transport Chamber. When a turbo pump is installed, the same dry pump may sometimes be used as a backing pump for the turbo.

Pump Vent Valve

For high vacuum systems using turbo pumps, the pumping system includes valves to permit venting and braking of each turbomolecular pump when it is to be stopped during evacuation and vent cycles. These valves, each connected directly to the vent port of its respective pump, are controlled by the host controller. Cryogenic pumps are equipped with a regeneration kit, which contains vent and rough vacuum valves.

Chamber Isolation Valves

Isolation valves are used to isolate the chambers of the system from vacuum system components or other chambers. All control and monitoring of the isolation valves is done through the I/O communications link with the host controller.

Vacuum Isolation Valves

The Load Locks and Transport Chamber vacuum systems include a valve located between the Load Lock chamber or the Transport Chamber and their respective pumps. This valve is used to isolate the chamber from the module's vacuum system during chamber vent cycles and when the vacuum system is not operating.

Transfer Isolation Valves

The M2 system is supplied with Transfer Isolation Valves (Slot Valves) located between the Transport Chamber and the Load Locks and Process Modules. Additional Transfer Isolation Valves (Atmospheric Doors) are located between the Load Locks and the Atmospheric Front End.

These valves are used to isolate the Transport Chamber from the environmentally controlled Process Modules during material processing and to isolate chambers during vent cycles (load and unload operations).

Vacuum Slot Valves

Vacuum slot valves are located between the Process Modules and the Vacuum Transport Chamber. These slot valves make use of a Facet Adapter Plate (FAP) to provide custom mounting and ease of service. These valves isolate the Process Module to allow independent pumping/venting of the PM chamber and to prevent contamination of the environment within the Vacuum Transport Chamber by the hostile environmental conditions within the Process Modules during material processing.

Vacuum slot valves are located between the Load Locks and the Vacuum Transport Chamber. These slot valves make use of a Facet Adapter Plate (FAP) to provide custom mounting and ease of service. These valves allow the Vacuum Transport Chamber to maintain a vacuum while the Load Lock is vented for material transfer into atmosphere.

Atmospheric Doors

The atmospheric door is located between the Atmospheric Front End and the Vacuum Load Locks. This allows the Load Locks to be pumped down for material transfer into vacuum.

Venting System

The M2 systems use two stage venting through a filter/diffuser. The Transport Chamber uses a fixed orifice vent valve, and a filter/diffuser which is either open or closed. Typically the Load Lock uses two-stage fixed orifice venting to minimize particle contamination.

To minimize particulate redistribution during the Load Lock chamber vent cycle, the variable flow venting subsystem employs a controlled flow of nitrogen to vent the evacuated chamber. The initial rate of flow of nitrogen into the chamber remains low (molecular pressure regime, no boundary layer to restrict particle movement) until the chamber pressure reaches a predetermined setpoint. After reaching the setpoint, venting proceeds at a higher rate (viscous pressure regime, boundary layer suppresses particle movement) until the chamber reaches atmospheric pressure.

Vent System

A venting system is provided with each loadlock. Construction is of Electropolished stainless steel tubing with welded fittings. A high purity POU filter/ diffuser membrane is installed on all vent inlet ports to provide true point of use filtration. A digital pressure gauge is provided to monitor vent gas pressure.

Purge System (Transport Chamber) - Optional

A Mass Flow Controller is located in parallel with the Transport Chamber vent line. Typically this is a 500 SCCM (N2 Calibration) device, however other flow ranges are available. This DeviceNet MFC may be used to control the flow of purge gas into the Transport Chamber as required.

Vacuum Measurement System

The vacuum measurement system permits the host controller to monitor and control pressure in each environmentally controlled chamber during evacuation and venting cycles. For each chamber, the system consists of a vacuum measurement controller, and one or two vacuum gauges.

Vacuum Measurement Controller

The vacuum measurement system includes Vacuum Measurement Controllers located in the smart gauges that interpret signals from the gauges and communicate with the host controller.

Gauges

High vacuum systems using turbo pumps or cryo pumps require gauges to monitor the vacuum pressure from atmosphere down to the 5×10^{-8} Torr region. Two types of vacuum gauges are used on the M2 system: Microlon and MiniConvectron. MiniConvectron gauges have a pressure range from atmospheric level down to 1 mTorr (1×10^{-3} Torr). Microlon gauges cover the pressure range from 50 mTorr down to 5×10^{-8} Torr. The ranges of both gauges overlap so that the Microlon gauges are turned on when the MiniConvectron indicates the pressure is below the maximum level for ion gauges. Each gauge contains a controller and uses DeviceNet for power and communications, all set-point relay signals are available through DeviceNet I/O points.

Convectron style gauges are installed on each Load Lock and on the Transport Chamber. A standard convectron gauge is also installed in the foreline manifold to measure backing vacuum.

Vacuum System Control

Vacuum System control resides with the host controller. During venting and evacuation cycles, each gauge monitors pressure levels in its respective chamber to ensure proper timing of vent and evacuate operations.

Vacuum/Vent System Operation

The Vacuum System is designed to distribute vacuum to the Load Locks and Transport Chamber. The Vent System is designed to deliver N2 to the M2 system for venting from vacuum to atmosphere.

Pressure Switch

The Pressure Switch on the N2 vent stick monitors the manifold pressure. The switch has an LCD display on the face of the gauge for setup and system troubleshooting. If a low pressure condition occurs, the switch may be used to send an alarm message to the host controller.

Diaphragm Valves

The diaphragm valves in the vent system are normally closed and require pneumatic pressure to open. The pneumatic line requires venting for the spring return to close the valve. These valves provide Fast Vent and Slow Vent (profiled) control for soft-start (refer to ["Vent System" on page 146](#)).

Vacuum System, Typical Vent Cycle

Vent Transport Chamber

Step	Action
1.	Shut the pump foreline valve.
2.	Open the fast vent valve.
3.	Close the vent when the chamber pressure gauge indicates pressure is equal to outside (atmospheric) pressure.

Vent Load Locks

Step	Action
1.	Shut the pump foreline valve.
2.	Open the profiled vent valve.
3.	When the pressure > 80 Torr (or any other specified crossover pressure), open the fast vent valve.
4.	Close the vent valve when the chamber pressure gauge indicates pressure is equal to outside (atmospheric) pressure.

Vacuum System, Typical Vacuum Cycle

Pump Transport Chamber

Step	Action
1.	Verify the vent valves are closed.
2.	Open the rough valve.
3.	Shut the rough valve when the Transport Chamber is at the desired vacuum level.

Pump Load Locks

Step	Action
1.	Open the slow rough valve.
2.	Open the fast rough valve at crossover pressure (80 Torr or any other specified crossover pressure)
3.	Close the slow and fast rough valves.

Pneumatic System

Compressed air is used to power various valves within the M2 system. The Pneumatic System provides control and routing of compressed air for control of all pneumatically operated subsystems. Located in the Vacuum Back End's frame, the Pneumatic Facilities Interface is easily accessible for service.

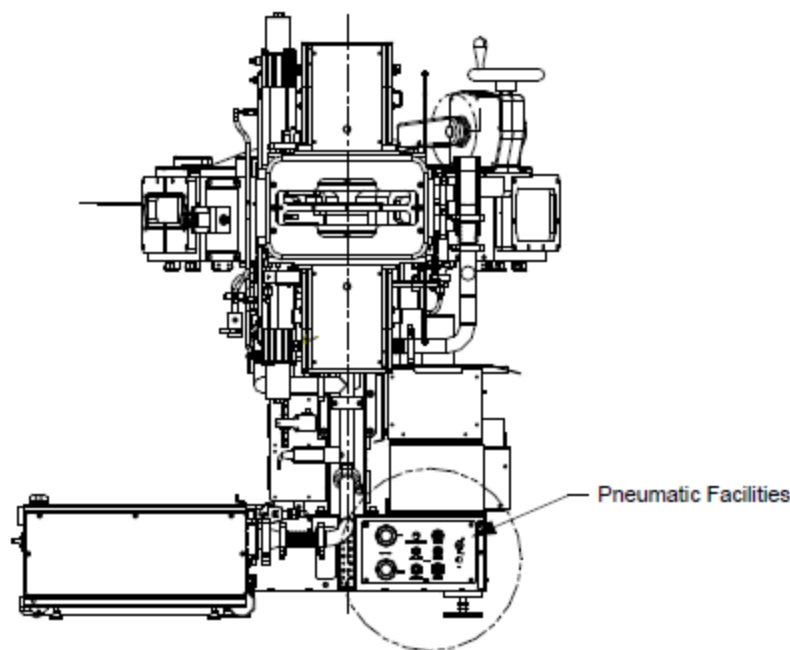


Figure 6-18: Typical Pneumatic Facilities

The Pneumatic Facilities connection is located underneath the chamber. The Pneumatic Facilities allows a single point interface for facilities supplied compressed air. The air pressure is monitored by a Digital Pressure Switch. The tubing for the pneumatics is color coded for easy tracing.

With the proper sizing of air lines and exhaust lines, minimal supply sag and exhaust back pressure is achieved. Connections are provided for Air In, Exhaust, Air Supply for EFEM, Exhaust from EFEM, and an Overpressure Exhaust. Refer to the ["Facilities Specifications" on page 58](#),

"[Vacuum/Venting Systems](#)" on page 144, and "[Pressure Switch](#)" on page 148 for operation. Refer to the Pneumatics Diagram supplied with the System Manual for additional information.

Pneumatic Manifolds

The M2 system requires compressed air for operation of pneumatic valves. Typically, four pneumatic banks control the valves in the M2 system. One pneumatic bank for each Load Lock, located near the LL, provides control for the pneumatic system of the Load Lock it is associated with. Two pneumatic banks located on the transport chamber provide control for the slot valves to the Process Modules and Load Locks as well as other valves located in the Transport Chamber.

Gas System

The M2 system's frame assembly includes a gas facilities interface. This provides a connection for the M2 system to nitrogen supplied by the facility. Located in the Vacuum Back End's frame below the ACPD, the Nitrogen Facilities Interface is easily accessible for service.

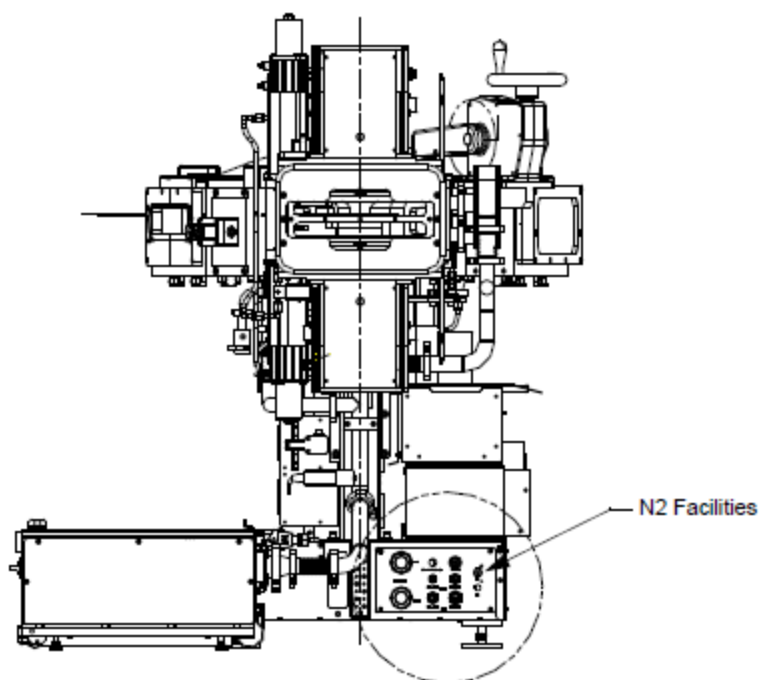


Figure 6-19: Typical Nitrogen Facilities

The Nitrogen Facilities connection is located underneath the chamber. The Nitrogen Facilities allows a single point interface for facilities supplied nitrogen. The gas pressure is monitored by a Digital Pressure Switch, refer to "[Pressure Switch](#)" on page 160. Refer to the "[Facilities Specifications](#)" on page 58, "[Vacuum/Venting Systems](#)" on page 144, and "[Pressure Switch](#)" on

[page 160](#) for operation. Refer to the Pneumatics Diagram supplied with the System Manual for additional information.

Cooling System

The M2 system's frame assembly may include optional cooling water distribution. This provides a connection for the M2 system to water supplied by the facility for cooling of pumps and any other system components that require water cooling. Located in the Vacuum Back End's frame below the ACPD, the Water Facilities Interface is easily accessible for service.

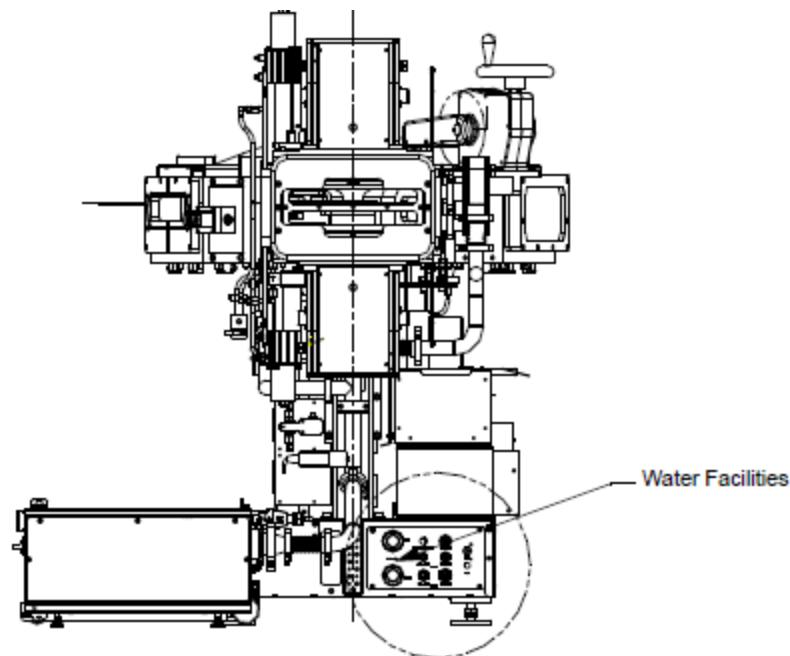


Figure 6-20: Typical Water Facilities

Cooling water is supplied to the M2 system for the three water cooling systems within the M2 system. One is used to distribute cooling water to the Process Modules. Another cooling system is used for the pumps and any other system components that require water cooling. Another cooling system provides cooling of hot wafers before they are returned to the Atmospheric Front End for storage in a wafer carrier. Each of the cooling tasks is optional and may not be installed on a specific system.

The Water Facilities connection is located underneath the chamber. The Water Facilities allows a single point interface for facilities supplied cooling water. Refer to the ["Facilities Specifications" on page 58](#).

Electrical System

Refer to the System Block Diagram supplied with this manual for specific details on the system.

The control system provides a single Ethernet connection from the host controller to the M2 system. This connection provides communications for all controlled and monitored devices on the M2 system including; robots, aligner, load locks, load ports, pumps, valves, and gauges. Refer to the System Block Diagram supplied with this manual for all factory configured IP and MAC ID addresses. For additional information on IP and MAC ID addresses refer to the M2 Software Programmer's Reference.

Enhanced safety interlocking capabilities exist, providing operational interlocks to protect the M2 system and the material moving through it. These interlocks, available through the Safety Node, include; slot valve operation checks, robot motion checks, and access lid position sensing. Additional interlocks may be provided through the host controller's software.

The AC power wiring runs in a tree-like structure with one main connection to the facility's power mating to the AC Power Distribution unit on the M2 system's frame.

Interlocks and System Controller

See the appropriate controls manual for more information.

Ethernet Switch

The Ethernet Switch provides a single point of connection for Ethernet communication. The switch is mounted on the Transport Chamber frame under the chamber and provides distribution for up to fifteen Ethernet devices. LEDs on the switch indicate the status of each Ethernet channel. The switch is powered from a remote AC Adapter module.

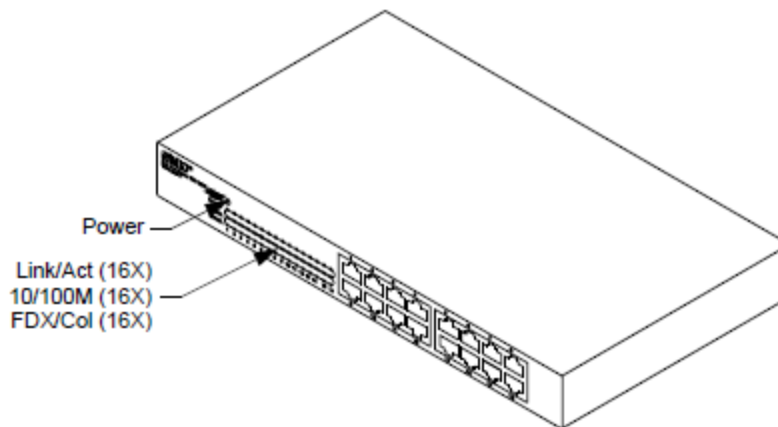


Figure 6-21: Typical Ethernet Switch Module - Controls and Indicators

Switch Operation

The devices connected to the Ethernet Switch are accessed through standard Ethernet communications to the specified IP Address for each device connected to the switch. LEDs on the switch indicate the status of each Ethernet channel. Refer to the System Block Diagram supplied with this manual for additional information, [Table 6-3](#) for pinouts, and [Table 6-4](#) for controls and indicators.

Table 6-3: Ethernet Switch Module Connections

Label	Description	Connector Type
Ethernet (x16)	10/100 Mbps MDI-X	RJ-45
PWR	110-240 VAC	Male IEC 320

Table 6-4: Ethernet Switch Module - Controls and Indicators

Name	Type	Function
Power	Green Lamp	Power Normal condition: ON
10/100M (16X)	Green Lamp	Connection Speed ON: 100 Mbps OFF: 10 Mbps
Link/Act (16X)	Green Lamp	Link Status/Activity ON: Port connected Off: Port not connected Blink: Port active
FDX/Col (16X)	Green Lamp	Duplex Mode/Collisions ON: Full duplex Off: Half duplex Blink: Data transfer packet collisions

AC Power Distribution

AC power within the Marathon Express is distributed throughout the tool from the AC Power Distribution Unit (ACPDU), which also provides circuit protection. Figure 6-22 shows the location of the controls and indicators on the ACPDU. Figure 6-22 shows the functions associated with each of them.

NOTE: The ACPDU is not intended to supply power to user installed modules.

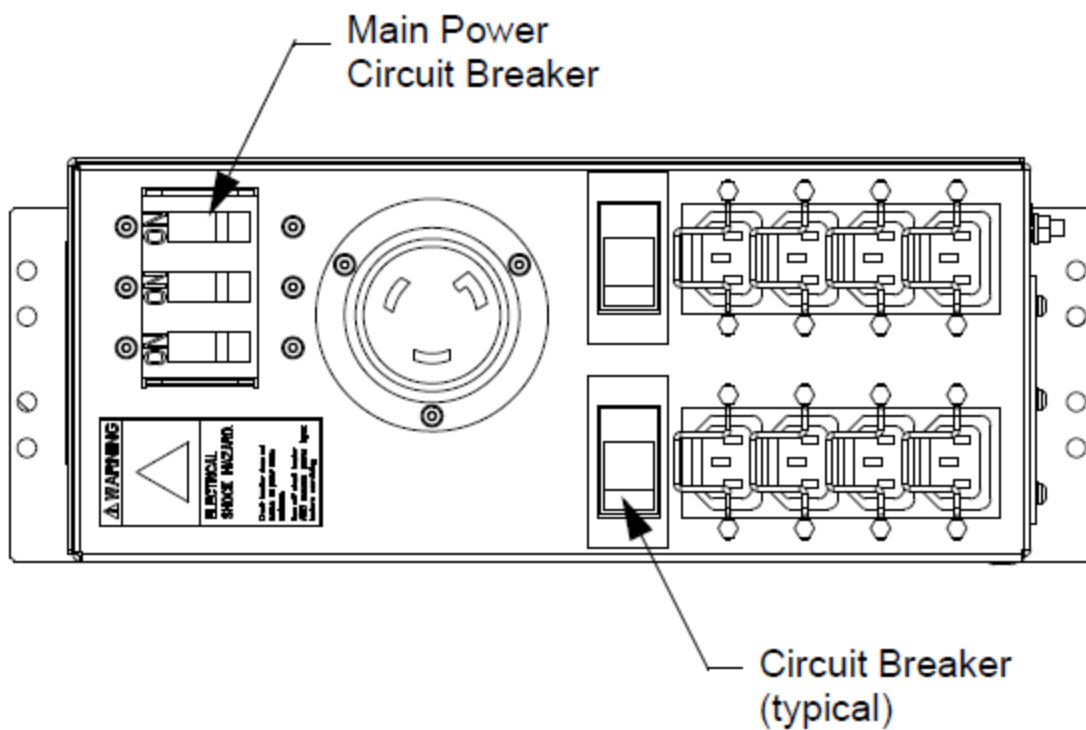


Figure 6-22: AC Power Distribution Unit - Controls and Indicators

Table 6-5: AC Power Distribution Unit - Controls and Indicators

Name	Type	Function
CB1	Circuit Breaker, 20 A	Main Circuit Breaker ON: Power on OFF: Power off

Name	Type	Function
CB1	Circuit Breaker, 10 A	Output Circuit Breaker 1 ON: Power on OFF: Power off
CB2	Circuit Breaker, 10 A	Output Circuit Breaker 2 ON: Power on OFF: Power off

Ethernet to Serial Gateway

The Ethernet to Serial Gateway provides a serial I/O (RS-232, RS-422, RS-485) communications interface through the Ethernet. The gateway is mounted on the Transport Chamber frame under the chamber and the serial communications cables are routed to the appropriate devices. Support for up to two serial I/O channels is provided with distribution including the pumps and other devices using serial communications. The Serial Gateway shown in [Figure 6-23](#) shows the typically configuration, however other configurations may be used.

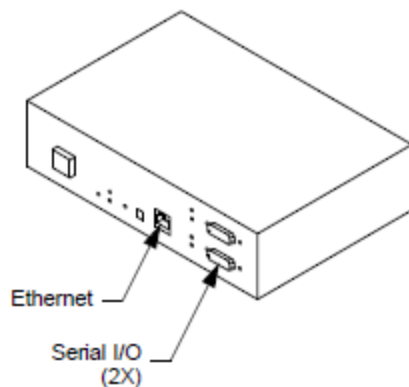


Figure 6-23: Ethernet to Serial Gateway

The Ethernet Serial Gateway provides web-based configuration of all operating parameters. The Ethernet address and serial I/O ports are user configurable. I/O types (RS-232, RS-422, RS-485) and serial communications settings for each channel are also user configurable.

Gateway Operation

The devices connected to the Ethernet Serial Gateway are accessed through standard Ethernet communications to the specified IP Address and Port for each device connected to the gateway. The serial data stream is internally buffered allowing the gateway to send and receive data using the standard software commands for the devices with a gateway header to direct the command to the appropriate serial communications channel.

LEDs on the serial gateway indicate the status of each serial I/O channel. The serial gateway is powered from a remote AC Adapter module.

NOTE: If more than one Ethernet Serial Gateway is installed on the M2 system, the IP address settings cannot be the same for each node.

Refer to the System Block Diagram supplied with this manual for additional information, Table 6-14 for pinouts, and Table 6-15 for controls and indicators.

Connections, Controls, and Indicators

For the typically configuration of the Ethernet to Serial Gateway [Figure 6-24](#) shows the location of all connections, controls, and indicators. [Table 6-6](#) lists the connections found on the gateway, and shows which type of connectors are used. [Table 6-7](#) provides descriptions of the user accessible controls and indicators.

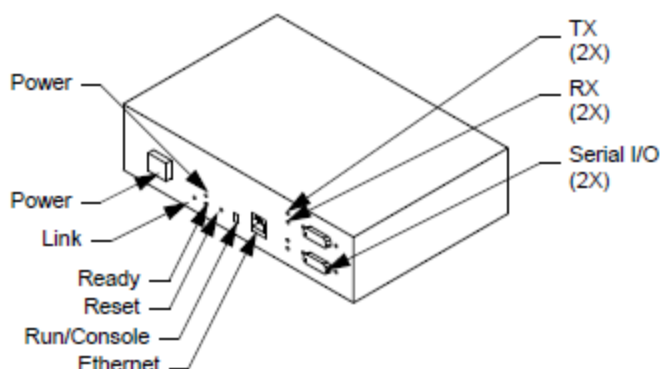


Figure 6-24: Ethernet to Serial Gateway

Table 6-6: Ethernet to Serial Gateway Connections

Label	Description	Connector Type
Ethernet	Ethernet In	Female RJ-45
1 - 2	Serial I/O	Male DB-9
PWR	24VDC	4-pin Terminal Strip

Table 6-7: Ethernet to Serial Gateway Controls and Indicators

Link	Type	Function
Link	Bi-color Light	Indicates working Ethernet connection Yellow: 10BaseT Green: 100BaseT)
Ready	Green Light	Gateway status Flashing: system ready)
Power	Red Light	Power Normal condition: ON
Reset	Push Button Switch	A recessed reset switch that allows the united to be reset. Insert a small plastic tool, press lightly and hold for three seconds. The Link and Ready lights will go out and then come back on.
Run/Console	Dip Switch	Allows the Serial Server to be switched between Run Mode and Console Mode. - Console Mode allows configuring the Serial Server from a PC running a terminal emulator without connecting the server to the network. - Run Mode is used to communicate with the connected serial devices through the Ethernet.
RX	Red Light	Serial communications receive Normal condition: Flickering
TX	Green Light	Serial communications transmit Normal condition: Flickering

Facet Adapter Plates

The Facet Adapter Plates used in the M2 system provide customization of the slot valve interface. The Facet Adapter Plate (FAP) is an aluminum housing that contains the slot valve door with a door actuator and provides the sealing surfaces. It also joins the transfer chamber to the Load Lock or Process Module.

The FAP is a comprised of four main components, the FAP body, the Actuator, which provides the motion for the Door Assembly, the Door Assembly, which is attached to the actuator shaft and seals against the Insert, and the Insert, which seals against the Process Module face, and contains the material slot opening, around which the seal between the insert and door occurs. Each of these components can be produced and supplied in a number of different materials, configurations, and sizes.

The slot valve components mount directly to the FAP body. All alignment and locating features are found on the FAP body. The insert face o-ring seals against the process chamber face, and, by design, there is no possible metal-to-metal contact between the FAP insert and the Process Module body.

The slot valve mechanism in the FAPs are controlled through the DeviceNet Network. The slot valves are controlled through a DeviceNet operated pneumatic manifold via 6 mm lines, one each

for up/close and down/open per slot valve. There are typically four manifolds in M2 system: the two TC manifolds, Load Lock A manifold, and Load Lock B manifold. Operation of the slot valves in unsafe condition is inhibited by the Safety Node.

For an overview of the Slot Valve cabling, refer to the system block diagram.

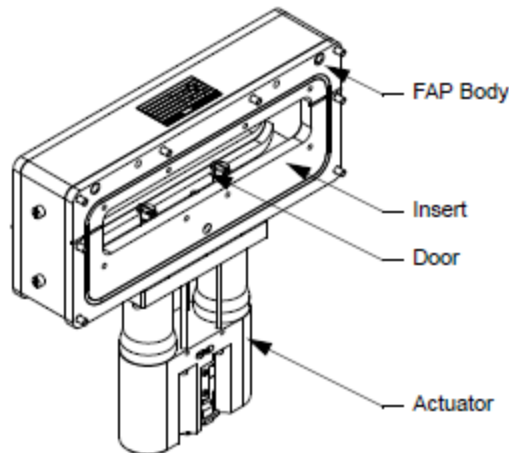


Figure 6-25: Facet Adapter Plate (Slot Valve)

Wafer Presence Sensors

To safeguard against material-handling mishaps, the Vacuum Back End contains optical material sensors at each station. The M2 system design has one material present sensor at each Process Module facet. Each sensor is located for use as a Radial Motion (R_MT) sensor for the robot and is located under the chamber at a radius outside the retracted position of the robot. These sensors are configured as either EXtend or REtract type sensors (refer to the robot user manual). The robot senses the material on-the-fly during PICK, PLACE, GOTO, and XFER operations.

Each sensor is capable of being associated to any station and configured as active or inactive during material transfer. The robot firmware will monitor these sensor inputs and use them to verify material presence status and determine the success of any material transfer operations.

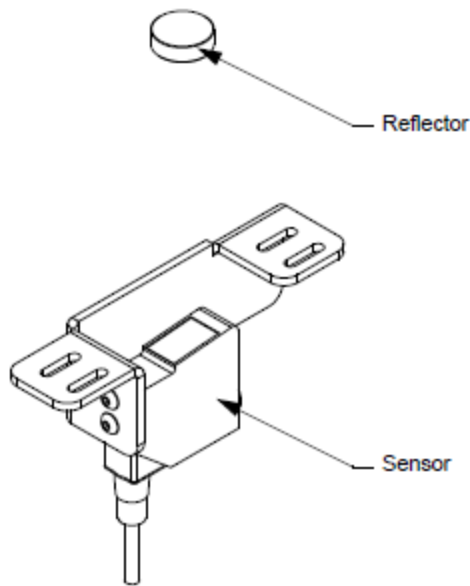


Figure 6-26: Wafer Presence Sensor

Pressure Switch

There are Pressure Switches on each M2 system that are used to monitor the pneumatic and nitrogen pressure. Both the pneumatic Pressure Switch and the nitrogen Pressure Switch are connected to the DeviceNet through an I/O Block. The signals from these switches are available to the system controller for monitoring the status of the air pressure within the Pneumatic System and the status of the nitrogen pressure within the Vent System.

The Pneumatic Pressure Switch is mounted in the Pneumatic Manifold at the facilities connection for compressed air, refer to "[Pneumatic System](#)" on page 150. The Nitrogen Pressure Switch is mounted on the Vent Manifold at the facilities connection for nitrogen, "[Gas System](#)" on page 151.

Refer to the System Block Diagram and Vacuum and Vent Diagrams supplied with this manual for additional information.

Nitrogen Switch Setup and Operation

The nitrogen switch is set at the factory for proper operation.

Pneumatic Switch Setup and Operation

The pneumatic switch is set at the factory for proper operation.

Ethernet

Ethernet communication allows the M2 system to send and receive data faster than with serial communication. Additionally, when using Ethernet multiple devices can communicate over the same cable through the use of a network switch.

Ethernet Implementation

Each device (serial gateway, etc.) connected to the Ethernet has its own address. Refer to the System Block Diagram supplied with this manual for identification of all factory configured Ethernet addresses. For additional information on Ethernet IP addresses refer to the M2 Software Programmer's Reference.

Ethernet Switch

The Ethernet Switch provides a single point of connection for host controller communication with the M2 system using Ethernet. Each device using Ethernet for communication is connected to the Ethernet Switch.

Ethernet to Serial Gateway

Support for devices using serial communication is provided in the M2 system by using an Ethernet to Serial Gateway. The user's host controller must establish an Ethernet connection with the Serial Gateway to exchange data between the host and the serial devices. Each device connected to the serial gateway is identified by the gateway's IP address and I/O channel. For each serial I/O devices a user assigned Link and Port Number is used to identify the connection to the device.

DeviceNet

Network communications using the DeviceNet tool network allows the host controller to communicate with the various subsystems of the M2 system over a single internal network cable. Additionally, power can be provided over the DeviceNet network cable to low power modules. Each device connected to the DeviceNet network has a unique network device address. Only communications addressed to a specific device through the network will be received by that device.

In the Vacuum Back End, the host controller may control the robot through an Ethernet connection. Those modules (i.e., robot, pumps) that use serial I/O communications (RS-232) are controlled through the Ethernet connection using an Ethernet to Serial Gateway. All other subsystems (i.e., valves, gauges, indicators, etc.) within the M2 system are controlled and monitored through a connection to the DeviceNet Master Node using both direct connection to the DeviceNet bus and DeviceNet I/O modules.

For more information, refer to the appropriate controls manual.

Vacuum Robots

The Brooks Automation vacuum robots are compact, direct drive, continuous rotation material handlers designed for high vacuum environments. The unique design of the robot allows unlimited motion in the T (rotational) axis. The robots are capable of accepting a variety of arm types supporting from one to four end effectors.

Refer to the Brooks Automation User Manuals for information on the robots.

Teach Pendants

See the appropriate robot manual for more information.

Start-up

The M2 system is started by applying power and plant facilities as previously specified in ["Installation" on page 65](#). Once this is done, the M2 system is ready to operate and will accept commands over the communications line.

NOTE: All switch settings, communications connections, power connections, and facilities connections should be made before power is applied.

This section describes the recommended procedure for powering up the Brooks Automation M2 Vacuum Transport System under normal circumstances.

Step	Action
1.	Verify that all of the installation procedures previously outlined in "Installation" on page 65 have been completed.
2.	Turn on the M2 system following the "Power-up Sequence" on page 89 . If the initialization sequence executes without error, then all the components are referenced, and all the components are communicating successfully.
3.	Power up the Transport Module Controller.
4.	Once all systems are up and running properly the host controller typically instructs the M2 system to begin pumping down the Transport Module chamber.

Normal Running

The exact usage of the M2 Vacuum Transport System must be determined by the user. Each component has been described in this manual with the intention of providing the user with the knowledge to use this tool in the most appropriate manner for their individual processes. During normal operation, typically, once the Transport Module chamber has been pumped down, proceed as directed by the Cluster Tool Controller.

Typical VBE Operating Sequences

Pick

The robot picks material from the specified slot in the specified station. If no slot is specified, Slot 1 is assumed.

Step	Action
1.	The host controller checks to verify that there is material present in the station's slot.
2.	The robot rotates to the specified station.
3.	The robot checks the station material sensor to verify that there is no material on the end effector.
4.	The host controller opens the slot valve after checking that the pressures are equal between the two chambers.
5.	The robot extends, picks the material, and retracts.
6.	The robot checks the station material sensor to verify that there is material present on the end effector.
7.	The host controller checks to verify that there is no material in the slot.
8.	The slot valve closes.

Place

The robot places material to the specified slot in the specified station. If no slot is specified Slot 1 is assumed.

Step	Action
1.	The host controller checks to verify that there is no material in the station's slot.
2.	The robot rotates to the specified station.

Step	Action
3.	The robot checks the station material sensor to verify that there is no material on the end effector.
4.	The host controller opens the slot valve after checking that the pressures are equal between the two chambers.
5.	The robot extends, places the material, and retracts.
6.	The robot checks the station material sensor to verify that there is material present on the end effector.
7.	The host controller checks to verify that there is no material in the slot.
8.	The slot valve closes.

Safe Shutdown

The following shutdown procedure is used to remove power from the M2 system in an orderly manner and place the robots and all other components within the system in safe conditions. This procedure is used to prepare the system for repair, removal, or maintenance.

NOTE: When the host controller is to be shutdown, the M2 system should be shutdown first.

NOTICE

The shut-down procedure is used in the normal shut-down of the M2 system. This procedure completely removes the power source and all other facilities supplied to the M2 system and provides guidelines for lockout/ tagout. This procedure is not the same as an EMO circuit or other safety interlock.

Step	Action
1.	All material transfers should be completed. All material should be in the Load Port Modules only. If this is not possible, at least ensure that no material is left on the end effectors.
2.	If permanent storage of values is desired for robots using robot software, STORE values using appropriate STORE commands for each robot, load port, and aligner. NOTE: <i>The Brooks robot load parameter values will be reset to default values if power is removed.</i>
3.	All robots should be in the Home position (arm(s) retracted).
4.	All chambers of the system should be at atmosphere.

Step	Action
5.	All Load Port Modules should be closed.
6.	All other material handling modules should be in their Home position.
7.	Turn off power to each robot by turning off the power switch on the Controller or power supply for each robot.
8.	Turn off the air supply from the facility to the M2 system.
9.	Turn off the nitrogen supply from the facility to the M2 system.
10.	Turn off the vacuum supply from the facility to the M2 system.
11.	Turn off the water supply, if used, from the facility to the M2 system.
12.	Turn off the main power disconnect for the M2 system.
13.	Secure the M2 system using Lockout/Tagout procedures defined by the facility. These procedures may include an energy isolating device to prevent the controller from being plugged into the facilities power outlet, along with information about the purpose of the lockout and the person responsible. If no such procedures exist, follow the guidelines provided in "Laser Hazards" on page 41 .
14.	Secure all gas and vacuum supply lines using Lockout/Tagout procedures defined by the facility. These procedures may include an isolating device to prevent the supply lines from being connected into the facilities supply, along with information about the purpose of the lockout and the person responsible. If no such procedures exist, follow the guidelines provided in "Laser Hazards" on page 41 .

NOTE: This procedure only shuts down facilities to the M2 system and its subsystems. Any user Process Modules or other equipment will remain powered up.

7. Preventative Maintenance

This chapter provides complete maintenance schedules and procedures for the Brooks Automation M2 system.

This section provides the schedule and procedures for routine preventive maintenance of the M2 system to reduce unscheduled downtime. The M2 system is designed to require very little routine maintenance. However, it is recommended that the preventive maintenance procedures and schedule provided in this section be followed to extend the operating life of the M2 system and to minimize unscheduled downtime. If additional procedures are required, they will be supplied along with their maintenance schedules by Brooks Automation.

All Preventive Maintenance procedures and schedules provided here assume that the Brooks M2 system is operating in a clean, dry, inert environment. Any deviation from this basic environment will affect the scheduling of PM and may also require additional PM procedures be performed. The user should adjust the Preventative Maintenance Schedule as appropriate to account for any deviations from this environment.

NOTE: Brooks Automation offers training for troubleshooting and repair of the M2 system. Only qualified, properly trained persons should perform any maintenance or repair procedures. Damage resulting from improperly performing a procedure is not covered under warranty or service agreements.

 CAUTION Unauthorized Service	
Personal injury or damage to equipment may result if this product is operated or serviced by unauthorized personnel. • Only qualified personnel are allowed to transport, assemble, operate, or maintain the Product. • Properly qualified personnel are those who have received certified training and have the proper qualifications for their jobs.	

Parts

Brooks Automation can provide all parts required for Preventive Maintenance. For a list of these parts, contact Brooks Automation Technical Support. To obtain additional information about parts for preventive maintenance, contact your local Brooks sales representative, or call Brooks Automation Technical Support at 978-262-2900 (Monday - Friday, 8:00 am - 5:00 pm Eastern Time).

Schedules and Procedures

The following maintenance schedule and procedures will provide the information required for standard user maintenance of the Brooks Automation M2 system. [Table 7-1](#) is provided as a quick reference to all scheduled maintenance. If additional procedures are required during the performance of any procedure, they will be provided. The frequency for performing the procedure is provided and the page number is provided for those procedures in this manual.

Refer to the individual component manuals and any separate preventative maintenance procedures provided with the individual system components for additional maintenance procedures.

NOTE: The following Preventive Maintenance Schedule is based on a certified clean, dry environment. The user should adjust the Preventative Maintenance Schedule to account for any deviations from this environment.

 WARNING	
Tip Hazard	
Moving this product without a hoist could cause a tip hazard which may cause death or serious injury. • Do not attempt to move the Product without the use of a fork lift or a hoist. • Roll on smooth floors only.	



WARNING

Automatic Movement / Crush Hazard

If any interlocks are disabled the possibility exists of automatic movement of systems within the M2 system.
The following systems have the possibility of automatic movement:

- Atmospheric Robot
- Atmospheric Aligner
- Load Port Modules
- Optional Wafer Inverter
- Vacuum Robot Vacuum
- Load Lock Z-lift
- Atmospheric Doors
- Vacuum Slot Valves
- Isolation Valves
- Pumps

Moving mechanisms have no obstruction sensors and can cause serious personal injury or death. Do not operate the M2 system without the protective covers in place.



NOTE: When equipment is off and power is secured per the facility's lockout/tagout procedure, the M2 system is classified as a Type 1 hazard category. When equipment is energized, live circuits covered, and work performed remotely, the M2 system is classified as a Type 2 category.

Table 7-1: Preventive Maintenance Schedule

Component	Maintenance Action	Frequency
M2 System	"Cleaning Procedure" on page 173	12 months or as required
	"O-Ring Removal/Replacement/Cleaning" on page 175	Frequency stated or as required
	"Material Presence Sensor Adjustment" on page 177	6 months or as required
	"Verifying Flatness of Robot's End Effector" on page 179	12 months or as required
	"Adjusting the Robot's End Effector(s)" on page 180	12 months or as required
	"Teaching Procedures" on page 101	12 months or as required
Load Locks	"Material Presence Sensor Adjustment" on page 177	12 months or as required
Vacuum Pumps	As specified for pumps being used Refer to the Pump User Manual	
Gauges	As specified for gauges being used Refer to the Gauge User Manual	

Component	Maintenance Action	Frequency
Vacuum Robot	Inspect every 6 months Refer to the Robot User Manual	
Atmospheric Aligner	Inspect every 6 months Refer to the Aligner User Manual	
Atmospheroc Robot	Clean Arm and End Effector every 6 months Refer to the Robot User Manual Inspect every 6 months Refer to the Robot User Manual	
Load Port Modules	Inspect every 6 months Refer to the appropriate Load Port Module User Manual.	
Fan Filter Unit (FFU)	Inspect every 6 months Refer to the FFU User Manual.	

Material Support (Pad) Inspection

Over time, repeated material transfers will deposit contaminants and wear away the surface of the pads on the end effectors and material shelves, which will decrease their friction. It is necessary to inspect pads to prevent material slippage and loss of repeatability.

Procedure Category

Type 1 Procedure: Equipment is fully de-energized.

Required Tools

None

Maintenance Strategy

Visual observation of material supports. Turn off and disconnect all power, communications, and air connections as detailed below.



WARNING

Lockout / Tagout

Working with energized equipment may cause sudden movement or electrical shock and may result in death or serious injury.

- All energy must be removed from the equipment per the facility's Lockout/Tagout procedure before servicing.
- If local procedures are not available, follow the procedure for Lockout/Tagout in **OSHA Standard 29CFR 1910.147**.




NOTICE



The M2 system may be used in an environment where hazardous materials are present, and surfaces may be contaminated by those materials. Refer to the facility's Material Safety Data Sheets for those materials to determine proper handling and follow the facility's procedures to certify the environment is safe.

Procedure

Step	Action
1.	HOME the robot then turn off and disconnect all power, communications, and air connections as detailed in "Safe Shutdown" on page 164 .
2.	Atmospheric Front End: - Open the access door. - Visually inspect the surface of the pads on the end effector and the vacuum aligner chuck for excessive wear or damage.
3.	Vacuum Back End: - Vent the Vacuum Chamber and Load Locks. - Remove the Load Lock lids and open the Transport Chamber lid. - Visually inspect the surface of the pads on the end effector, and the material support shelves in the Load Locks for excessive wear or damage.
4.	If any of the above inspection points report a discrepancy, refer to "Pad Cleaning Procedure" on page 171 and "Pad Removal/Replacement" on page 189 for replacement.

Step	Action
5.	On the Vacuum Back End, replace the Load Lock lids and close the Transport Chamber cover. Inspect the O-ring for the Load Lock lids and Transport chamber before closing. Replace if there is any scratches, nicks, or damage.
6.	On the Atmospheric Front End, close the access doors.
7.	Reconnect all power, communications, and air connections, then re-energize the system following the "Power-up Sequence" on page 89.

Pad Cleaning Procedure

Collection of debris and other contaminants on the material support pad surface may cause material slippage. For optimum robot and system performance, pads should be cleaned as a part of normal servicing to remove contaminants deposited on them from the process or other sources.

Procedure Category

Type 1 Procedure: Equipment is fully de-energized.

Required Tools

- Kalrez® pads: use de-ionized water
Stainless Steel pads: use Isopropyl Alcohol
Quartz pads: use Isopropyl Alcohol
- Lint-free, clean room Wipes

Maintenance Strategy

Cleaning procedures depend on the type of pads; Kalrez, Stainless Steel, or Quartz. Separate procedures are provided for each support type. Turn off and disconnect all power, communications, and air connections as detailed in "Safe Shutdown" on page 164.

NOTICE



The M2 system may be used in an environment where hazardous materials are present, and surfaces may be contaminated by those materials. Refer to the facility's Material Safety Data Sheets for those materials to determine proper handling and follow the facility's procedures to certify the environment is safe.

Dispose of cleaning cloths per the facility's procedures and local regulations.

 WARNING Lockout / Tagout	
Working with energized equipment may cause sudden movement or electrical shock and may result in death or serious injury. • All energy must be removed from the equipment per the facility's Lockout/Tagout procedure before servicing. • If local procedures are not available, follow the procedure for Lockout/Tagout in OSHA Standard 29CFR 1910.147.	 

Maintenance Procedure

Step	Action
1.	HOME the robots and then turn off and disconnect all power, communications, and air connections as detailed in "Safe Shutdown" on page 164 .
2.	Cleaning Aegis and Kalrez® Pads Procedure: - Dampen a cleanroom wipe with de-ionized water. - Clean the entire end effector or support shelf, paying special attention to the Kalrez pads or Aegis pads. Do not apply excessive pressure or force to the pads while cleaning. Excessive force may dislodge or bend the end effector or shelf. - Once all residues have been removed, use dry cleanroom wipes to dry all surfaces. NOTE: Do not use isopropyl alcohol on Kalrez pads, aegis pads or O-Rings. Damage to the O-rings will occurs. NOTE: Wipe must be moistened only; squeezing the wipe should not cause any water to drip. Do not allow water to come in contact with bearings, seals, etc.,
3.	Cleaning Stainless Steel or Quartz Pads Procedure: - Dampen a cleanroom wipe with isopropyl alcohol. - Clean the entire end effector or support shelf, paying special attention to the pads. Do not apply excessive pressure or force to the pads while cleaning. Excessive force may bend the end effector or shelf. - Once all residues have been removed, use dry cleanroom wipes to dry all surfaces. NOTE: Wipe must be moistened only; squeezing the wipe should not cause any water to drip. Do not allow water to come in contact with bearings, seals, etc. Alcohol should not be used on the optional perfluoroelastomer (Kalrez) pads. NOTE: Wipe must be moistened only; squeezing the wipe should not cause any water to drip. Do not allow water to come in contact with bearings, seals, etc.

Step	Action
4.	On the Vacuum Back End, ensure the Load Lock lids and the Transport Chamber lid are closed. Be sure to check for damage to the o-rings before closing. If wear or damage is observed, replace the o-ring.
5.	On the Atmospheric Front End, ensure the access doors are closed.
6.	Reconnect all power, communications, and air connections, then re-energize the system following the "Power-up Sequence" on page 89 .

Cleaning Procedure

Occasionally the M2 system will need to be cleaned. This could be done as a part of normal servicing or to remove contaminants deposited on it from the process or other sources.

Procedure Category

Type 1 Procedure: Equipment is fully de-energized.

Required Tools

- Isopropyl Alcohol (100%)
- DI Water
- Cleanroom Wipes

Maintenance Strategy

A general cleaning procedure is provided with specific directions for each of the major components within the system. Turn off and disconnect all power, communications, and air connections as detailed in ["Safe Shutdown" on page 164](#).

NOTICE



The M2 system may be used in an environment where hazardous materials are present, and surfaces may be contaminated by those materials. Refer to the facility's Material Safety Data Sheets for those materials to determine proper handling and follow the facility's procedures to certify the environment is safe.

Dispose of cleaning cloths per the facility's procedures and local regulations.

 WARNING Lockout / Tagout	
Working with energized equipment may cause sudden movement or electrical shock and may result in death or serious injury. • All energy must be removed from the equipment per the facility's Lockout/Tagout procedure before servicing. • If local procedures are not available, follow the procedure for Lockout/Tagout in OSHA Standard 29CFR 1910.147.	 

Maintenance Procedure

Step	Action
1.	HOME the robots and then turn off and disconnect all power, communications, and air connections as detailed in "Safe Shutdown" on page 164 .
2.	Cleaning the Load Lock (with or without the cooling option): - Remove the cassette and all wafers from the Load Lock. - Loosen the screws in the Load Lock top cover and remove the top cover. - Clean the interior of the Load Lock using the steps in Step 3 to thoroughly clean the plate. Do not allow alcohol to permeate the o-ring. - Replace the lid and secure the hardware.
3.	General Cleaning Steps: - Remove any wafers or other material that may be within the M2 system. - Remove any hazardous materials from the M2 system's surfaces following the facility's procedures for those materials. - Clean all exposed surfaces using cleanroom wipes moistened with isopropyl alcohol. - Once all contaminants have been removed, use cleanroom wipes moistened with DI water to remove any residues. - Once all residues have been removed, use dry cleanroom wipes to dry all surfaces. NOTE: Wipe must be moistened only. Squeezing the wipe should not cause any isopropyl alcohol to drip. Do not allow alcohol to come in contact with bearings, seals, etc. Alcohol should not be used on the optional perfluoroelastomer (Kalrez) end effector pads. NOTE: Wipe must be moistened only. Squeezing the wipe should not cause any water to drip. Do not allow water to come in contact with bearings, seals, etc.
4.	On the Vacuum Back End, ensure the Load Lock lids and the Transport Chamber lid are closed. Inspect the o-rings for any damage or wear before closing the lids. Replace the o-rings if any damage is observed.

Step	Action
5.	On the Atmospheric Front End, ensure the access doors are closed.
6.	Reconnect all power, communications, and air connections, then re-energize the system following the "Power-up Sequence".

O-Ring Removal/Replacement/Cleaning

All o-rings should be inspected periodically to ensure proper operation. Occasionally o-rings will need to be cleaned (if contaminated with particulates) or replaced (if damaged).

O-ring Replacement Frequency

- Replace an o-ring if it has cuts, abrasions, or other wear or damage.
- Replace the Transport Chamber clear lid o-ring every 50 open/close cycles or as required.
- Replace the Load Lock view port lid o-ring every 100 open/close cycles or as required.
- Replace the Load Lock aluminum lid o-ring as 12 months or as required.

Procedure Category

Type 1 Procedure: Equipment is fully de-energized.

Required Tools

- Brass or plastic pick
- Isopropyl Alcohol (100%)
- DI Water

Maintenance Strategy

The o-ring replacement procedure requires removal of the existing o-ring, inspection of the seal area, repair of the seal area if necessary, inspection of the o-ring, and replacement of the o-ring if necessary. Turn off and disconnect all power, communications, and air connections as detailed in "Safe Shutdown" on page 164.

NOTICE



The M2 system may be used in an environment where hazardous materials are present, and surfaces may be contaminated by those materials. Refer to the facility's Material Safety Data Sheets for those materials to determine proper handling and follow the facility's procedures to certify the environment is safe.

Dispose of cleaning cloths per the facility's procedures and local regulations.

 WARNING Lockout / Tagout	
Working with energized equipment may cause sudden movement or electrical shock and may result in death or serious injury. • All energy must be removed from the equipment per the facility's Lockout/Tagout procedure before servicing. • If local procedures are not available, follow the procedure for Lockout/Tagout in OSHA Standard 29CFR 1910.147.	 

Maintenance Procedure

Step	Action
1.	HOME the robots and then turn off and disconnect all power, communications, and air connections as detailed in "Safe Shutdown" on page 164 .
2.	Removal Procedure: - Using the pick, pry the old o-ring out of the o-ring groove starting at the sniffer groove. - Once a section of the o-ring is free of the groove, gently remove the rest of the o-ring by hand, being careful not to damage or scratch the o-ring or the seal area. NOTE: Use only a tool made of brass, plastic, or similar soft material. The O-ring groove is aluminum and EXTREMELY sensitive to ANY small scratches left in the surface.

Step	Action
	Replacement Procedure: - Clean the o-ring seal surface and the o-ring groove with isopropyl alcohol, refer to Step 3 in "Cleaning Procedure" on page 173. - Clean the o-ring with DI water prior to installation in the system. - Install the o-ring in the groove provided. The o-ring groove is a double dove-tail slot with the narrow portion of the slot at the top. The o-ring has to be compressed in order for it to be placed into the groove. - Once the o-ring has been replaced the seal should be checked for leaks using a leak-checker.
3.	The easiest method for placing the o-ring in the groove is: - Insert a small portion of the o-ring into the groove at opposite ends of the ring. - Insert a small portion of the o-ring into the groove at 90° from the points above. - Press the o-ring into the groove evenly in each 90° segment. Do not stretch the o-ring to prevent excessive looping as the balance of the o-ring is inserted. NOTE: Clean the o-ring by wiping down with DI water only. Do not use alcohol or other solvents as they may cause the o-ring to become brittle. NOTE: Do not allow the o-ring to twist during installation.
4.	On the Vacuum Back End, ensure the Load Lock lids and the Transport Chamber lid are closed.
5.	On the Atmospheric Front End, ensure the access doors are closed.
6.	Reconnect all power, communications, and air connections, then re-energize the system following the " Power-up Sequence " on page 89.

Material Presence Sensor Adjustment

The Transport Module's Material Presence Sensors should be checked, and adjusted if necessary, to ensure correct detection of material within the Transport Chamber.

Procedure Category

Type 2 Procedure: Equipment is energized and all energized circuits are covered or insulated. All work is performed remotely using the CDM or service computer.

Required Tools and Equipment

- Expendable material of type and size to be processed
- Small flat-blade screwdriver

Adjustment Strategy

If material is not detected correctly, the material presence sensor needs adjustment. The Photoelectric Switch requires no maintenance. However, it is recommended that the optical interface is cleaned during the scheduled cleaning procedure and that all screws and connections be checked.

NOTE: When performing this service procedure all equipment is on. For this procedure, the M2 system is classified as a Type 2 hazard category.

Adjustment Procedure

The Photoelectric Reflex Switch sensor is able to detect all material types including clear material. During normal operation, with the beam not being blocked, the switch indicator light is lit. This indicates that the beam is sent to the reflector and enough reflected light is being received. If the indicator is out or if it is blinking, the switch needs to be adjusted.

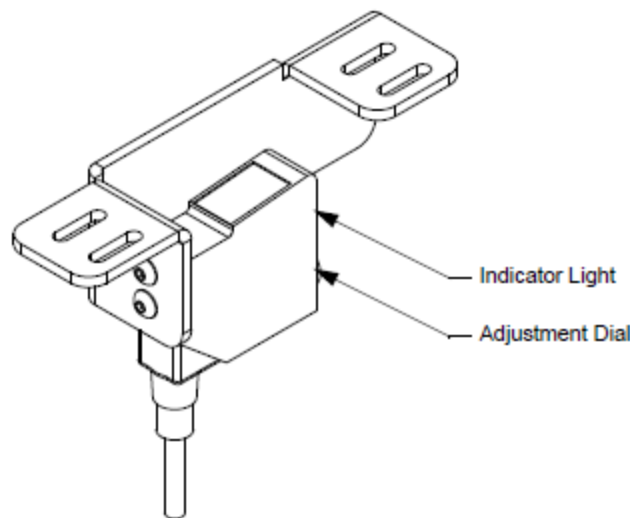


Figure 7-1: Material Presence Sensor

Step	Action	
1.	Verify that no object is blocking the sensor. The red beam of the LED should be centered on the reflector.	
2.	Adjust signal strength by turning the dial until the indicator lights up.	
3.	Verify the object detection function is working correctly. - Move the material into the beam; the indicator should turn off. If it stays on or is blinking, reduce the sensitivity using the dial adjustment until the indicator is off. - Remove the material; the indicator should switch on. If it does not, readjust the sensitivity. - Continue this procedure until the sensitivity threshold is set correctly.	

The LED in the sensor is safe to look at and allows the lid of the chamber to be opened without optical hazard.

Verifying Flatness of Robot's End Effector

The end effector(s) must be flat to ensure proper support of the material being handled by the robot. This procedure checks for the top surfaces of the material supports on the end effector to be within 0.076 mm (0.003 in) of each other and that no part of the end effector rises above the lowest material support.

This procedure must be performed during initial setup if the end effector is suspected of damage during shipment and at any time that the robot's arms or end effector(s) are damaged, removed and replaced, or changed while in the system. It is also recommended that this procedure be performed as a preventive maintenance practice.

NOTE: To successfully align the robot and to obtain consistent and precise handling of material, the limits and tolerances stated in this verification procedure must be met.

Procedure Category

Type 1 Procedure: Equipment is fully de-energized.

Required Tools and Test Equipment

- Granite surface block
- Height gauge

Limits and Tolerances

- Maximum deviation between supports 0.076 mm (0.003 in).
- No point on the end effector's surface will be higher than the lowest support.

Adjustment/Calibration Strategy

This procedure uses the granite surface block as a reference point to determine the height of each material support on the end effector and to ensure that no part of the end effector rises above the material supports.

NOTICE



The M2 system may be used in an environment where hazardous materials are present, and surfaces may be contaminated by those materials. Refer to the facility's Material Safety Data Sheets for those materials to determine proper handling and follow the facility's procedures to certify the environment is safe.

Dispose of cleaning cloths per the facility's procedures and local regulations.

 WARNING Lockout / Tagout	
Working with energized equipment may cause sudden movement or electrical shock and may result in death or serious injury. • All energy must be removed from the equipment per the facility's Lockout/Tagout procedure before servicing. • If local procedures are not available, follow the procedure for Lockout/Tagout in OSHA Standard 29CFR 1910.147.	 

Measurement Procedure

Step	Action
1.	Remove the end effector from the robot arm as specified in the robot's User Manual and place the end effector on a granite surface block with the material supports facing up.
2.	Using the height gauge, measure the height of each material support.
3.	Verify that all supports are within 0.076 mm (0.003 in) of each other. Replace supports if any are out of specification using the procedures provided in the robot's User Manual.
4.	Once all material supports are within specification, measure the height of the top surface of the end effector to ensure that no portion of it exceeds the height of the lowest material support.
5.	Once all material supports are within specification, measure the height of the top surface of the end effector to ensure that no portion of it exceeds the height of the lowest material support.
6.	Reconnect all power, communications, and air connections, then re-energize the system following the "Power-up Sequence" on page 1 .

Adjusting the Robot's End Effector(s)

The end effector of the robot must be adjusted for planar motion within the material delivery zone of any material transfer. This adjustment procedure must be performed at the material delivery zone.

This procedure is performed during initial setup and at any time that the robot's arms or end effector (s) are damaged, removed and replaced, or changed. It is also recommended to perform this procedure as a preventative maintenance procedure.

NOTE: This procedure assumes that the end effector is properly located in the arm, is flat, and that the top surfaces of the material support pads are within 0.076 mm (0.003 in) of each other.

Procedure Category

Type 1 Procedure: Equipment is fully de-energized.

Required Tools and Test Equipment

- Metric hex wrenches
- The robot's Teach Pendant
- MicroTool Wafer Level

Limits and Tolerances

- The end effector must be level within 0.02 degrees

Adjustment Strategy

This procedure uses any flat surface, such as the bottom surface of a Process Module, as a reference point to determine planar movement within the material delivery zone. The arm should be extended to the delivery zone while measuring the end effector runout.

NOTICE



The M2 system may be used in an environment where hazardous materials are present, and surfaces may be contaminated by those materials. Refer to the facility's Material Safety Data Sheets for those materials to determine proper handling and follow the facility's procedures to certify the environment is safe.

Dispose of cleaning cloths per the facility's procedures and local regulations.

 WARNING Lockout / Tagout	
Working with energized equipment may cause sudden movement or electrical shock and may result in death or serious injury. • All energy must be removed from the equipment per the facility's Lockout/Tagout procedure before servicing. • If local procedures are not available, follow the procedure for Lockout/Tagout in OSHA Standard 29CFR 1910.147.	 

Adjustment Procedure

Step	Action
1.	Place the MicroTool wafer level on the end effector located approximately where a wafer would be located on the end effector. If a bubble level is being used place the test material on the end effector and place the bubble level in the middle of the material.
2.	Verify that the end effector is level within 0.02 degrees. If the end effector is not level, adjust the end effector as specified in the robot's User Manual.

Do not over-tighten any of the Adjusting Screws as the end effector may become permanently twisted.

8. Troubleshooting and Repair

Troubleshooting problems that might occur with the Brooks Automation M2 system is provided to the Field Replaceable Unit (FRU) level. Once the FRU has been identified a replacement may be ordered from Brooks Automation. The replacement FRU is supplied with the appropriate remove/replace procedure.

Be sure that only trained, qualified persons attempt to troubleshoot the M2 system. Brooks Automation provides training in the troubleshooting and repair of the M2 system.

Initial Troubleshooting

This section covers the initial determination of the problem area within the M2 system and provides direction to the second step of the troubleshooting process. If a specific problem is suspected refer to that problem in Table 8-1. If the problem has not been identified review each step of [Table 8-1](#), no matter how trivial, in order to ensure proper determination of the problem area. If the problem encountered is not covered here, refer to the individual User Manuals for the components within the system.

This section provides a list of commonly encountered problems and the appropriate solution for each problem. Refer to the individual component manuals for additional troubleshooting procedures.

Table 8-1: Initial Troubleshooting

Symptom	Possible Problem Area
Unexpected movement of modules	See "Mechanical Troubleshooting" on page 184
Power lights do not turn on	See "Power Distribution Troubleshooting" on page 184
System powered, but not all modules on page 8-4 are on	
System powered but no response to host controller	See "Communications Troubleshooting" on page 185
System powered but no response from components within system	

Symptom	Possible Problem Area
Load Port Modules not operating Unexpected movement of modules Material slipping or left on end effector	See "Material Transport Troubleshooting" on page 186
Wafer not cooling	See "Load Lock with Cooler Troubleshooting" on page 186
Pressure switch not responding correctly	See "Pressure/Indicator Switch Troubleshooting" on page 187
Chamber not pumping down correctly	See "Vacuum System Troubleshooting" on page 187

Mechanical Troubleshooting

This section covers determination of problems within the frame, and other mechanical subsystems.

Table 8-2: Mechanical Related Troubleshooting

Problem	Corrective Action
System loses alignment over time	- Modules may be moving, verify the Atmospheric Front End and Vacuum Back End are bolted to the floor using the tie down points provided. - Verify the EFEM and VBE are firmly secured to each other and to the Process Modules. - Verify taught positions at all stations.

Power Distribution Troubleshooting

This section covers determination of problems within the AC and DC power distribution. Refer to the System Block Diagram supplied with this manual for additional information.

Table 8-3: Power Distribution Troubleshooting

Problem	Corrective Action
Power lights do not turn on.	- Check the facility's power to the system. Verify correct power rating. - Verify Power Cable from the facility's power is fully seated and secured.
Individual module (pump, robot, etc.) not turned on.	- Verify circuit breakers on the ACPD are in the ON position. - Verify circuit breaker(s) on the module are in the ON position. - If the module uses DC power, verify the voltage output from the power supply supplying power to the module. - If the module receives power through the DeviceNet, verify the voltage output from the power supply supplying power to the DeviceNet (i.e., Safety Node).

Communications Troubleshooting

This section covers determination of communications problems within the M2 system. Refer to the System Block Diagram supplied with this manual for additional information.

Table 8-4: General Communications Troubleshooting

Problem	Corrective Action
System powered but no response to host controller.	• Verify Interface Cable is fully seated and secure. • Verify proper connection and continuity. • Verify host controller is correctly set-up.
System powered but no response from components within system.	• Verify the Ethernet cable is properly connected at both ends. • Verify all DeviceNet and Ethernet IP Addresses are properly configured (refer to the System Block Diagram and the M2 Software Programmer's Reference). • Verify that serial communications cables are properly connected at both ends. • Verify that the CDM does not have control of the robot.

Table 8-5: DeviceNet Troubleshooting

Problem	Corrective Action
System powered but no response from DeviceNet components within system.	• Check DeviceNet Node LEDs : Power Green - OK Orange - 24V Low Status Green - OK Flashing Green - On line, no communication signal Red - Critical Module Fault Flashing Red - Recoverable Fault Node Address Solid Red - Address not valid Output Fault Solid Red - Short, Overload, Over Temp • Verify that the node addresses are correct (refer to the System Block Diagram and the M2 Software Programmer's Reference).

Problem	Corrective Action
Intermittent Communication.	- Ensure that all network cables are properly seated. - Ensure that network is properly terminated. Only one terminator required, typically located in the Series 8 Controller or the Safety Node.
Fault lights displayed on one or more modules.	Ensure that all network cables are properly seated.

Material Transport Troubleshooting

This section covers determination of problems within the material transport subsystems (aligner, robot, etc.).

Table 8-6: Material Transport Troubleshooting

Problem	Corrective Action
Material slipping on end effector.	- For vacuum-grip end effectors, check that vacuum is connected and meets pressure specifications. - Verify that robot application number is correct for the arm set/end effector (contact Brooks Technical Support)
Material is left on the end effector. Material must be placed back into a Load Lock or a Process Module.	- Identify cause of the failure that left the material on the end effector. - Put the material back into the desired Module using the robot's CDM.
Material is left on the end effector. Corrective actions outlined above failed.	- Shutdown the system and recover manually. - Remove the vacuum chamber's lid and check all components associated with the failure. Manually remove the material.

Load Lock with Cooler Troubleshooting

This section covers the initial determination of the problem area within the Load Lock with Cooler and provides suggested solutions for those problems.

Table 8-7: Load Lock with Cooler Troubleshooting

Problem	Corrective Action
Cooler leaks.	Verify that the cool ring fittings are properly secured.

Problem	Corrective Action
Wafer not cooling.	- Verify that both the flow rate and temperature of the cooling water is within the range specified in "Facilities Specifications" on page 58. - If the main chamber is running at a very high temperature, the cooling parameters may have to be increased beyond the specified parameters. Contact Brooks Automation for assistance.

Pressure/Indicator Switch Troubleshooting

This section covers determination of problems within the N2 Digital Pressure Switch. Errors of the Pressure Switch are displayed on the LCD. After locating and solving the problem, press RESET to clear the error.

Table 8-8: N2 Digital Pressure Switch Troubleshooting

Display	Problem	Corrective Action
E1 dE	Calibration settings have changed	- Press Reset. - Set all data again.
E2 CE1	Output 1 current exceeding 80 mA.	- Turn off power. - Verify load connected to output . - Verify output not shorted. - Press Reset.
E2 CE1	Output 2 current exceeding 80 mA.	- Turn off power. - Verify load connected to output . - Verify output not shorted. - Press Reset.
E3 PE	Max operating pressure has been exceeded for more than 2 seconds.	- Reduce supply pressure. - Press Reset.
E4 HP	Pressure is 2% above rated pressure during clear.	- Apply atmospheric pressure. - Press Reset.

Vacuum System Troubleshooting

This section covers determination of problems within the Vacuum System.

Table 8-9: Vacuum System Troubleshooting

Problem	Corrective Action
Vacuum chamber does not pump down in a normal manner.	• Ensure that the vacuum chamber's vacuum gauge is calibrated and is functioning properly. • Check for contaminants on substrates, cassettes, or in the chamber. • Ensure that the vacuum chamber's pump controller is functioning properly. Reset it if necessary, refer to the Pump Controller User Manual. • Ensure that the vacuum chamber's pump stack isolation valve is functioning properly (air pressure is okay). • Check vacuum chamber's slot valve seals to ensure they are still in place, free of debris, and in working order. • Check the backing pump system if present. • Perform a leak check if all above fails to isolate possible leaks.
Vacuum chamber fails to pump down in set time.	• Ensure the vacuum gauge is calibrated and is functioning properly. • Check for contaminants in the chamber. • Ensure that the pump controller is functioning properly. Reset it if necessary, refer to the Pump Controller User Manual. • Ensure that the isolation valve is functioning properly (air pressure is okay). • Check the lid seals to ensure that they are still in place, free of debris, and in working order. • Check the seals on all valves and blank-offs to ensure that they are still in place, free of debris, and in working order. • Perform a leak check if all above fails to isolate possible leaks.

Repair Philosophy

If a M2 system malfunctions, refer to ["Initial Troubleshooting" on page 183](#) in this manual for diagnostic procedures. If these procedures are not adequate to determine the source of the problem, refer to the M2 system operational descriptions in ["Operation" on page 110](#) for in-depth descriptions of the various subsystems of the M2 system. Once the failed unit has been identified, a Field Replaceable Unit (FRU) can be ordered. The FRU is shipped with directions for removing the failed unit from the M2 system and installing the new unit into the M2 system. Refer to the appropriate component User Manuals for additional troubleshooting and repair procedures.

A series of FRUs have been identified for the M2 system to reduce MTTR and to simplify repair procedures in the field. Some of these FRUs may comprise a complete assembly. A number of alternatives are available for obtaining replacement FRUs and other parts to repair the M2 system. The following service options are available (descriptions follow):

- Facilitated on-site repair via a Service Sales Order utilizing Brooks' Field Service personnel and factory authorized repair parts
- Advanced Exchange Units can be established for all major systems
- Brooks' Factory Repair Services
- Brooks spare parts can be ordered from Brooks Technical Support on both a priority and non priority basis

Contact Brooks Automation Technical Support for more information or quotes.

NOTE: Safety and Operations training classes on how to troubleshoot and repair a M2 system to a FRU level are available. Contact Brooks Automation for information about these classes.

Repair Procedures

The following repair/replacement procedures provides the information required for standard user servicing of the Brooks Automation M2 system.

NOTE: Procedures for removing and replacing FRUs are not included as each FRU is shipped with a detailed Remove and Replace procedure.

Refer to the individual component manuals and any separate repair procedures provided with the individual system components for additional repair procedures.

Pad Removal/Replacement

Repeated material transfers will eventually wear away the friction pads. In time, the surface of the material may touch the surface of the End Effector or Material Support Shelves resulting in abrasion and particle generation. To prevent this abrasion of the material surface, periodic replacement of the pads according to the maintenance schedule is recommended.

Procedure Category

Type 1 Procedure: Equipment is fully de-energized.

Required Tools

None

Replacement Strategy

Turn off and disconnect all power, communications, and air connections as detailed in "[Safe Shutdown](#)" on page 164.

NOTICE



The M2 system may be used in an environment where hazardous materials are present, and surfaces may be contaminated by those materials. Refer to the facility's Material Safety Data Sheets for those materials to determine proper handling and follow the facility's procedures to certify the environment is safe.

Dispose of cleaning cloths per the facility's procedures and local regulations.



WARNING

Lockout / Tagout

Working with energized equipment may cause sudden movement or electrical shock and may result in death or serious injury.

- All energy must be removed from the equipment per the facility's Lockout/Tagout procedure before servicing.
- If local procedures are not available, follow the procedure for Lockout/Tagout in **OSHA Standard 29CFR 1910.147**.



Procedure

Step	Action
1.	Turn off and disconnect all power, communications, and air connections as detailed in "Safe Shutdown" on page 164. Grommet Style Pad Replacement - Remove the pad by pulling it out of the end effector from the top side. - Replacing the pads requires no special tools or materials. Press the pad into the holes on the end effector by hand until fully seated.
2.	On the Vacuum Back End, ensure the Load Lock lids and the Transport Chamber lid are closed.
3.	On the Atmospheric Front End, ensure the access doors are closed.

Step	Action
4.	Reconnect all power, communications, and air connections, then re-energize the system following the "Power-up Sequence" on page 89 .

9. Appendices

The following appendices are included to provide the user with a single location for specific information related to the Brooks Automation M2 system.

Appendix A: Contact Brooks Automation Technical Support

Have the following information available when contacting Brooks Automation Technical Support.

- a. Part number and serial number from the product.
- b. Installed location of the product.
- c. Name, e-mail address, and telephone number of the person to contact.
- d. List of error codes received during the failure.
- e. Prepare a detailed description of the events relating to the error.
 - Time that the equipment has been in operation
 - Work that was done on the equipment prior to the error
 - Functions that the equipment was performing when the error occurred
 - Actions taken after the error and the results of those actions
 - Other information that may assist the Specialist
- f. Contact Brooks Automation Technical Support at these numbers:

Location	Contact Number	Website
North America	+1-800-447-5007 (Toll Free) +1-978-262-2900 (Local)	http://www.brooks.com/
Europe	+49 800 000 9347 (Toll Free Germany) +49 364 176 9999 6 (Has Toll)	
Japan	+81 120-255-390 (Toll Free) +81 45-330-9005 (Local)	
China	+86 21-5131-7066	
Taiwan	+886 080-003-5556 (Toll Free) +886 3-5525258 (Local)	
Korea	1800-5116 (Toll Free)	
Singapore	+65 1-800-4-276657 (Toll Free) +65 6309 0701 (Local)	

Technical Support Customer Care: <https://www.brooks.com/services/pathway-connect>

Appendix B: Factory Default Settings

Default Robot Settings

The Quality Report shipped with each robot contains a list of all the factory default settings. Refer to the QR to reset to the default.

Default Aligner Drive Settings

The Quality Report shipped with each aligner contains a list of all the factory default setting. Refer to the QR to reset to the default.

Default LPM Settings

The Quality Report shipped with each LPM contains a list of all the factory default setting. Refer to the QR to reset to the default.

Appendix C: Station Identification

The Brooks Automation M2 system is customized at the factory to the users specified parameters. Accompanying the M2 system is a Brooks Automation Acceptance Test (ATP) which lists all the factory assigned parameters.

In the occurrence that the user replaces any modules within the M2 system or re-configures the M2 system, the new parameters should be recorded in the tables provided in this section. Tables are provided for the stations accessed by the robot in the Atmospheric Front End and the stations access by the robot in the Vacuum Back End.

Table 9-1: System Assignments Log - Atmospheric Front End

Stn	Station Name (Position Wafer Size)	R	T	W	Z (BTO)	Lower	Slots	Pitch
1	Load Lock B	Final Via						
2	Load Lock A	Final Via						
3	Load Port Module 1	Final Via						
4	Load Port Module 2	Final Via						
5	Load Port Module 3	Final Via						
6	Load Port Module 4	Final Via						
7	Aligner	Final Via Final Via Final Via						

Table 9-2: System Assignments Log - Atmospheric Front End

Stn	Station Name (Position Wafer Size)	R	T	W	Z (BTO)	Lower	Slots	Pitch
1	Load Lock B	Final						
		Via						
2	Load Lock A	Final						
		Via						
3	Load Port Module 1	Final						
		Via						
4	Load Port Module 2	Final						
		Via						
5	Load Port Module 3	Final						
		Via						
6	Load Port Module 4	Final						
		Via						
7	Aligner	Final						
		Via						
		Final						
		Via						
		Final						
		Via						

Table 9-3: System Assignments Log - Vacuum Back End, M2 Tandem

Stn	Station Name (Position Wafer Size)	R	T	W	Z (BTO)	Lower	Slots	Pitch
Front Robot								
1	LL - Arm 'A'							
	LL - Arm 'B'							
2	LL - Arm 'A'							
	LL - Arm 'B'							

Stn	Station Name (Position Wafer Size)	R	T	W	Z (BTO)	Lower	Slots	Pitch
3	PM 1 - Arm 'A'							
	PM 1 - Arm 'B'							
4	PassThru - Arm 'A'							
	PassThru - Arm 'B'							
5	PM 5 - Arm 'A'							
	PM 5 - Arm 'B'							
Back Robot								
1	PassThru - Arm 'A'							
	PassThru - Arm 'B'							
3	PM 2 - Arm 'A'							
	PM 2 - Arm 'B'							
4	PM 3 - Arm 'A'							
	PM 3 - Arm 'B'							
5	PM 4 - Arm 'A'							
	PM 4 - Arm 'B'							

Table 9-4: System Assignments Log - Vacuum Back End, M2 Quad

Stn	Station Name (Position Wafer Size)	R	T	W	Z (BTO)	Lower	Slots	Pitch
1	LLB-UR							
	LLB-UL							
2	LLA-LR							
	LLA-LL							
3	PM 1 - Arm 'A'							
	PM 1 - Arm 'B'							
4	PM 2 - Arm 'A'							
	PM 2 - Arm 'B'							
5	PM 3 - Arm 'A'							
	PM 3 - Arm 'B'							

Table 9-5: System Assignments Log - Vacuum Back End, M2C 4, M2C 5, M2C 6

Stn	Station Name (Position Wafer Size)	R	T	W	Z (BTO)	Lower	Slots	Pitch
1	LL B - Arm 'A'							
	LL B - Arm 'B'							
2	LL A - Arm 'A'							
	LL A - Arm 'B'							
3	PM 1 - Arm 'A'							
	PM 1 - Arm 'B'							
4	PM 2 - Arm 'A'							
	PM 2 - Arm 'B'							

Stn	Station Name (Position Wafer Size)	R	T	W	Z (BTO)	Lower	Slots	Pitch
5	PM 3 - Arm 'A'							
	PM 3 - Arm 'B'							
6	PM 4 - Arm 'A'							
	PM 4 - Arm 'B'							
7	PM 5 - Arm 'A'							
	PM 5 - Arm 'B'							
8	PM 6 - Arm 'A'							
	PM 6 - Arm 'B'							

Table 9-6: System Assignments Log - Vacuum Back End, M2 4 - 7

Stn	Station Name (Position Wafer Size)	R	T	W	Z (BTO)	Lower	Slots	Pitch
1	LL B - Arm 'A'							
	LL B - Arm 'B'							
2	LL A - Arm 'A'							
	LL A - Arm 'B'							
3	PM 1 - Arm 'A'							
	PM 1 - Arm 'B'							
4	PM 2 - Arm 'A'							
	PM 2 - Arm 'B'							
5	PM 3 - Arm 'A'							
	PM 3 - Arm 'B'							
6	PM 4 - Arm 'A'							
	PM 4 - Arm 'B'							
7	PM 5 - Arm 'A'							
	PM 5 - Arm 'B'							

Stn	Station Name (Position Wafer Size)	R	T	W	Z (BTO)	Lower	Slots	Pitch

Appendix D: Document Abbreviations

The abbreviations provided in this table are used with Brooks' documentation.

AIR	Air, pressurized	FN	Facet Node board	PN	Pneumatic manifold
AL	Load Lock 'A'	FDP	Front Buffer Defeat Plug	PP	Poppet valve
AR	Argon gas	FM	Foreline Manifold	PR	Pressure Relief valve
AS	Atmospheric Switch	FS	Flow Switch	PS	Pressure Switch
ASA	Atmospheric Switch Adapter	FV	Fast Vent	PU	Purge valve
BL	Load Lock 'B'	GP	Gas Panel	PV	Profiled Vent valve
BV	Bleed valve	H2O	Water	RM	Rough Manifold
C2	Communications board RS-232	HP	Heater Power Supply	RV	Rough Valve
C4	Communications board RS-422	HT	Heater cartridge	S	Sensor
CC	Cold Cathode	IG	Ion Gauge	SP	Wafer Lift Spider
CG	Convectron Gauge	IL	Inligner (TopLigner)	SR	Slow Rough
CL	Cooling valve	IO	System I/O distribution board	SS	Substrate Sensor
CM	Capacitance Manometer	IV	Isolation Valve	SV	Slot Valve
CP	Cryo Pump	LF	Lower Facilities	T/C	Thermocouple
CS	Cool Station	LL	Load Lock	T5	T5X system controller
CT	Temperature controller	LN	Load Lock Node	TB	Turbo Backing valve
CV	Charge Valve or Cryo Vent	M7	MagnaTran 7 robot	TC	Transport Chamber
DB	D-subminiature connector	MCC	Motion Control Card	TMC	Transport Module Controller
DC	DC Power Supply	MP	Mechanical Pump	TP	Turbo Pump
DP	Differential Pump	N2	Nitrogen gas	TS	Thermal Switch
DR	Atmospheric Door	NMA	Null Modem Adapter	TV	Turbo Vent valve
F	Filter	P#	Process Module <i>number</i>	VS	Vacuum Switch
FB	Front Buffer	PDP	Process Module Defeat Plug	WP	Water Pump

Appendix E: Consumables

Consumable items are identified for each unique system based on the demands placed upon that system. All standard consumable items are listed below in [Appendix E](#). Refer to the individual User Manuals for lists of the consumable items to be stocked for the components of the M2 system. Refer to the System Manual Addendum, if provided, for a list of all consumable items for that specific configuration. Contact Brooks Automation Technical Support for the part numbers for specific consumables and for additional consumables requirements.

Table 9-7: Consumables

Description	Frequency
EFEM FFU Filter ULPA, 19"x50"x3"	As Required
ATMOSPHERIC DOOR	As Required
MONOVAT GATE, VITON	As Required
MONOVAT INSERT, LOADLOCK BARE AL KIT	As Required
MONOVAT INSERT, LOADLOCK SS KIT	As Required
MONOVAT INSERT, LOADLOCK HARD ANODIZED AL KIT	As Required
O-RING FOR MONOVAT DOOR INSERT, LOADLOCK	As Required
MONOVAT GATE, PERLAST G67P	As Required
MONOVAT GATE 8085 KALREZ	As Required
MONOVAT GATE 8575 KALREZ	As Required
VAT L DOOR	As Required
SMC L DOOR	As Required

Appendix F: Tooling and Fixtures

Table 9-8 provides a list of the specialized tools and fixtures supplied with the M2 system, including shipping brackets and teach fixture kits for servicing the M2 system..

Table 9-8: Tools and Fixtures Supplied with the M2

Tool	Description and Use
Robot Shipping Brackets	Used to secure the robot arm to the robot flange during shipment.
LPM Shipping Brackets	Used to secure the paddle to the LPM frame during shipment.
Controller Shipping Brackets	Used to secure the controller to the UI Panel during shipment.
Teach Fixtures	Used to align the robot to specific stations.

Appendix G: Packing and Shipping Instructions

If the M2 system will be shipped, for return to Brooks or to another location, it must be properly packaged to ensure it arrives undamaged. The M2 system was originally assembled and packaged in a cleanroom environment. Care should be taken to ensure that it is repackaged in the same type of environment. The following procedure provides the correct method of handling and packaging the system for shipment.

NOTE: The original shipping crates must be used when shipping the M2 system. If the original crates have become lost or damaged, contact Brooks Automation for replacements.

 WARNING Lockout / Tagout	
Working with energized equipment may cause sudden movement or electrical shock and may result in death or serious injury. • All energy must be removed from the equipment per the facility's Lockout/Tagout procedure before servicing. • If local procedures are not available, follow the procedure for Lockout/Tagout in OSHA Standard 29CFR 1910.147.	 

 CAUTION Heavy Object	
The Atmospheric Front End Module weighs at least 756.6 kg (1668 lb). The Vacuum Back End weighs at least 580.6 kg (1280 lb). Failure to take the proper precautions when lifting or moving any modules could result in personal injury. Use a minimum of four people to move the M2 EFEM and VBE, and a minimum of two people to move all other modules. Do not attempt to move it without the use of a fork lift or a hoist. Roll on smooth floors only. Marathon 2 System Appendices User	  

 CAUTION Tip Hazard	
Ensure that all force exerted on the modules of the M2 system when moving them is below their center of gravity. Failure to take the proper precautions before moving any module, especially while rolling it into the shipping crate, could result in personal injury. Do not attempt to move it without the use of a fork lift or a hoist. Roll on smooth floors only.	 

Required Tools and Equipment

- Fork truck or appropriate lift
- Open End Wrench, Adjustable or size 19 mm, 1/2 in, 3/4 in, and 1 1/8 in
- Metric hex wrenches
- Phillips screwdriver

EFEM Packing Procedure

Step	Action
1.	Remove the bolts securing the Atmospheric Front End to the Vacuum Back End.
2.	Refer to the Atmospheric Front End User Manual for removal, crating, and shipping information. NOTE: <i>Inspect the travel route of the Atmospheric Front End and the Load Port Modules. Cover dips, thresholds, or any uneven floor transitions with plates.</i>

VBE Packing Procedure

Step	Action
1.	Disconnect all external wiring and facilities connections.
2.	Remove the tie-downs from the frame.
3.	Release the clamps securing the Vacuum Back End to the Process Module(s).
4.	Reattach the wheels to the Vacuum Back End's frame using the hardware that was supplied with them.
5.	Lower the wheels until the feet have been raised off of the floor.
6.	Screw in the system leveling feet so that they are fully retracted into the frame.
7.	Secure the robot's arms in the Vacuum Back End to prevent movement and damage during shipment by using the shipping brackets supplied with the Vacuum Back End when it was received.
8.	Roll the Vacuum Back End away from the Process Modules.
9.	Attach blank-offs to the atmospheric doors and vacuum slot valves on the Vacuum Back End module as required.
10.	Secure any loose cables in the Vacuum Back End and protect all cable ends and connectors.
11.	The entire Vacuum Back End should be wrapped, bagged, and packed following standard packing procedures for a cleanroom environment. Ensure that all wrapping/bagging covers the bottom of the frame to ensure cleanliness.
12.	Lower the system by raising the casters until the system is resting on the feet inside of the bag.
13.	Remove the casters. Replace them on the outside of the bag.
14.	Evacuate and seal the inner and outer poly-bags using a heat sealer.

Step	Action
15.	Lower the jacking casters.
16.	Roll the system to the shipping area.
17.	Using the fork lift, pick the Transport Chamber up only enough to clear the shipping skid.
18.	Raise the casters until the wheels are up to the frame.
19.	Using the crate the Vacuum Back End was originally shipped in, slide the shipping skid under the system.
20.	Secure the system to the shipping skid. Additional blocking should be added as required to ensure that the system is adequately secured to the pallet.
21.	Add tip indicators, shock indicators, moisture indicators, etc. to the outside of the crate as desired to verify proper handling during shipment.