Rigaku

Metal Film Monitor

MFM65

(Model: MFM65S2RFFFLFL)

Instruction Manual

1. Operation Section

Manual No. ME12058B02

Rigaku Corporation

Thank you for your purchase of Rigaku's product.

This manual describes the correct use of the product as well the usage precautions to be observed. To obtain full, expected performance from the product, thoroughly read this manual.

Also, store this manual at an easily accessible place so that you can promptly refer to it whenever necessary.

If you have any questions, problems, or emergencies, please contact the personnel in charge of Service at Rigaku at one of the addresses below.

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1. This manual may not be disclosed to a third party or copied, in whole or in part, without the written consent of Rigaku.
2. As a rule, one set of the instruction manual has to be purchased for each product.
3. If there are any missing or incorrectly collated pages in the delivered instruction manual, contact the nearest Rigaku branch office or sales office for a replacement manual.
4. In no event will Rigaku be responsible for the results of the use of this manual.
5. The contents of this manual are subject to change without prior notice.

Safety Notes

Potentially Dangerous Parts within the MFM65 system components.

Warning labels have been affixed on or near potentially dangerous parts. They are expressed with universal safety pictographs as described in the next paragraph. A summary label containing the main hazards from these potentially dangerous parts appears on the front panel of this instrument. Warning labels concerning prevention of exposure to X-rays, high voltage or other hazards use the signal word "**WARNING**" or "**CAUTION**". The use of Warning does not imply there is a hazard during ordinary measurements, but a potential danger may arise due to carelessness or mishandling during maintenance work or the like.

(1) Classification of Warning Indication. The degree of possible danger or damage in the case of mishandling and the urgency of warning are classified into the following levels:

a) DANGER

In the case of carelessness or mishandling, an operator may immediately be killed or suffer a serious injury to cause later death.

This indication is used very limitedly, and it must be strictly observed.

b) WARNING

In the case of mishandling, an operator may be killed or suffer a serious injury. It is also used to denote an action that could cause serious damage to system components of the MFM65.

c) CAUTION

In the case of mishandling, an operator may suffer a slight or medium injury or material damage alone is expected. The serious injury mentioned above means loss of eyesight, an injury, a burn (high temperature or low temperature), an electric shock, a fracture, poisoning or the like which involves an aftereffect, hospitalization or going to hospital for a long-term for medical treatment.

The slight injury means an injury, a burn, an electric shock or the like which does not involve hospitalization or going to hospital for a long-term for medical treatment. Material damage means damage to related facilities or acquired data.

(2) Pictographs for Warning Indication. Pictographs prepared according to ISO and ANSI guidelines are attached. For details, see the list of warning labels. When a warning label is damaged, please contact Rigaku to obtain a replacement label.

NOTE : Please read the SAFETY chapter in this manual before operating the MFM65 system.



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1. OVERVIEW

This manual is described the operation of MFM65 system (RFBFLFL Model).

This equipment can measure the thickness, density, and roughness of the surface and boundary of thin films deposited on a wafer (max. of 12 inches (300 mm), or 8 inches).

This is a complex equipment that can estimate a crystalline by the X-ray diffraction (**XRD**), and the compositions of multi-layer films by the X-ray fluorescence (**XRF**), in addition to measuring film thickness by the X-ray reflectometry (**XRR**).

This equipment can be used in clean rooms, and meets a wide array of needs ranging from condition estimation for semiconductor films (R&D) to process monitoring.

NOTE : 

In the case of modifying the MFM65 system without consulting RIGAKU, the system may not satisfy the specifications of this system, and RIGAKU does not warrant the system.

RIGAKU may change the specifications of the MFM65 system and the contents of the printed materials including the manual without notice in the future.

2. SAFETY

Please read the following safety information before operating the MFM65 system.

2.1 Hazards and Risks

The MFM65 system has potentially hazards and risks as follows.

WARNING



Don't use the maintenance keys in the daily operation, because these keys must be used for the purpose of maintenance only.

These keys must be in safekeeping strictly with the maintenance manager of this system.

(1) X-ray Hazards

NOTE: **The red lamps turn on during X-ray generation.** The MFM65 system has no risk of X-ray exposure during normal operation, because this system has a shielded radiation enclosure and interlocks to prevent X-ray exposure. (Refer to "2.3 Interlock List".)



Pay attention to the warning labels affixed on the enclosure of this system.

The border of the radiation-controlled area is defined at the outside surface of the enclosure. The dose equivalent limit at the border of the radiation-controlled area is **1.3 mSv / 3 months** by Publication 60 issued by the International Commission on Radiological Protection (ICRP). The dose equivalent limit on the MFM65 is designed to be **2 micro Sv/H**, that is based on Rigaku's design standards. (1.3 mSv / 13 weeks / 6 days / 8 hours = 2 micro Sv/H)

NOTE: **In fact, the dose of X-ray radiation outside the enclosure is almost zero.**



(2) Electrical Hazards

NOTE : The MFM65 system has no electric hazards in the daily operation.



Pay attention to the warning labels to be affixed on the enclosure of this system.

(3) Laser Hazards

NOTE : The MFM65 system has no laser hazards in the daily operation.



Pay attention to the warning labels to be affixed on the enclosure of this system.

(4) Mechanical Hazards

WARNING When squatting down to work, example for turning on the PC, take due care to avoid injury from hitting your head against the mechanical projections.



Pay attention to the warning labels to be affixed on the enclosure of this system.

NOTE : The MFM65 system has no mechanical hazard to catch your finger in the daily operation.



Pay attention to the warning labels to be affixed on the enclosure of this system.

(5) Material Hazards

NOTE : The MFM65 system has no material hazards in the daily operation.



Pay attention to the warning labels to be affixed on the enclosure of this system.

(6) Fire Hazards

WARNING Plastics and electric cables used in the MFM65 are class V0 or V1.

If smoke occurs from the equipment, push an EMO Switch.



(7) Hot Surface Hazards

NOTE : The MFM65 system has no hot surface hazards in the daily operation.



Pay attention to the warning labels to be affixed on the enclosure of this system.

(8) Trip Hazards

NOTE : The MFM65 system has no trip hazards in the daily operation.



Pay attention to the warning labels to be affixed on the enclosure of this system.

2.2 Hazard Indications

(1) Labels for hazard indications

The MFM65 system has the following labels for hazard indications.

1	X-ray Hazard



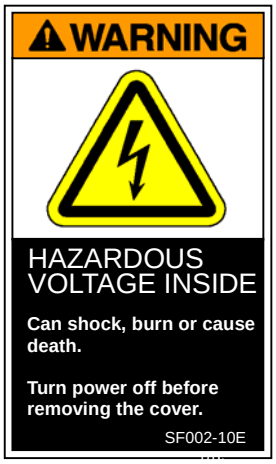
2	X-ray Hazard



3	Mechanical Hazard



4	Electric Hazard



5	Mechanical Hazard



6	Material Hazard



Fig. 2-2-1 Hazard Labels 1

7	Material Hazard



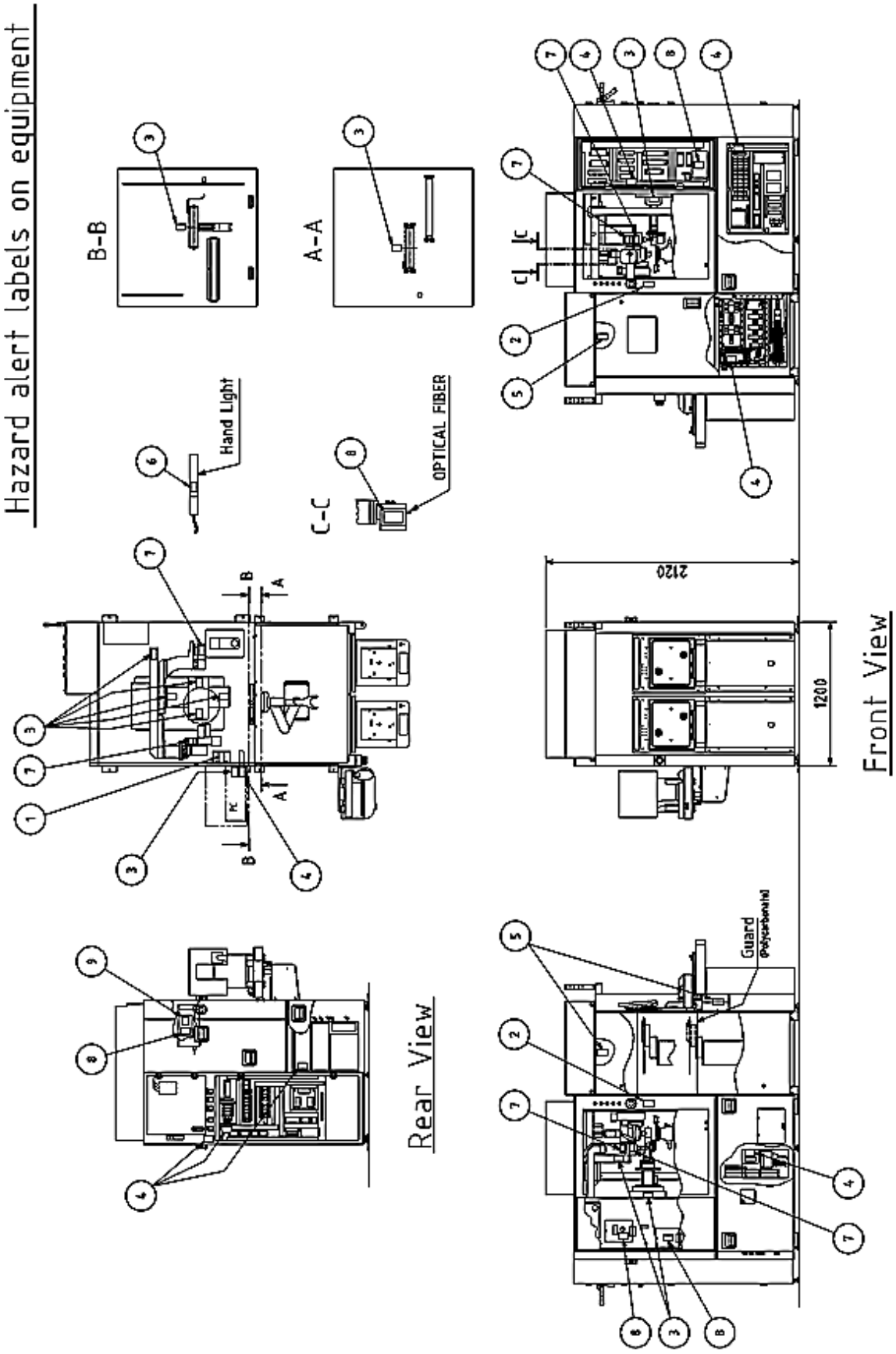
8	Hot Hazard



9	Caution



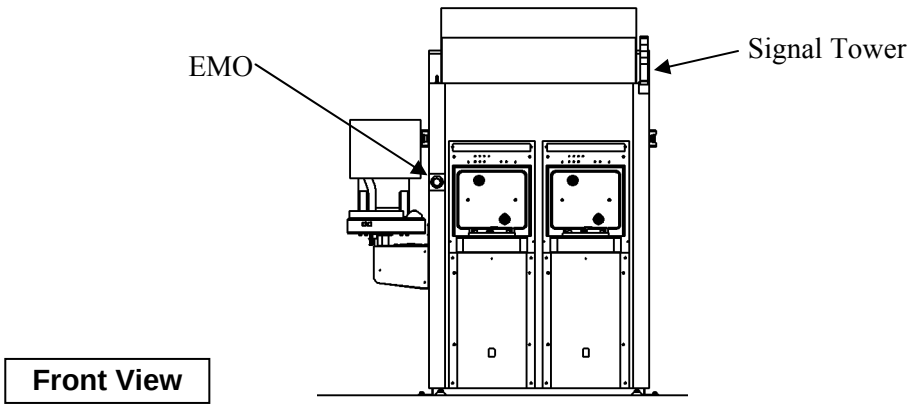
Fig. 2-2-2 Hazard Labels 2

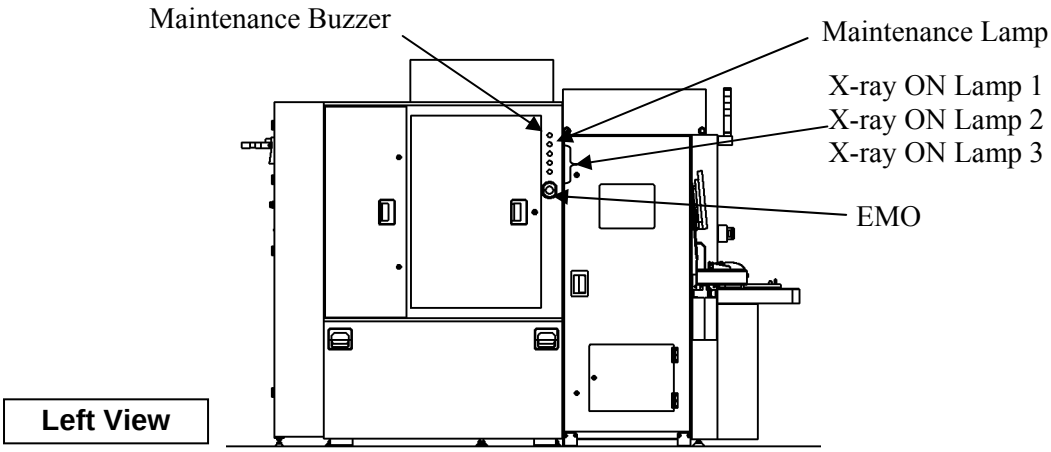


The location of the hazard indication labels is the following figure.

Fig. 2-2-3 Location of Hazard Indication Labels

(2) Signal Towers and Buzzers





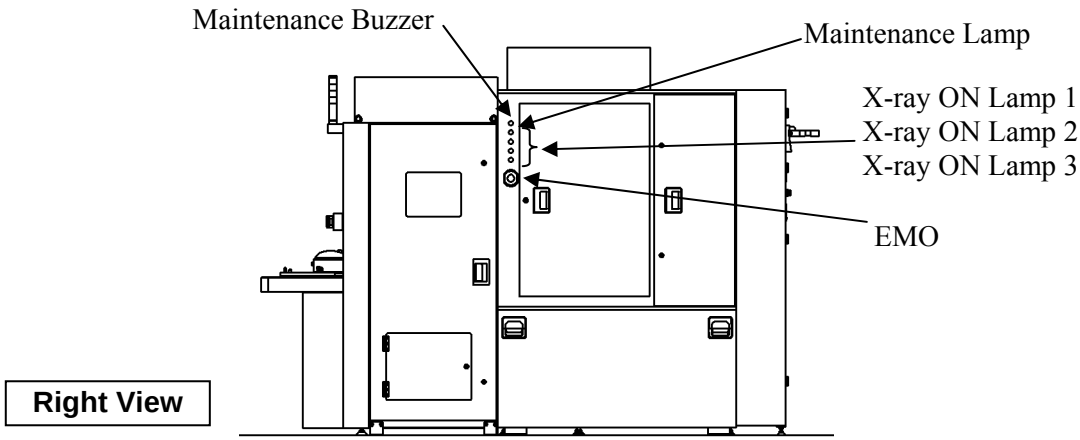


Fig. 2-2-4 Signal Towers and Buzzers

2.3 Interlock List

The interlock list in the following table helps operators and maintenance personnel avoid hazard risks.

No.	Inter Lock Name	A risk of being protected	The working MCs / The stopping parts																		
			none		MC1										MC3	MC4		MC5	MC2		
			EMO circuit	PC(UPS)	UPS	Display	Load Port	Bar-code Reader	FAN	I/O	PLC	Air Valve	Light	Signal Lamp	ROBOT	Pattern Navi	Moter Driver	Moter Controller	Moter Driver	X-Ray(A) High Voltage Power Supply	X-Ray(B) High Voltage Power Supply	X-Ray(C) High Voltage Power Supply
1	Upper Door at Power Box	Electric shock & Fire	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓		✓	✓	✓	✓
2	EMO	Unexpected danger			✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓		✓	✓	✓	✓
3	Electric protection panel in the lower right of EFEM	Electric shock			✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓		✓	✓	✓	✓
4	Electric protection panel at the Power distribution Box	Electric shock			✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓		✓	✓	✓	✓
5	Electric protection panel at the Motor driver Box	Electric shock			✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓		✓	✓	✓	✓
6	Electric protection panel at the Pattern NAVI Box	Electric shock			✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓		✓	✓	✓	✓
7	Electric protection panel at the X-ray power supply	Electric shock			✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓		✓	✓	✓	✓
8	Electric protection panel in the lower of Power Box	Electric shock			✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓		✓	✓	✓	✓
9	Water leak sensor	Electric shock			✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓		✓	✓	✓	✓
10	Rear side Door of main module	The injury by the operation part			✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓		✓	✓	✓	✓
11	Right side Door of EFEM	The injury by the operation part. Exposure of X-rays													✓				✓	✓	✓	✓
	Right side Door of EFEM (Gate and Cover at Wafer aligner closed)	The injury by the operation part													✓							
12	Left side Door of EFEM	The injury by the operation part. Exposure of X-rays													✓				✓	✓	✓	✓
	Left side Door of EFEM (Gate and Cover at Wafer aligner closed)	The injury by the operation part													✓							
13	Right side Door of Main module	The injury by the operation part. Exposure of X-rays													✓	✓	✓		✓	✓	✓	✓
	Right side Door of Main module (Gate and Cover at Wafer aligner closed)	The injury by the operation part. Exposure of X-rays														✓	✓		✓	✓	✓	✓
14	Left side Door of Main module	The injury by the operation part. Exposure of X-rays													✓	✓	✓		✓	✓	✓	✓
	Left side Door of Main module (Gate and Cover at Wafer aligner closed)	The injury by the operation part. Exposure of X-rays														✓	✓		✓	✓	✓	✓
15	Robot Arm Sensor (The robot arm comes in contact with the gate.)	The injury by the operation part													✓							
16	Load Port (Remove)	The injury by the operation part													✓							

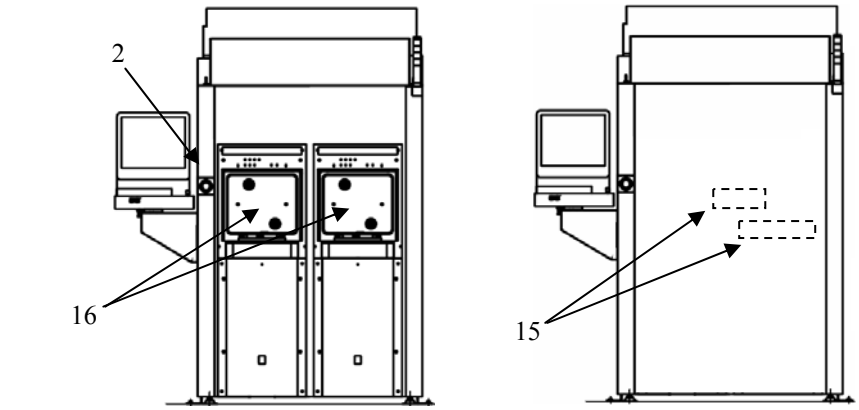
NOTE : Refer to the “A3.1 Power Circuit Diagram” for the interlock circuit.

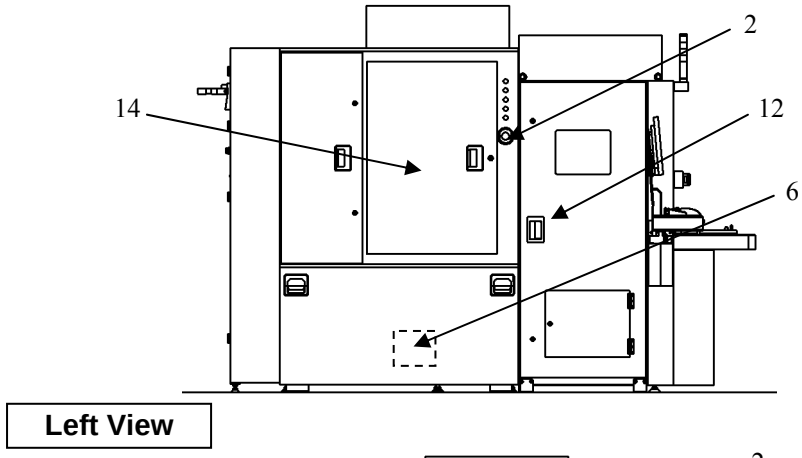


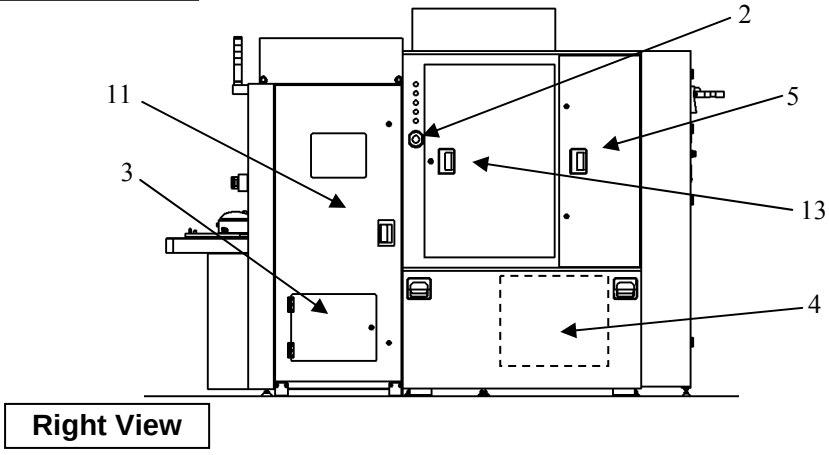
[Interlock location]

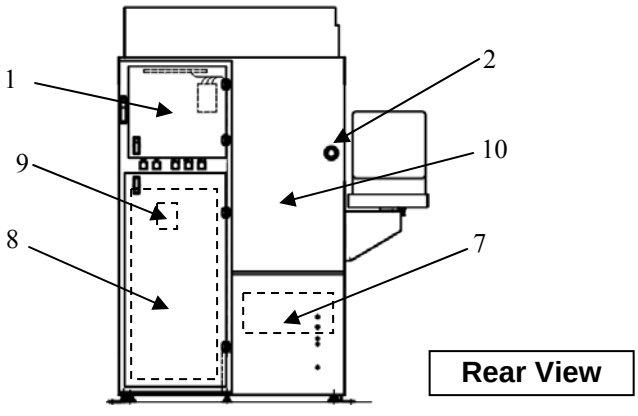
	Interlock Name
1	Upper Door at Power Box
2	EMO
3	Electric protection panel in the lower right of EFEM
4	Electric protection panel at the Power distribution Box
5	Electric protection panel at the Motor driver Box
6	Electric protection panel at the Pattern NAVI Box
7	Electric protection panel at the X-ray power supply
8	Electric protection panel in the lower of Power Box
9	Water leak sensor
10	Rear side Door of Main module
11	Right side Door of EFEM
	Right side Door of EFEM (Gate and Cover at wafer aligner closed)
12	Left side Door of EFEM
	Left side Door of EFEM (Gate and Cover at wafer aligner closed)
13	Right side Door of Main module
	Right side Door of Main module (Gate and Cover at wafer aligner closed)
14	Left side Door of Main module
	Left side Door of Main module (Gate and Cover at wafer aligner closed)
15	Gate Sensor (The robot arm comes in contact with gate)
16	Load Port (Removed)

9 : The sensor line is in the main module.









NOTE : The measurement software displays the messages during interlock operation.

Fig. 2-3-1 Interlock Locations

2.4 Lock-out / Tag-out

WARNING When electrical power off and isolating the cooling water of facility, strictly follow lock-out/tag-out of the instrument as follows.

In the daily operation, the lock-out/tag-out of the cooling water is normally unnecessary.

(1) The main breaker lock-out handle

1. Pull down the lock-out handle.
2. Set the tag to the lock-out handle.
3. Lock the tag.

The power box on the rear side



Fig. 2-4-1 Lock-out Handle

(2) The cooling water lock-out

1. Open the lower panel on the left side.
2. Remove the internal cover.
3. Close the bulbs.
   (The third bulb is option.)
4. Lock-out the bulbs.

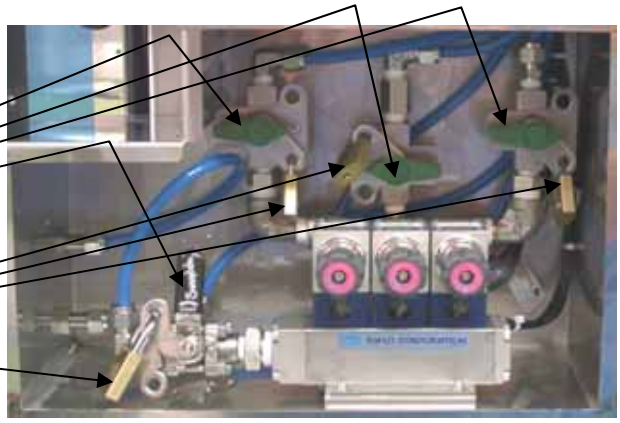


Fig. 2-4-2 Water Lock-out

NOTE: Check and adjustment of the cooling water should be performed by the maintenance personnel. Contact the maintenance personnel, if they need.

Refer the “8.ROUTINE CHECK”.

2.5 EMO

When the EMO button is pushed, electric power is OFF immediately. (See “2.3 Interlock List”.)

Push this button, when an accidental event occurs, for example loss of mechanical control, water leakage, or fire.

The MFM65 system has four EMO buttons, one on each side of the tool. (See “2.3 Interlock List”.)

2.6 Maintenance Keys

The MFM65 system has many interlock functions for safety. When the enclosure covers of the equipment are opened, electric power is OFF immediately. The X-ray generations are turned off, and the mechanical systems, for example the goniometer, the robot, and so on, are turned off. But, some items for maintenance need to be powered on with the covers open. In this case, maintenance keys are used to release the interlock functions.

WARNING: **There are two kinds of maintenance keys in the MFM65 system.**



One is the key for mechanical maintenance. This key must be in safe keeping with the maintenance personnel in charge, and only maintenance/service personnel can use these keys for maintenance only.



Another is the key for X-ray maintenance. This key must be in safe keeping with the service personnel in charge, and only the service personnel can use these keys for maintenance only.

It is strictly prohibited to use these keys other than for maintenance operations.



If these keys are used, mechanical hazards, electric hazards and X-ray hazards occur inside the main module or the EFEM.

[Inside locations of the maintenance key switches]

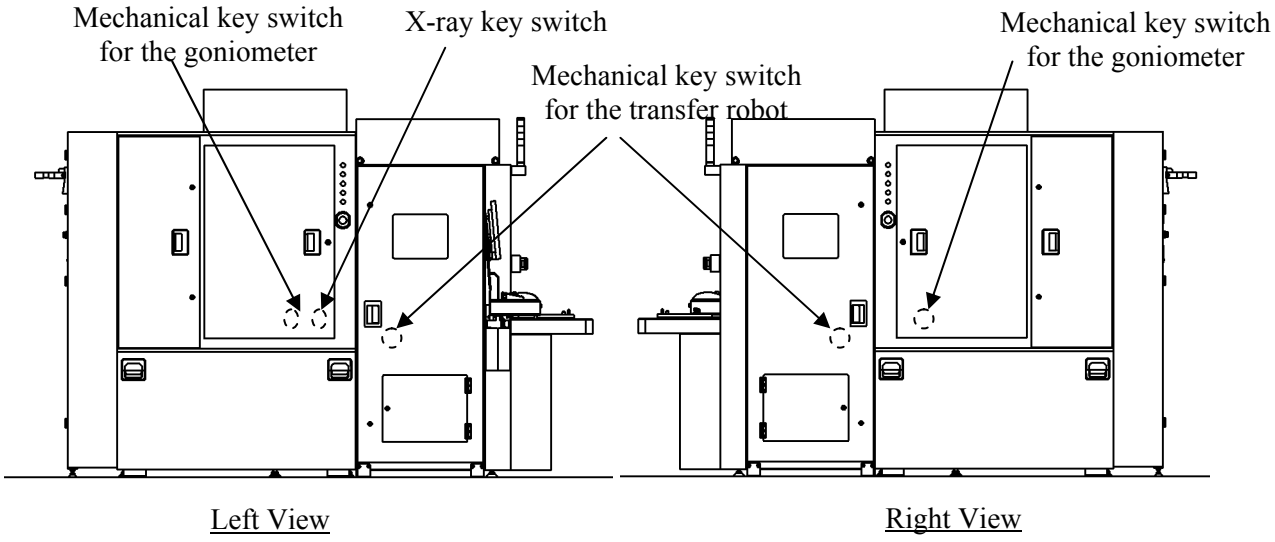


Fig. 2-6-1 Maintenance Key Locations

3. CONFIGURATION

3.1 MFM65 External Figure

[External Figure]

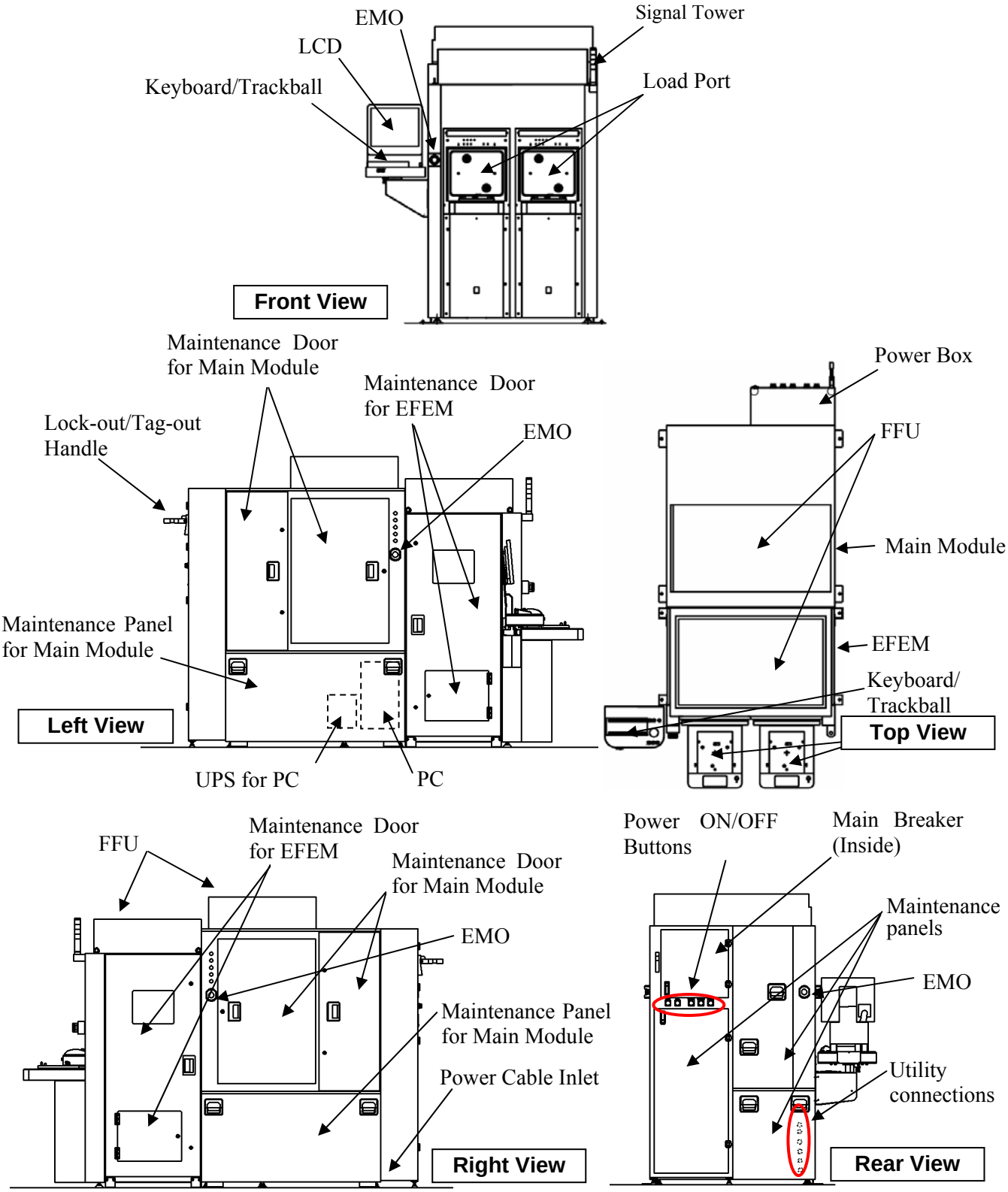


Fig. 3-1-1 External Figure

[Goniometer Figure]

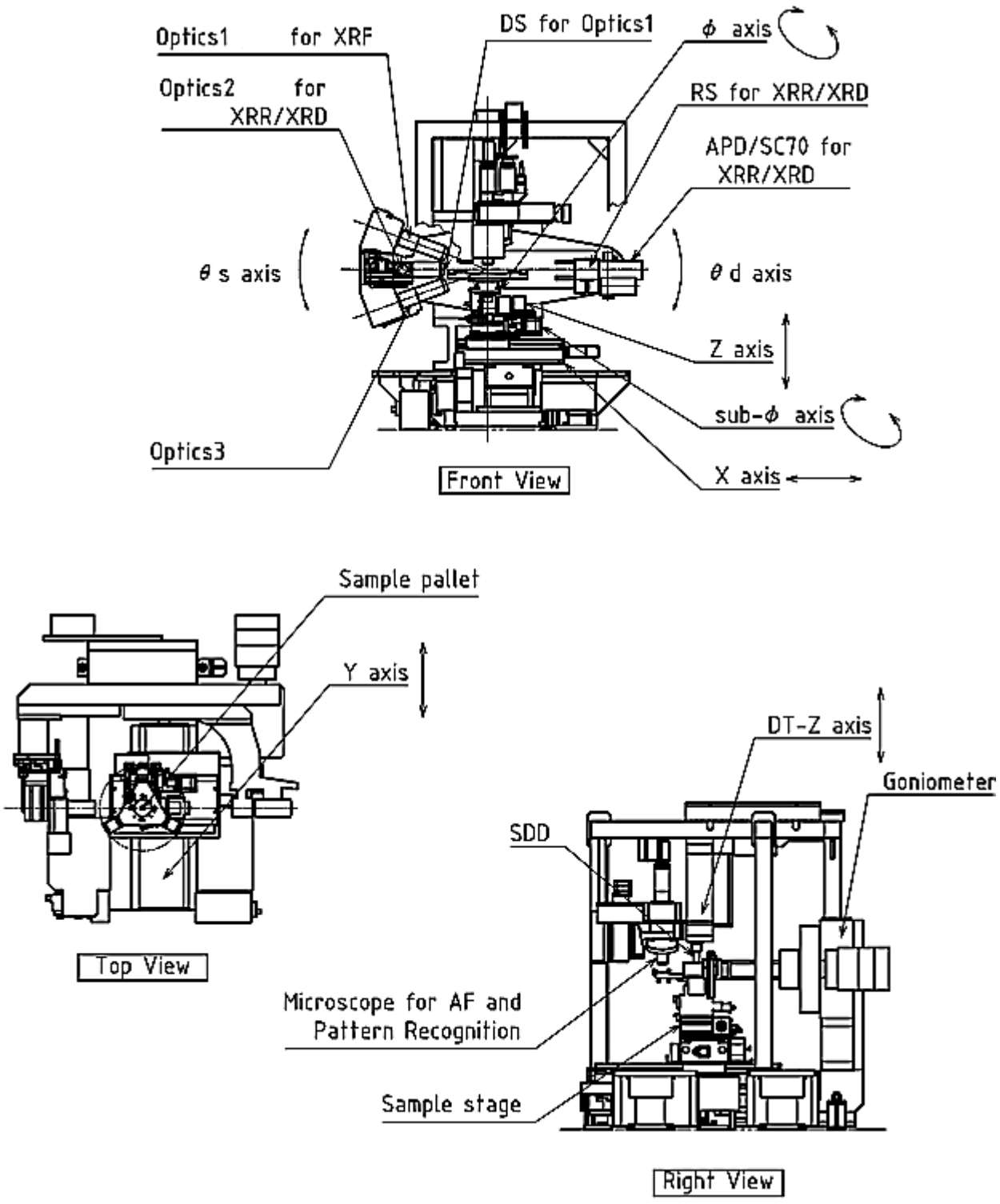


Fig. 3-1-2 Gonimeter

[EFEM Figure]

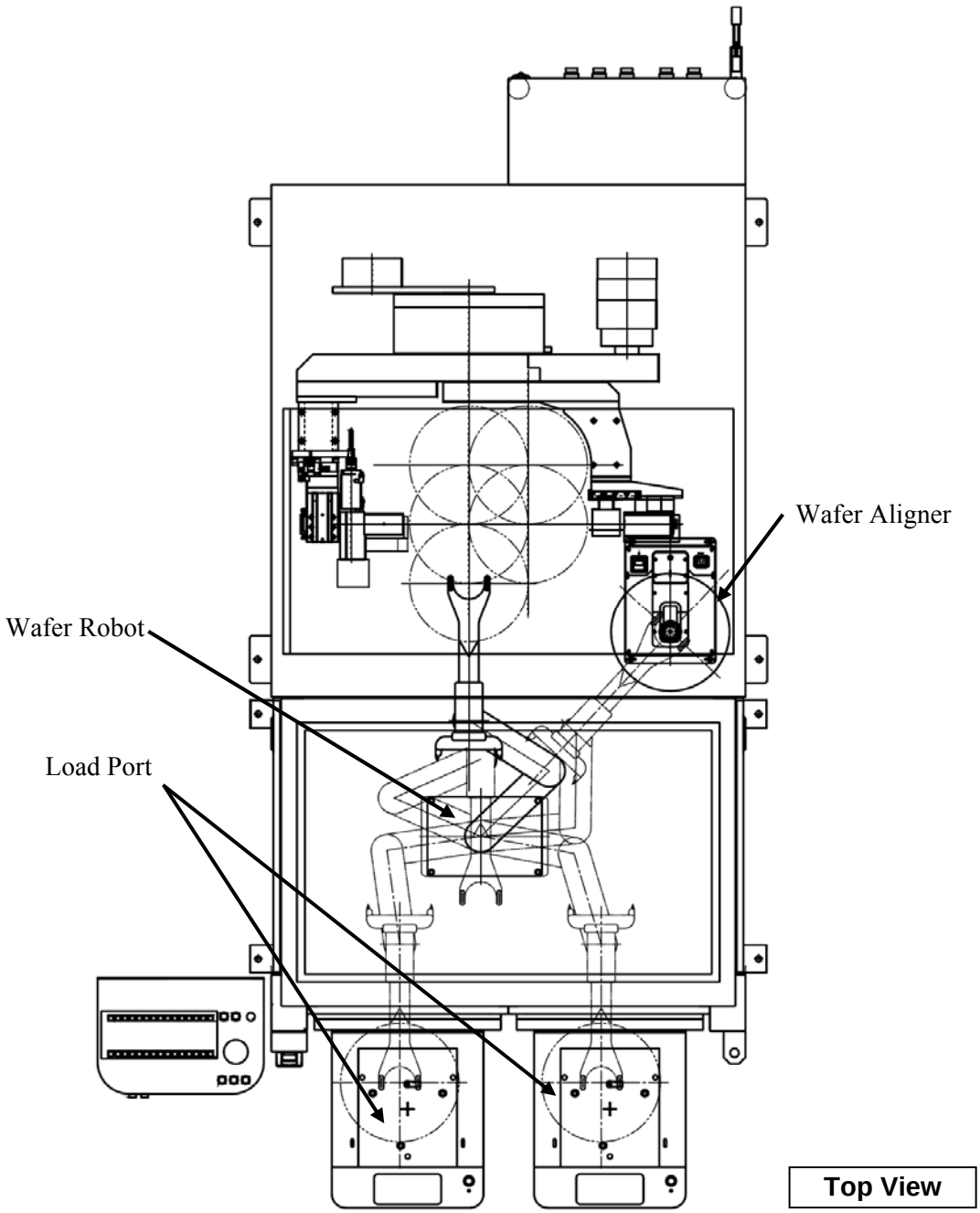


Fig. 3-1-4 EFEM Figure

3.2 MFM65 Configuration Block Diagram

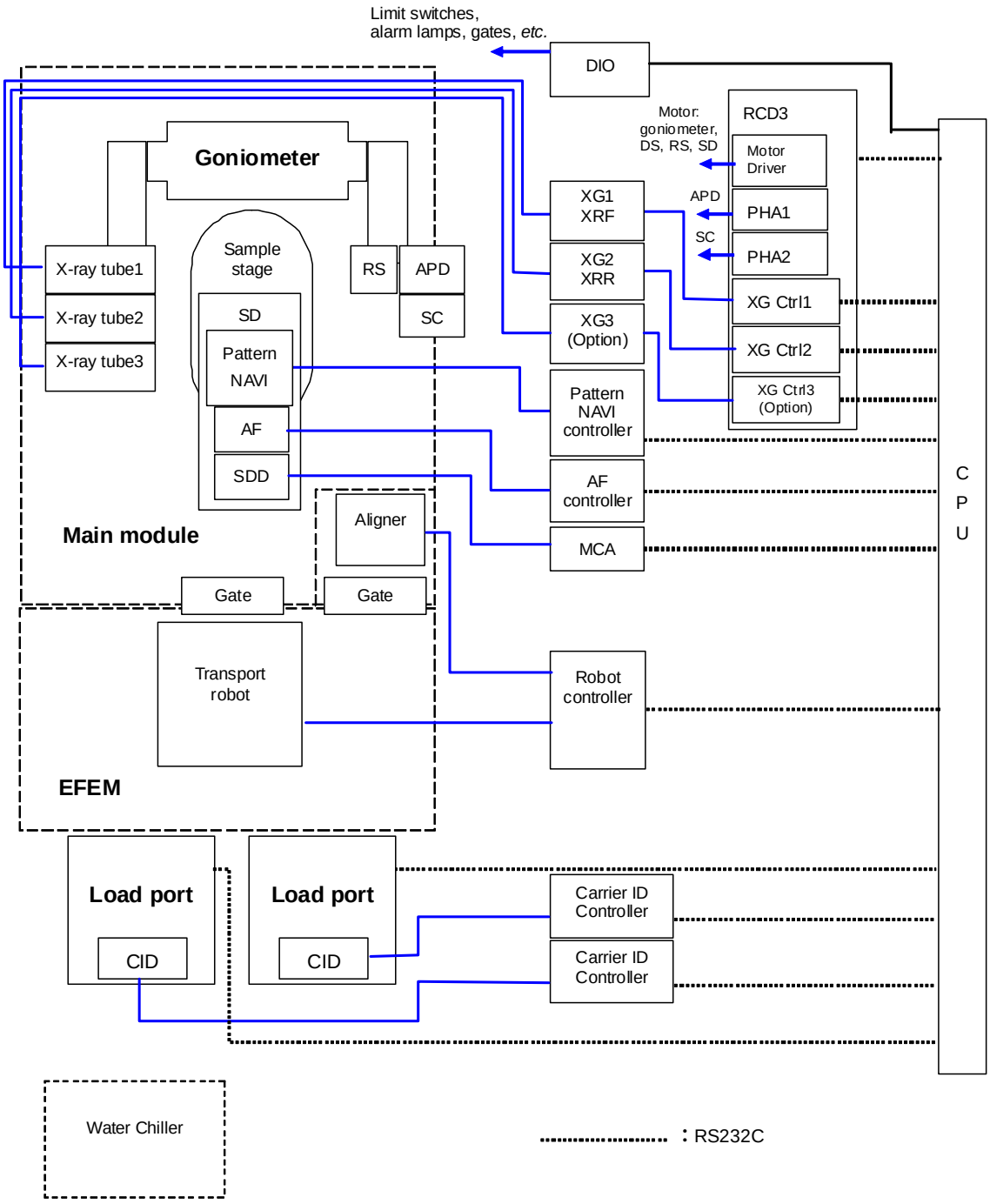


Fig. 3-2-1 Configuration Block Diagram

NOTE : Refer to the "A3.1 Power Circuit Diagram".



3.3 Functions

Units		Functions
Load port	FOUP	2 load ports for 300 mm or 200 mm wafers Set the adapter into the FOUP for 200 mm wafers Carrier ID reader Slot mapping function
EFEM	Sample transport robot Notch aligner	Open cassette for 300 mm or 200 mm wafers; selectable by software
Main module	Sample stage	Support the wafer for measurement horizontally Measurement position: r-axis (0 to 150 mm), ϕ-axis (0 to 360 degrees) Surface height: Z-axis (-13 mm to +1 mm)
	Goniometer	Type: θ-θ drive, θ_d-axis (-3 to 60 degrees), θ_s-axis (0 to 60 degrees) 2θ/ω scan: 0 to 120 degrees Rocking scan: maximum 0 to 60 degrees Scanning can be performed along each axis separately XRF incident-angle control: up to 0 to 15 degrees (up to 40 degrees if the distance between the SDD and the sample is aligned)
	X-ray source For XRR, XRD, XRF	Cu target sealed tube 25 W 1 corner CMF mirror Automatic single slit
	X-ray counter (APD) For XRR	Counting linearity: Up to the order of 10^8 cps Automatic double slits
	X-ray counter (SC70) For XRD	Counting linearity: Up to the order of 10^5 cps Automatic double slits
	X-ray source For XRF	Mo target sealed tube 25 W 4-corner CMF mirror
	Fluorescent X-ray counter (SDD) For XRF	Silicon Drift Detector (Peltier cooling) Hi-speed counting circuit, MCA: max. 10^5 cps Mechanism for moving between measurement points
	Pattern Navigation	CCD camera system for wafer pattern recognition
	Auto focus	Auto focus system for wafer height alignment
	Gate	The door separating the goniometer from the EFEM
(Water Chiller)		(Should be prepared separately)

3.4 Software Configuration

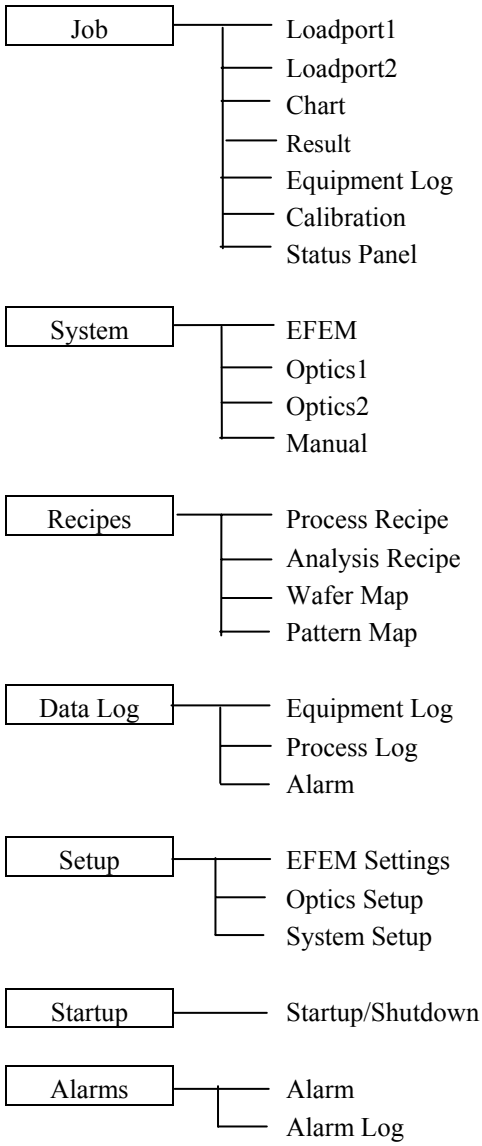


Fig. 3-4-1 Software Block Diagram

Accessory off-line analysis software:

1. **GXRR**: XRR analysis software
2. **XTFbatch**: XRF processing software
3. **XTFcalib**: XRF calibration curve software
4. **XTFstd**: XRF drift correction software
5. **XRDbatch**: XRD processing software (Option)

3.5 Hardware Specifications

X-ray Generator 1 (XRR, XRD, XRF)	
Maximum power	40 W (50 kV, 0.8 mA)
Target	Cu (Max. 25 W, (50 kV, 0.5 mA))
Focus size on tube target	ϕ40 μm
Alignment mechanism	Manual alignment for X-ray tube position.
X-ray Generator 2 (XRF)	
Maximum power	40 W (50 kV, 0.8 mA)
Target	Mo (Max. 25 W, (50 kV, 0.5 mA))
Focus size on tube target	ϕ40 μm
Alignment mechanism	Manual alignment for X-ray tube position.
Incident Optics 1 (XRR, XRD, XRF)	
Monochromator	One-corner multi-layer mirror unit
X-ray beam size	ϕ85 μm
Alignment mechanism	Fine adjustment with screws (manual operation)
Divergence slit (DS)	One dimensional automatic variable slit (0.01 to 3 mm < 0.005 mm/step)
Incident Optics 2 (XRF)	
Monochromator	Four-corner multi-layer mirror unit
X-ray beam size	ϕ70 μm
Alignment mechanism	Fine adjustment with screws (manual operation)
Receiving Optics (XRR,XRD)	
Receiving slit	One-dimensional automatic variable slit (Double slits) (0.01 mm to 20 mm 0.001 mm/step)
Detector	APD (Avalanche Photo Diode)
Dynamic range	Greater than 8 orders of magnitude
Receiving Optics (XRF)	
Detector	Peltier cooling SDD (Silicon Drift Detector)
Dynamic range	Greater than 5 orders of magnitude

Goniometer	
Type	Theta-Theta goniometer ----- Horizontal Sample Placement
θs axis (X-ray tube mounted)	– 3 to 60 degrees 0.001 degree/step
θd axis (Detector mounted)	– 3 to 60 degrees 0.001 degree/step
θs/θd (2θ/θ)coupled scan	Scanning range – 10 to 120 degrees, 0.002 degree/step
Scanning mode	Independent θs or θd scan Radial scan θs = θd Rocking scan -θs = θd
Sample Stage	
Sample holder	For 300 mm and 200 mm wafers
Sample chuck	Vacuum chuck at edge exclusion area on the backside of wafer
ϕaxis (in-plane rotation)	0 to 360 degrees 0.2 degree/step
Z axis (up / down)	-13 to 1 mm 0.000156 mm/step
Sub ϕaxis (in-plane rotation)	±5 degrees 0.0001 degree/step
X axis (left / right)	0 to 150 mm 0.0002 mm/step
Y axis (front / back)	-150 to 150 mm 0.0002 mm/step
Pattern Recognition Unit	
Positioning accuracy	X : ±2 μm (σ), Y : ±1 μm (σ), Z : ±1 μm (σ)
Imaging unit	Lens magnification : ×5, CCD camera (monochrome)
Auto focusing unit	Lens magnification : ×5
AF-Z axis (up / down)	0 to 4 mm 0.0001 mm/step (For auto focus lens)
DT-Z axis (up / down)	0 to 40 mm 0.002 mm/step (For SDD)
EFEM	
Load port	2 load ports (model TAS300) manufactured by TDK FOUP for 300 mm wafers Adapter for 200 mm wafers in the FOUP
Wafer transfer robot	For 300 mm and 200 mm wafers
Wafer aligner	For 300 mm and 200 mm wafers
PC system	
PC main body	IBM PC Compatible (OS : WindowsXP)
Display	LCD
Keyboard	Compact type
Track ball	Optical type
Joy stick	For pattern recognition

3.6 Explanation of Software

Navigation Buttons		Contents
Job	Daily operation using recipes	
	Loadport1	Executes recipes for load port 1.
	Loadport2	Executes recipes for load port 2.
	Chart	Displays graphs on the main window.
System	Enables manual operation for maintenance purposes.	
	EFEM	Loads or unloads a wafer from the carrier to the sample stage.
	Optics1	Sets x-ray power for optics 1.
	Optics2	Sets x-ray power for optics 2.
Recipes	Constructs recipes to execute jobs.	
	Process Recipe	Creates and edits process recipes by combining analysis recipe and wafer recipe.
	Analysis Recipe	Creates and edits analysis recipes at an arbitrary point on wafers.
	Wafer Map	Creates and edits recipes for the mapping of points on non-patterned wafers.
	Pattern Map	Creates and edits recipes for the mapping of points on patterned wafers.
Data Log	Displays recent LOGs.	
	Equipment Log	Displays the current equipment log on the main window.
	Process Log	Displays the current process log on the main window.
	Alarm	Displays the current alarms and the history log of past alarms.
Setup	Sets the equipment parameters for the MFM65 system.	
	EFEM setting	Sets the equipment parameters for EFEM.
	Optics Setting	Sets the equipment parameters for optics.
	System Setup	Sets the system parameters.
Startup	Sets the equipment parameters for the MFM65 system.	
	Startup/Shutdown	Executes startup or shutdown of this equipment.
Alarms	Displays the current alarm information and the history log of past alarms.	
	Alarm	Displays the current alarm information.
	Alarm Log	Displays the history log of past alarms.

4. START UP

This section describes the steps for starting up the equipment from the deactivated state to the standby state for analysis.

Follow the startup sequence specified below.

(1) Preparation of the water chiller

(2) Power on the equipment

(3) Start up the control software

(4) Initialization and aging

(5) Equipment diagnosis

4.1 Preparation of the Water Chiller

Open the cooling water valves on the primary side.

Power on the water chiller, and flow the cooling water to X-ray tube in the equipment before generating X-ray.

(Refer to the manual of the water chiller)

When power on, check the flow rate, pressure and temperature of the secondary cooling water.

(These values are dependent of the chiller.)

4.2 Power on the Equipment

Power on as the following sequence.

(1) Main breaker **lock-out handle** ON.
(2) Push the **[POWER ON]** button. (Button indicator lamp is ON.)
(3) Push the **[X-RAY]** button. (Button indicator lamp is ON.)
(4) Push the **[ROBOT]** button. (Button indicator lamp is ON.)
(5) Push the **[GONIO]** button. (Button indicator lamp is ON.)

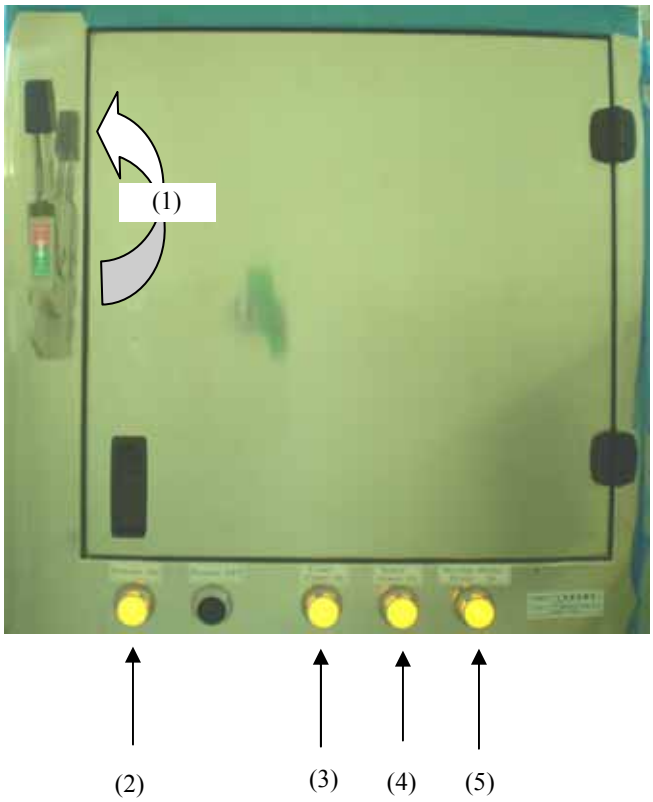


Fig. 4-2-1 Power Switch

4.3 Start Up the Control Software

The PC is housed in the left below panel of the Main Module.



Fig. 4-3-1 PC Power Switch

(1) Power on the UPS and the PC.power on the PC.

WARNING Take care not to hit your head against the keyboard table.



(2) Windows starts up.

(3) Log into Windows.

(4) Double click on the MFM65 icon to start up the control software.

(5) Log into the control software, and the MFM65 control software starts up as follows.

NOTE : In the daily operation, login by a general user account.



Administrator account is for the maintenance personnel.

Refer to the maintenance manual about the account setup.

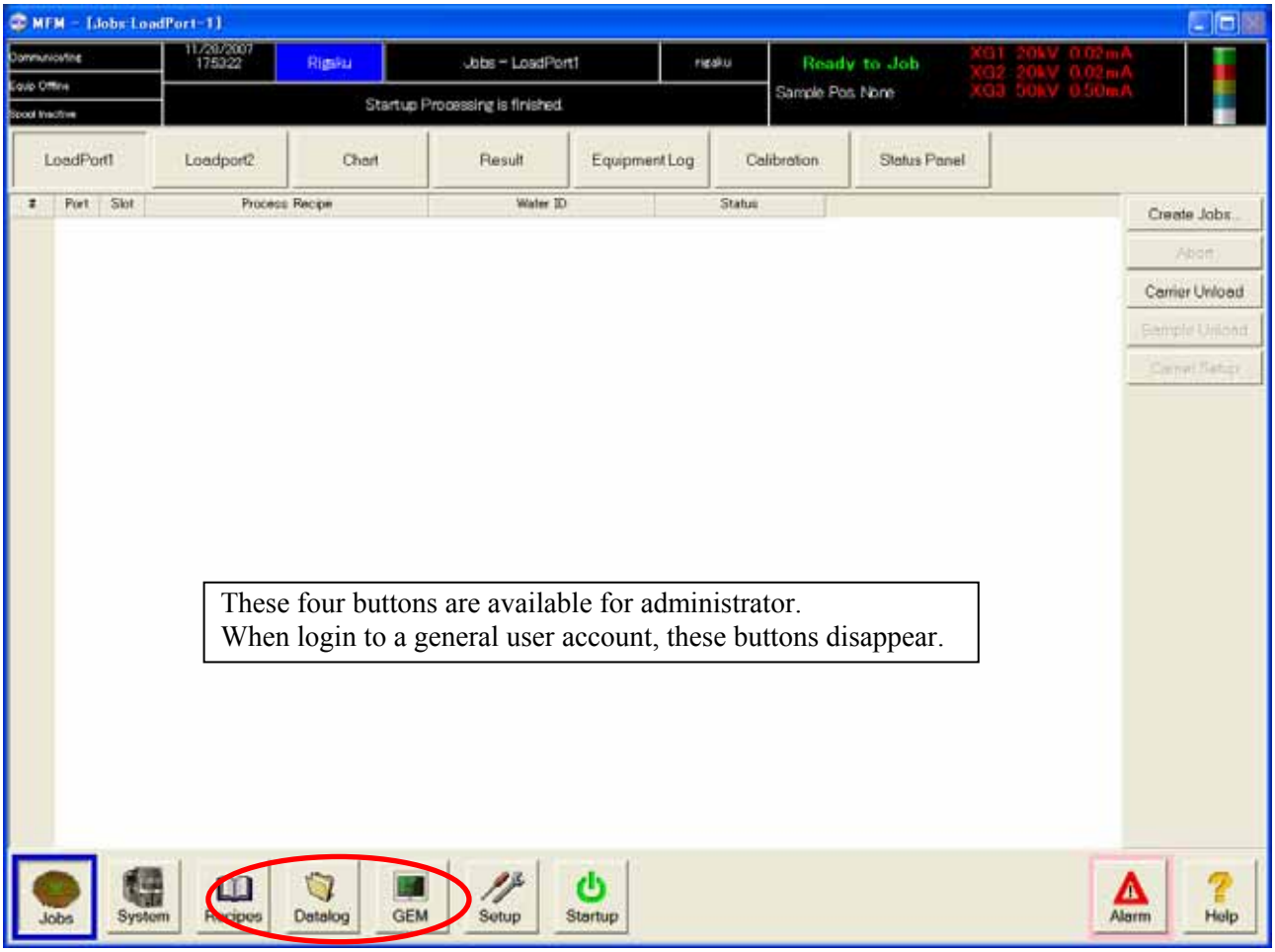


Fig. 4-3-2　Main Window of Control Software

4.4 Equipment Initialization and Aging

(1) Click on **[Startup]** among the navigator buttons.

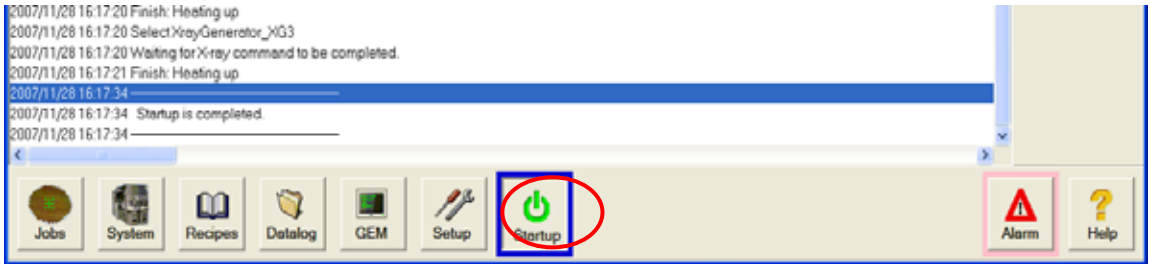


Fig. 4-4-1 Navigation Button

NOTE : **[System]**, **[Recipes]** ,**[Datalog]**and **[Setup]** buttons are available for administrator. When login to a general user account, these buttons disappear.

(2) Initialize the equipment. Click on **[Startup]** among the sub-sub-navigation buttons; the startup dialog box is displayed.Select “All of system”or “Select startup target”.

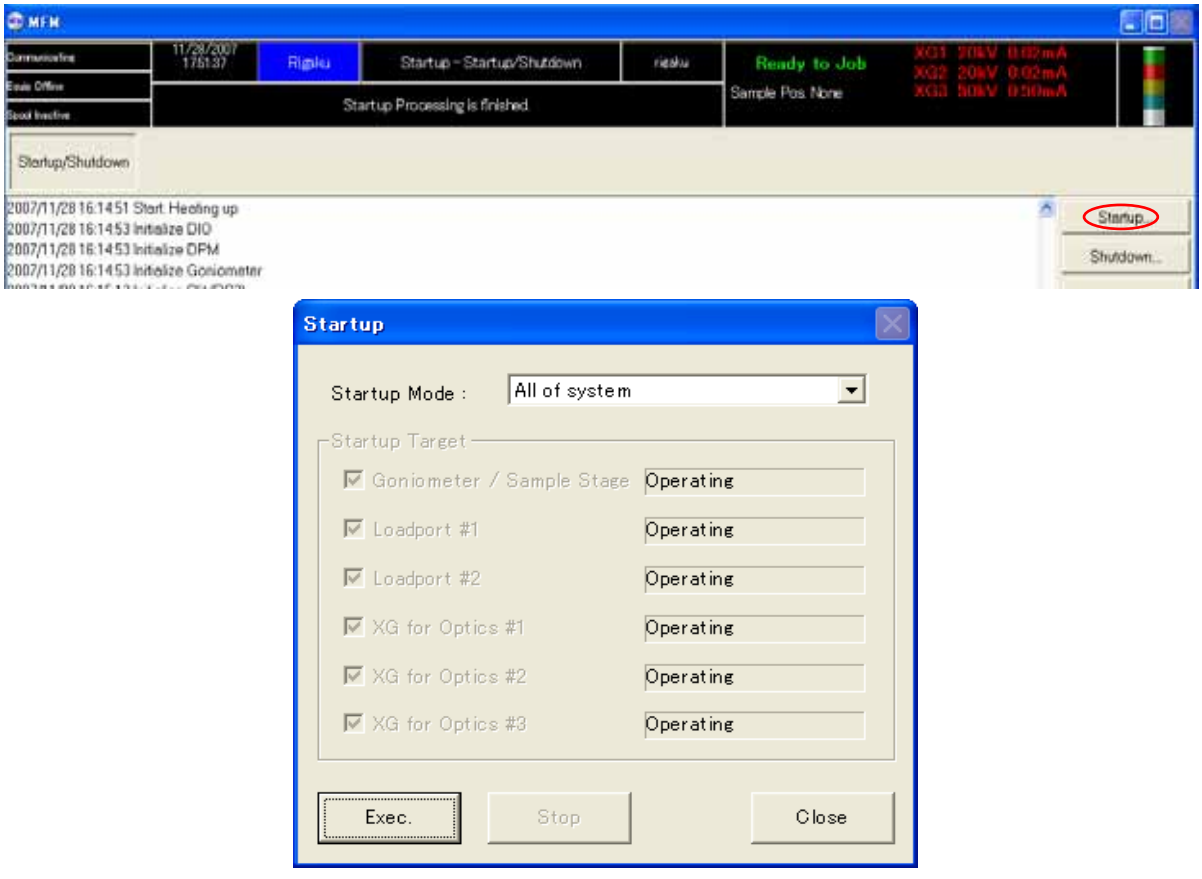


Fig. 4-4-2 Startup Display

(3) When "**Goniometer/Sample Stage**"is selected, the initialization of the mechanical units of goniometer and wafer transportline are carried out.

When "**Loadport #1**"is selected, the initialization of Loadport #1 is carried out.

When "**Loadport #2**"is selected, the initialization of Loadport #1 is carried out.

When "**XG for Optics #1**"is selected, aging of the X-ray tube #1 is carried out.

When "**XG for Optics #2**"is selected, aging of the X-ray tube #2 is carried out.

When "**XG for Optics #3**"is selected, aging of the X-ray tube #3 is carried out.

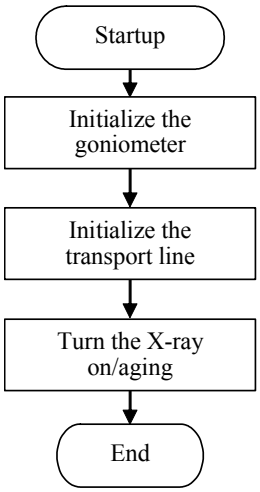


Fig. 4-4-3 Startup Flow

20 - 30 minutes are required for initialization, because the X-ray power is ramped up slowly according to the aging schedule.

In addition, allow **approximately 30 minutes** for the X-ray output to stabilize.

NOTE : When the X-ray power is already set before the startup procedure, ramping up is omitted.

4.5 Equipment Diagnosis

Beam Diagnosis

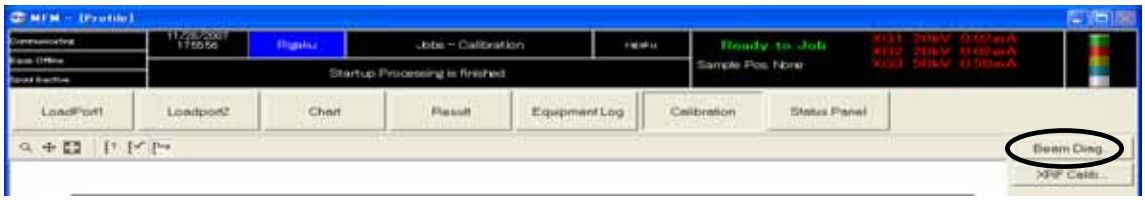


Fig. 4-5-1 Navigation Button

Check the position of the X-ray output beam and the intensity of direct X-rays.

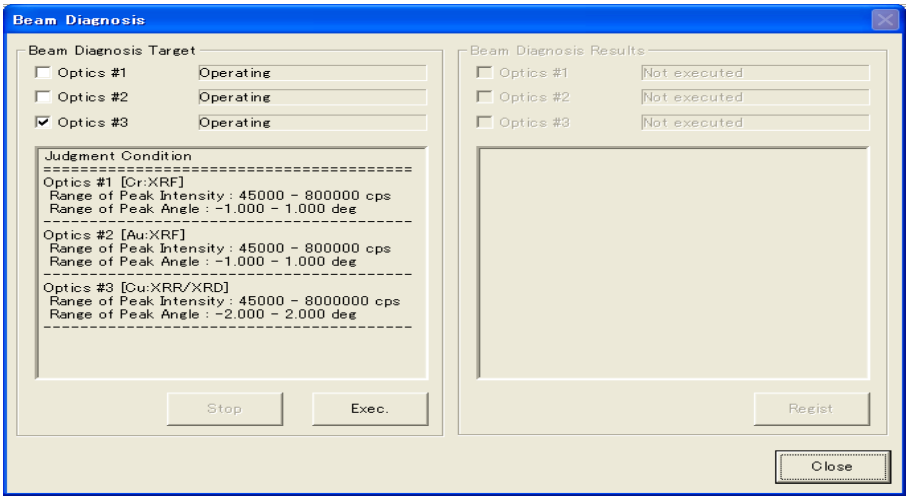


Fig. 4-5-2 Beam Diagnosis Dialog

Upon completion of beam diagnosis, a confirmation dialog box is displayed.

When complete message is displayed in the confirmation dialog box, click on **[OK]** to save the current measurement values.

If NG message is displayed, refer to the below table.

Results	Solutions
XRR intensity differs from the previous value by more than ±5%.	No action is required if the 2θ angle is 0.01 or smaller.
XRR beam position (2θ angle) shifts by more than 0.01 degree.	Measure the check sample. If the obtained film thickness differs from the standard value, the optic system will require alignment.
XRF intensity differs from the previous value by more than 5%.	Measure the check sample. If the obtained film thickness differs from the standard value, the calibration curve will require standardization.
XRF beam position (2θ angle) shifts by more than 0.01 degree.	Measure the check sample. If the obtained film thickness differs from the standard value, the calibration curve or optic system will require standardization or alignment, respectively.

5. SHUTDOWN

The following are the steps for terminating operation and deactivating the equipment.

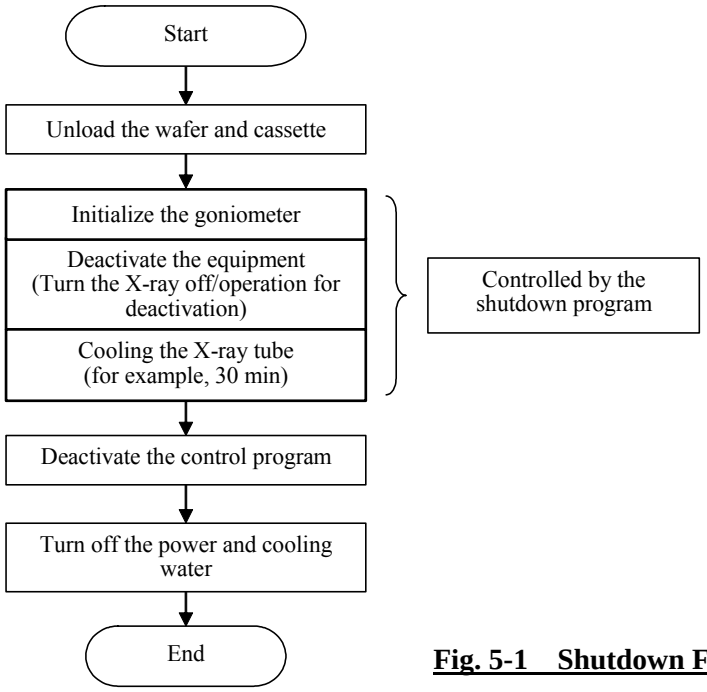


Fig. 5-1 Shutdown Flow

NOTE : Make sure the measured wafer, the wafer or the cassette that is untreated due to the emergency stop, are not left in the equipment for the next start up.

5.1 Unload Sample

Upon completion of continuous operation in accordance with a normal job list, the wafer is returned to the FOUP, FOUP is undocked and **[Control Job is finished.]** is displayed in the title bar.

NOTE : If any wafer is left in the equipment, remove it in accordance with the procedure specified in Section 5.3.

5.2 Deactivate the Equipment

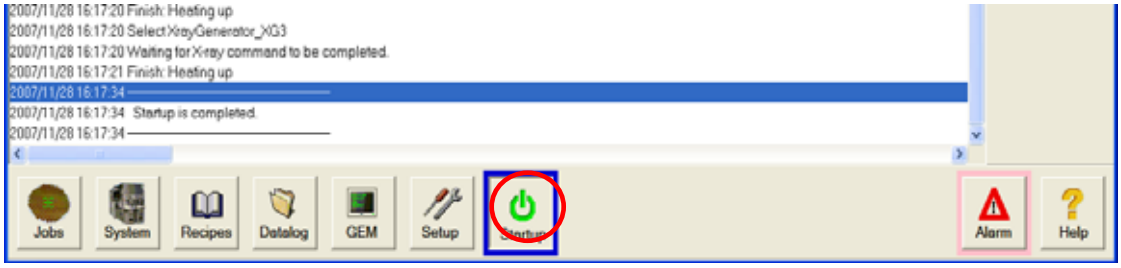


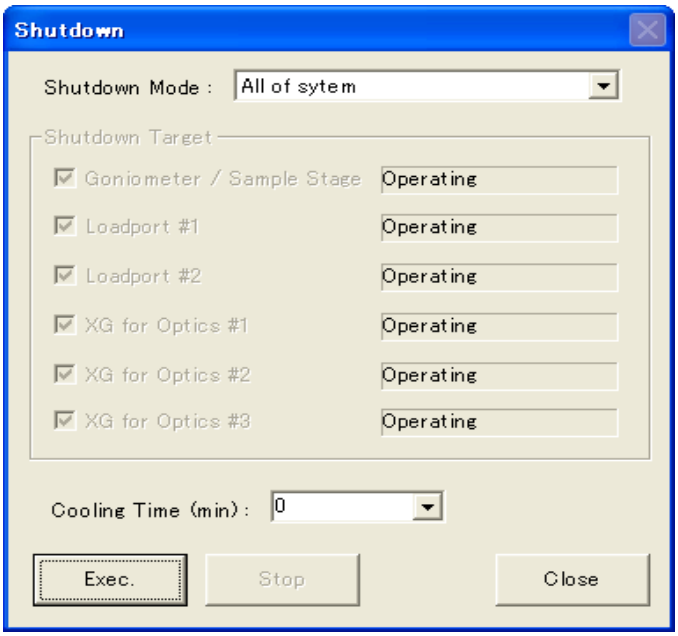
Fig. 5-2-1 Navigation Button

NOTE : **[System]**, **[Recipes]** ,**[Setup]** ,**[DataLog] and [Setup]** buttons are available for administrator.
When login by a general user account, these buttons disappear.

Click on **[Jobs]** – **[Shutdown]**; a dialog box is displayed.



Fig. 5-2-2 Shutdown Display



(1) **[Shutdown]** moves the mechanical units to their initial positions and turns off the X-ray.

(2) Allow **30 minutes** for cooling to ensure the long life of the X-ray tube.

(3) Click on **[Terminate MFM65]** to exit the control program.

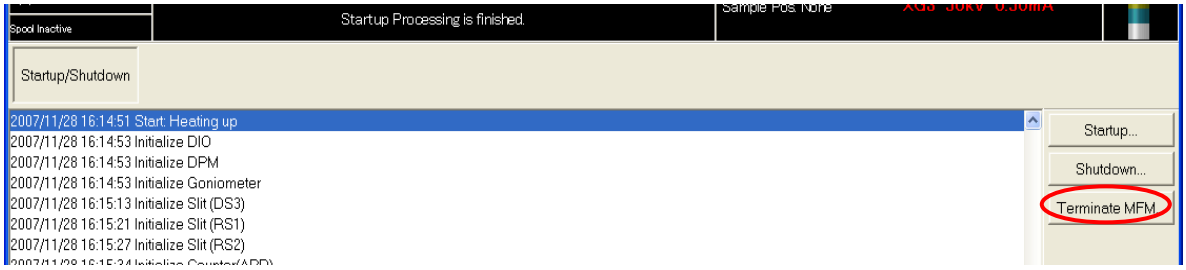


Fig. 5-2-3 Exit Display

(4) Shut down the PC.

(5) Push the [POWER OFF] button.

(6) Pull down the main breaker lock-out handle of the main module and the water chiller.
(Refer to "2.4 Lock-out/Tag-out".)

(7) Close the manual valve on the primary cooling-water side.
The equipment is now deactivated.

NOTE : When pulling down the main breaker lock-out handle, strictly follow the Lock-out/Tag-out. (Refer to "2.4 Lock-out/Tag-out".)

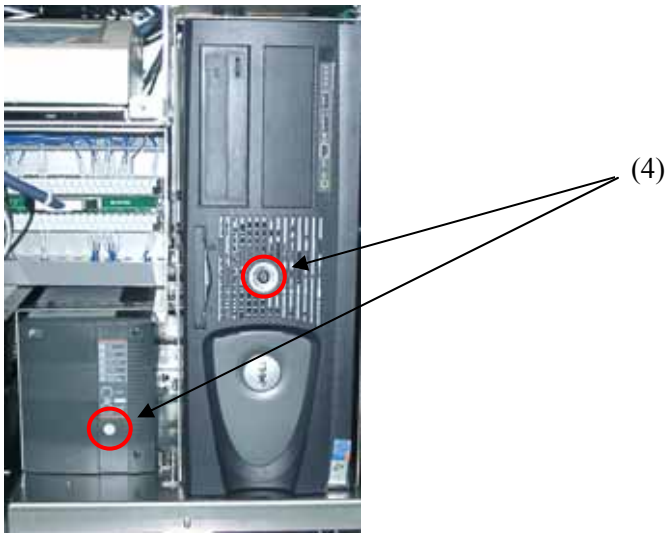
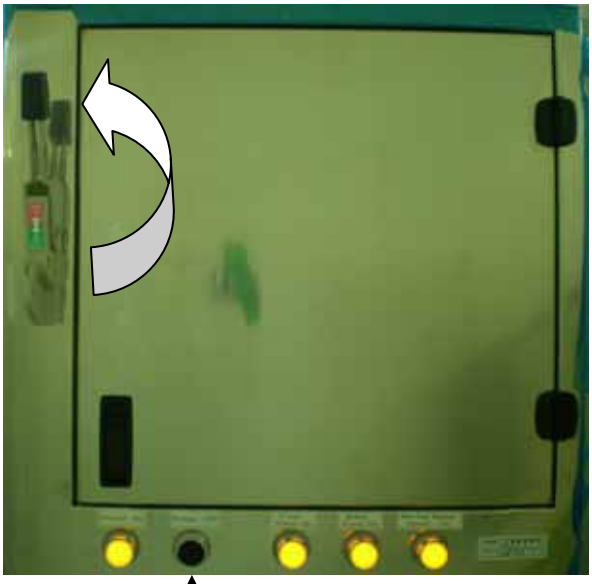


Fig. 5-2-4 PC Power Switch

(6)



(5)

Fig. 5-2-5 Power Switch

5.3 Sample Unloading in the Event of Emergency

If a wafer or carrier is left in the equipment or they cannot be removed in the normal ways, follow the steps specified below.

(1) Sample unload

Click on the **[Sampler Unload]** button to remove the wafer from the equipment.

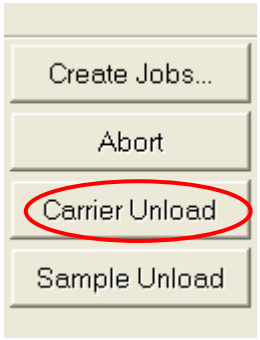


Fig. 5-3-1 Wafer Unload Button

When the Wafer Control dialog is displayed, make sure there is no wafer in the slot. First confirm that the slot is empty, and then unload the wafer.

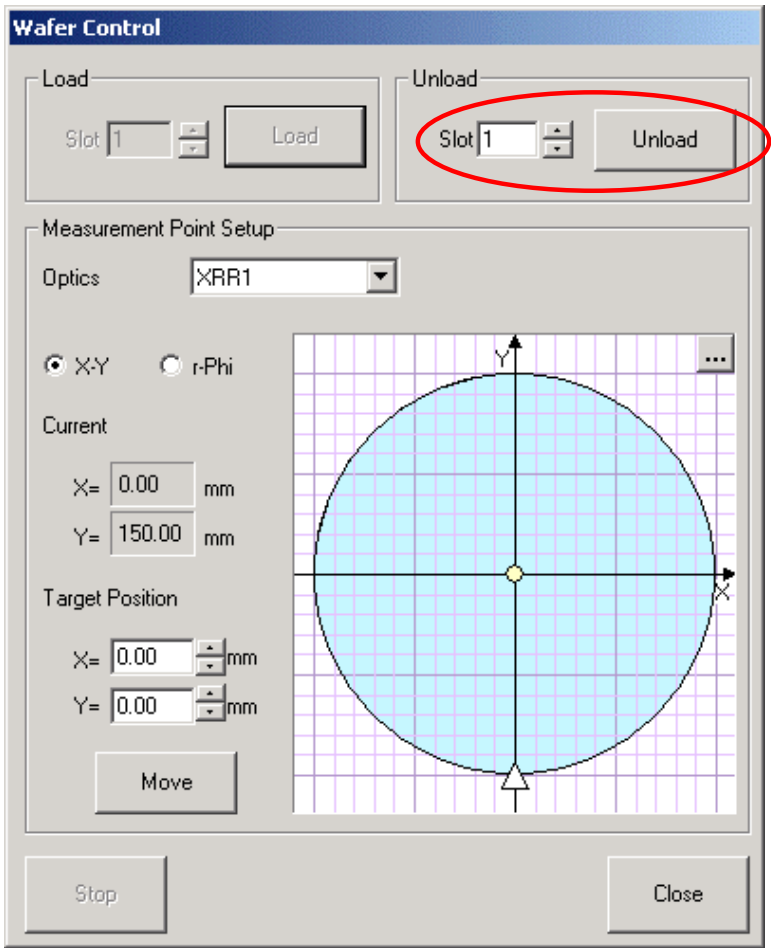


Fig. 5-3-2 Wafer Control

(2) Carrier Unload

Click on the **[Carrier Unload]** button; the carrier is undocked.

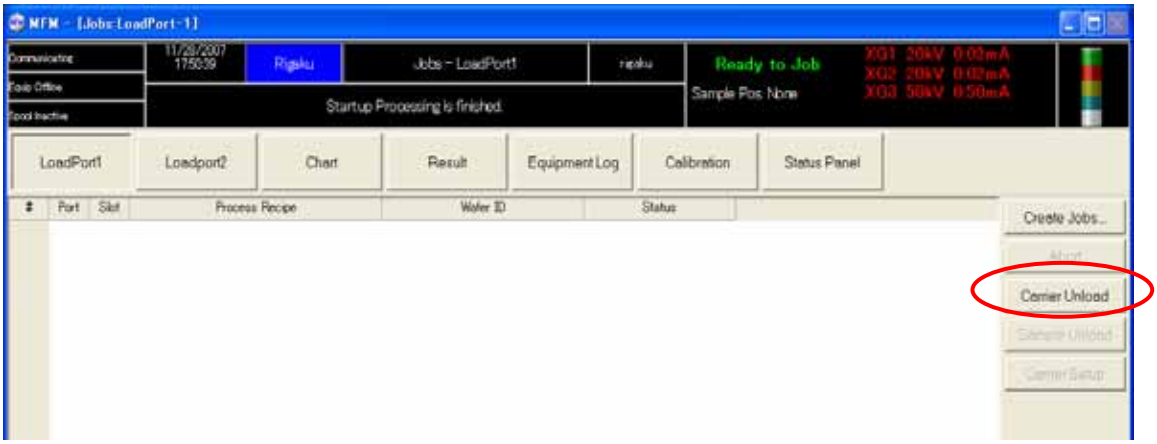


Fig. 5-3-3 Carrier Unload Button

(3) If the Sample Unload or Carrier Unload button is inoperable, follow the steps specified below to unload it.

① Click on **[Jobs]** – **[Startup]**.

② If the above button is also inoperable, click on **[Jobs]** – **[Terminate FMF]** or click on the X button at the upper right of the window to deactivate the program. Then, restart the program to activate the **[Jobs]** – **[Startup]** button.

③ When the **[Startup]** command is executed, the wafer, if any, is unloaded onto the transport arm. The carrier is undocked.

④ Confirm the green **[Load]** lamp on after removing the FOUP carrier from the load port.

⑤ If the **[Load]** lamp is not on, execute **[Startup]** again without putting the FOUP carrier to the load port. The load port is initialized and **[Load]** lamp is on.

⑥ Push the **[OP-ACCESS]** button to dock the FOUP carrier, and then click on **[Sample unload]** to unload a wafer. At this time, confirm that the destination slot of the carrier is empty.

⑦ Click on **[Carrier Unload]** to undock the carrier, and remove the carrier from the equipment.

By following the above steps, the equipment is returned to its initial state.

NOTE : Otherwise, the carrier can be removed by turning off the main power.

6. DAILY CHECKS

Check the following points in daily operation:

(1) Initialize the mechanical units using the startup command. (See 6.1)

(2) Check the X-ray intensity and angular positions by beam diagnosis. (See 6.2)

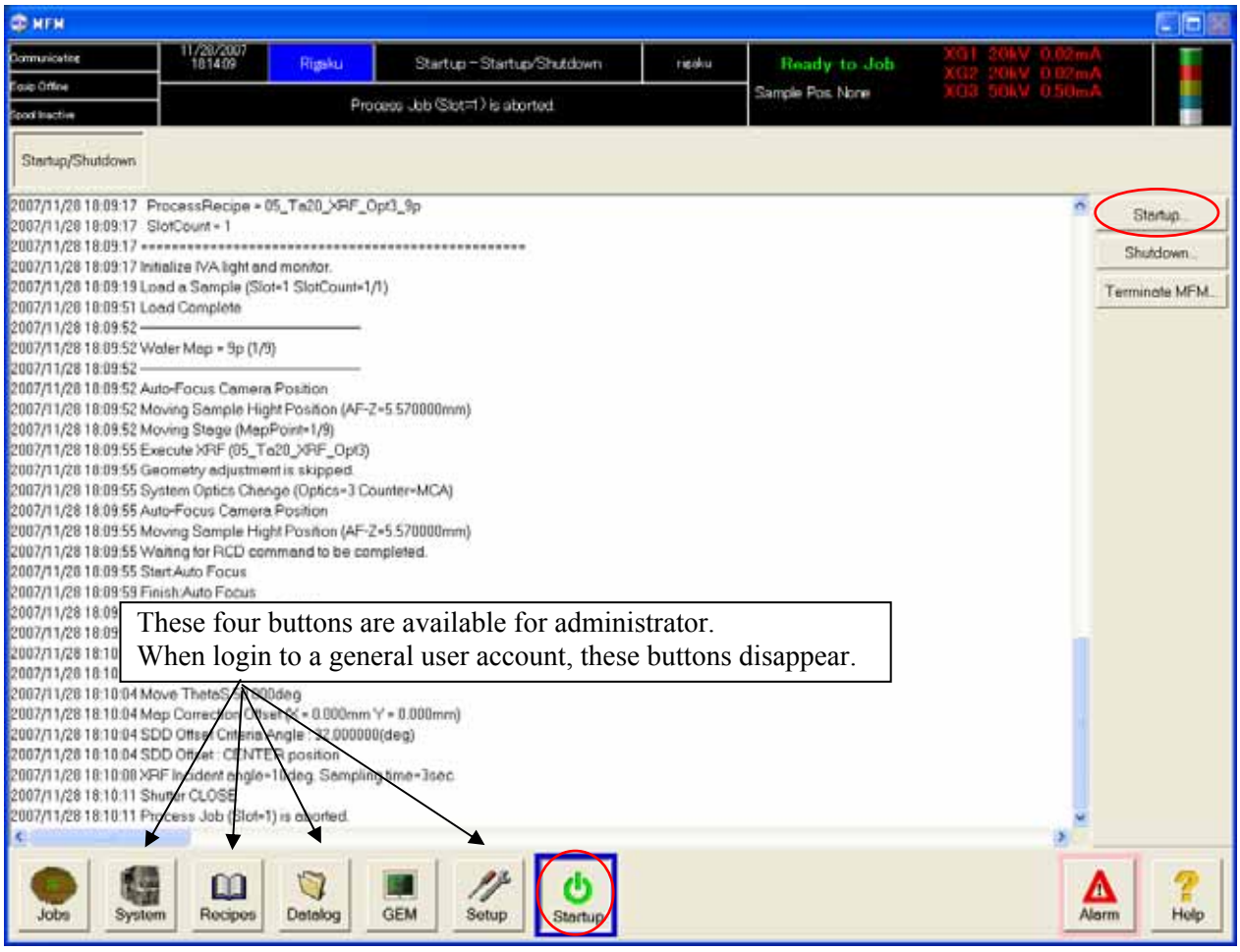
(3) Measure the check sample. (See 6.3)

Others,

(4) Check for unusual noise or odor.

6.1 Initialization

Execute the **[Startup]** — **[Startup]** command.



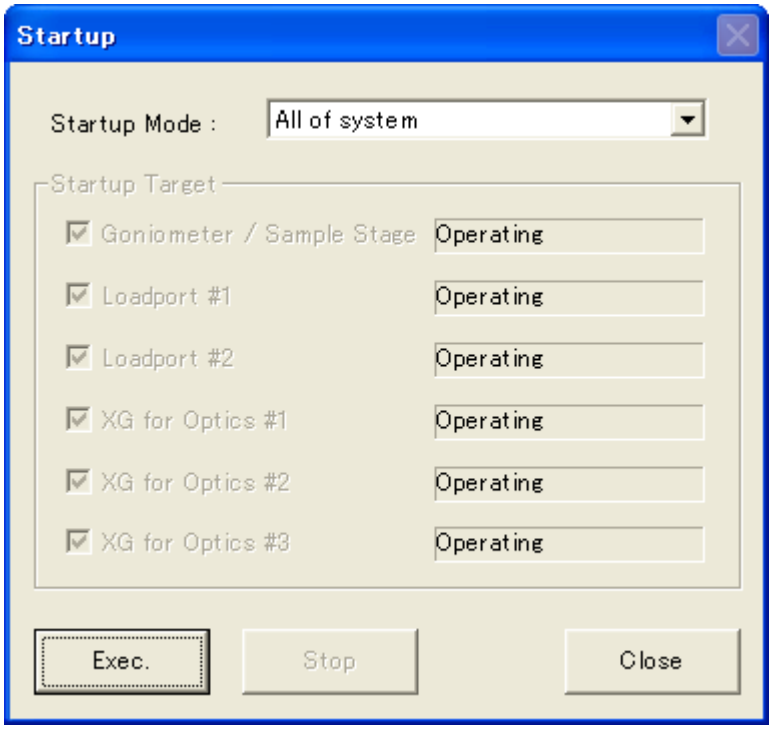


Fig. 6-1-1 Startup Display

NOTE : If an error occurred in the startup procedure, see “9.Trouble Shooting”.
And then, contact to the maintenance personnel.

6.2 Beam Diagnosis

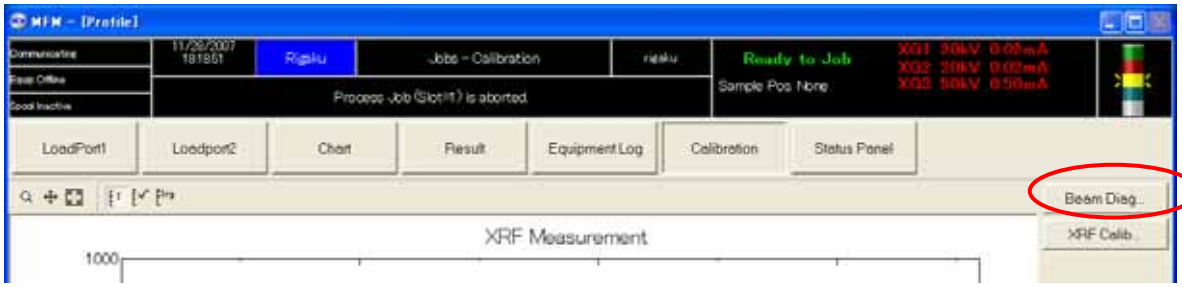


Fig. 6-2-1 Diagnosis Button

Execute the **[Jobs]** – **[Diagnosis]** command.

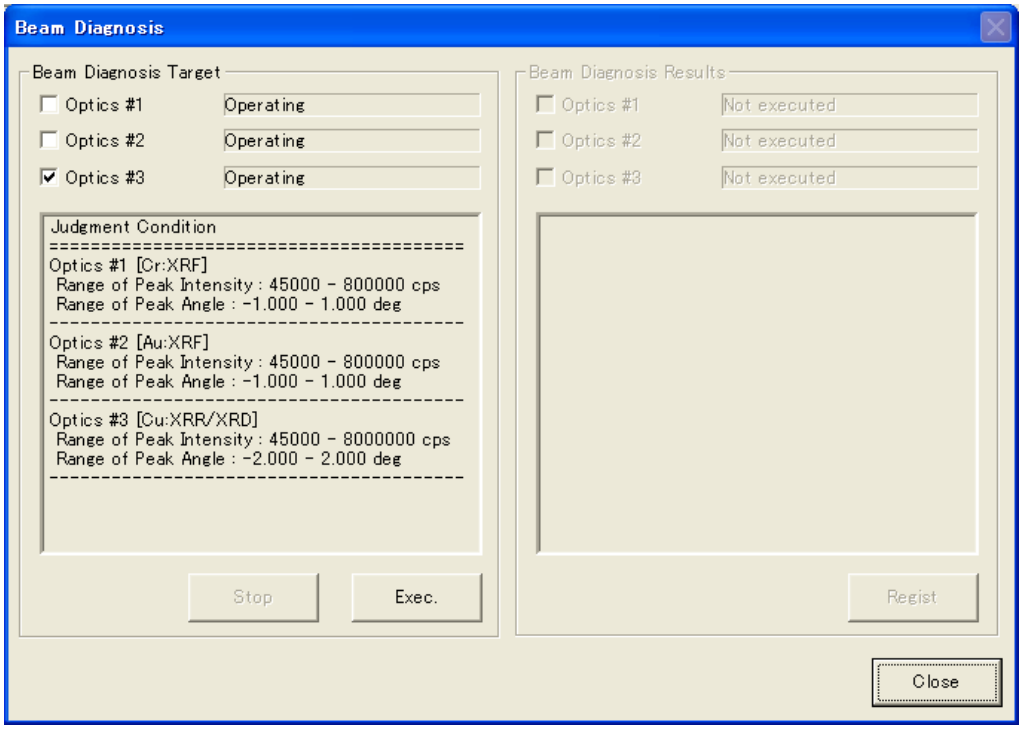


Fig. 6-2-2 Diagnosis Dialog

Upon completion of the beam diagnosis, the beam intensity and the 2θ position are displayed along with the previous values, and the confirmation dialog box appears.

Click on **[OK]**; the beam position is saved in the XRR and XRF setup data of Setup, and is added to "Diagsis.log" of the equipment.

Make sure the beam-intensity error and angle position error are **within 5% and 0.01 degree**, respectively.

NOTE : If the result of diagnosis is NG, see "9.Trouble Shooting".



And then, contact to the maintenance personnel.

6.3 Analysis of the Check Sample

To ensure the accuracy of the analysis values, analyze the predetermined reference sample and check the repeatability of the analysis results.

Use the predetermined job and recipe to analyze the sample. (See “7.Daily Analysis”.)

NOTE : Please ask how to check sample to the maintenance personnel.



If there are significant errors, contact the maintenance personnel.

7. DAILY ANALYSIS

Setting a carrier, specifying a recipe, and clicking on the **[Start Jobs]** button can perform daily analysis. Sample setup, measurement, and printout of results can be performed on a continuous-operation basis.

CAUTION **This equipment can measure wafers of different sizes. If the wafer size is specified incorrectly and measurement is performed, problems such as damage wafers and collision of transport mechanism will occur.**

Be sure to confirm the wafer size prior to measurement.

(1) Confirm the wafer size

(2) Set the wafer cassette on the Load Port #1,2

(3) Set the Process Recipe

(4) Start measurement

(5) Print out results

(6) Remove the wafer cassette

7.1 Confirm the Wafer Size

Check the wafer size and the carrier by confirming the display.

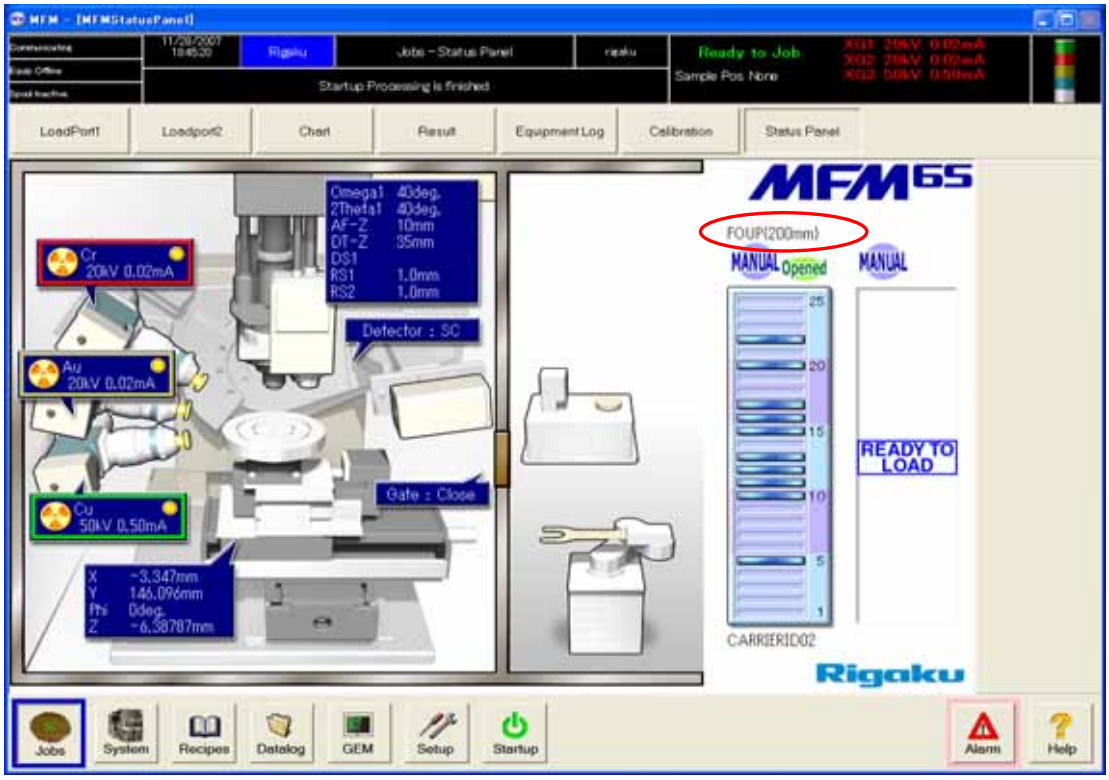


Fig. 7-1-1 Carrier Display

NOTE : If the wafer size is different from the display, contact the maintenance personnel or the administrator account user, because **[Setup]** navigation button and **[Wafer Setup]** sub-navigation button must be used to change the setup of wafer size.

7.2 Set the Wafer Cassette

(1) Make sure that the **blue LED [Ready]** of the status signal tower is on and the **green lamp [LOAD]** of the loadport is on.

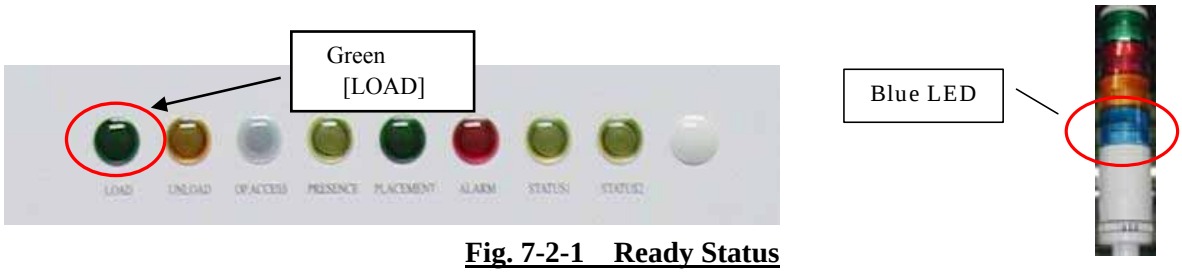


Fig. 7-2-1 Ready Status

(2) Install a FOUP carrier to the loadport.



Fig. 7-2-2 FOUP Setting

(3) Push **[OP-ACCESS]** button after confirming that the **[PRESENCE]**, **[PLACEMENT]** and **[OP-ACCESS]** lamps are on.

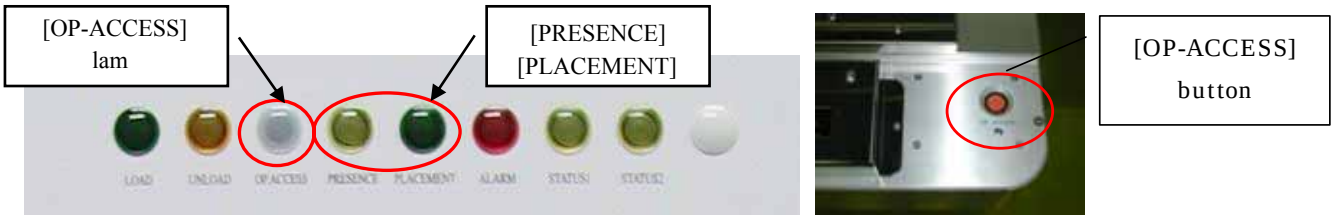


Fig. 7-2-3 OP.ACCRSS Button

(4) The FOUP carrier is docked, and the map figure is displayed on the LCD after wafer slot mapping.

7.3 Set theCreate Jobs List

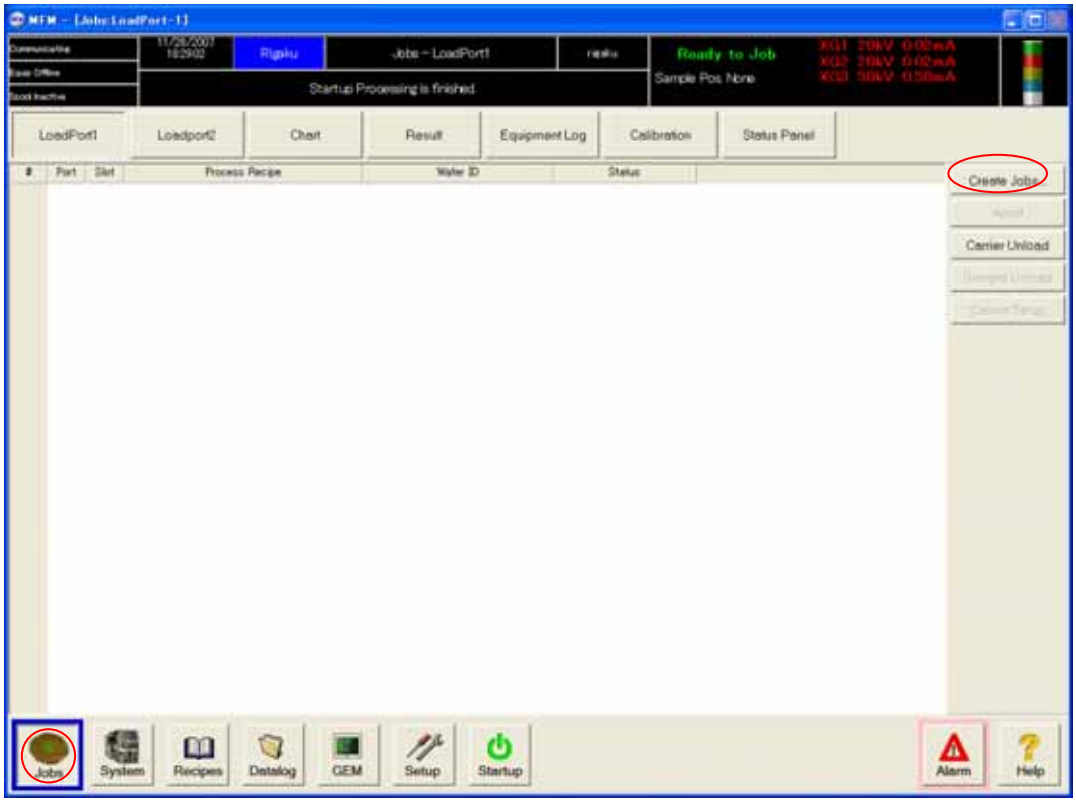
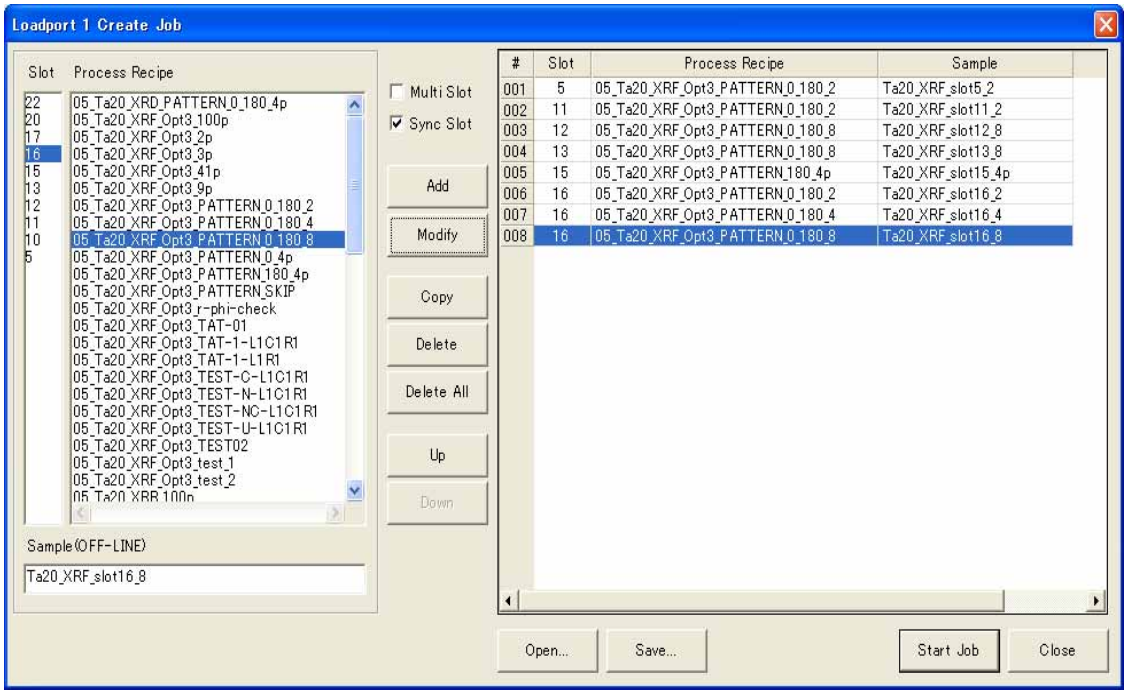


Fig. 7-3-1 Job List

(1) Select [Jobs] –[Create Jobs] to display the job list.



(2) Functions of the Edit buttons.

Names	Functions
Multi Slot	
Sync Slot	
Add	Creates a new measurement condition and adds it to the end of the list.
Modify	Changes the content of the selected (blue) Process Recipe.
Copy	Copies the selected (blue) job and adds it to the next line.
Delete	Deletes the selected (blue) job.
Delete All	Deletes all selected (blue) job.
Up	Changes the order of the selected (blue) job in the job list.
Down	Changes the order of the selected (blue) job in the job list.
Close	
Start Job	Executes the process recipe
Open	
Save	Creates a new job name and adds it to the end of the list.

(3) Specify the wafer name and the measurement recipe. Click on [OK] to add the measurement condition at the end of the list.

Items	Contents
#	Order of the Job list (cannot be edited)
Port	Load Port number
Slot	Number of the slot holding a wafer. Set the slot numbers between 1-25 from the bottom.
Process Recipe	Select the Process Recipe
Wafer ID	Name of the wafer. Used in the head of the name of the measurement result file.
Status	
[PJ][Trans]	

The measurement result file is automatically created and named as follows.

WaferID – yymmdd – hhmmss – MappingNo.

WaferID : The above Wafer ID.

yymmdd : 6 characters of year, month and day. (E.g. 030101 ; 2003.01.01)

hhmmss : 6 characters of hour, minite and second. (E.g. 010100 ; 01:01.00)

MappingNo. : 3 characters of the mapping order in a wafer. (From 001)

The result file is saved in the data directory specified by each login user.

NOTE : When changing the data directory, contact the maintenance personnel or the administrator account user, because **[Setup]** navigation button and **[User Admin.]** sub-navigation button must be used to change the data directory.

(4) Specify all jobs for each wafer by using the Edit buttons.

7.4 Start Measurement

Click on **[Start Job]**.

The steps are executed from the create job list sequentially for measurement purposes.

The status lamp of the signal tower turns green during the measurement.

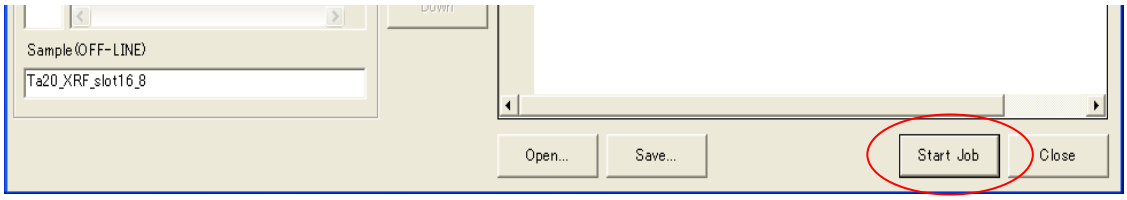


Fig. 7-4-1 START Button

7.5 End Analysis

Upon completion of measurement, all of the job-list lines turn light yellow and **[Control Job is finished.]** is displayed in the title screen.

The status lamp of the signal tower then turns yellow and blinks as it waits for an operator command.

If **V** automatic carrier unloading is selected, the carrier is unloaded.

7.6 Unload the Cassette

(1) Confirm that the **[UNLOAD]** and **[OP-ACCESS]** lamps are ON.

(2) Push **[OP-ACCESS]** button to undock the FOUP carrier.

(3) Remove the FOUP carrier from the loadport.

(4) **[LOAD]** lamp becomes on, and next FOUP cassette can be loaded.

8. ROUTINE CHECKUP LIST

Items		Cycle					
		Day	Week	Month	6months	Year	Others
1	Cooling water: Checking and adjusting the flow rate of secondary-water flow rate		✓				
2	Compressed dry air: Checking and adjusting of the pressure of compressed dry air		✓				
3	Vacuum: Checking and adjusting the suction pressure of vacuum		✓				
4	Cleaning of the transport line			✓			
5	Checking the suction pressure of the transport robot			✓			
6	Exchange of cooling water and filters				✓		
7	Exchange of X-ray tubes						5000H – 8000H
8	Check for the operation of the water leak sensor					✓	
9	Add mechanical grease					✓	

NOTE : The maintenance personnel should check the routine checkup of the above table. Contact to the maintenance personnel and refer to the maintenance manual about the contents of the routine checkup.

9. TROUBLE SHOOTING

9.1 Electric Power

Troubles	Causes and remedies
The Start button does not operate.	Check to make sure that the circuit breaker of the power box on the facility side is turned on, and power is supplied to the equipment. **NOTE:** Contact the maintenance personnel.
The Start button turns off during equipment operation.	Check to make sure that the water leak detector has not activated. Check the cooling water hoses from the inlet connector to the outlet connector. If water leakage is detected, repair leaks, wipe leaked water, and turn on the Start button again. **CAUTION** When checking the water leak detector, contact the maintenance personnel.
	Check to make sure that the EMO buttons are not pressed in. (See “2.5 EMO”.) If the EMO button is activated, rotate the EMO buttons to set them in the extended position.
	Check to make sure that the interlock panels are not left open. (See “2.3 Interlock List”.) **CAUTION** When checking the power box, contact the maintenance personnel.

9.2 Startup

Troubles	Causes and remedies
The goniometer cannot be initialized.	Check to make sure that the side doors of the main module or EFEM are not open. (See "2.3 Interlock List".) Check to make sure that the load port panels or rear panels are not open. Opening any of these panels or doors turns off the power of the goniometer. Be sure to close the side doors and panels.
	If the cause of the problem is unknown, shut down the PC, turn off the main breaker lock-out handle of the equipment, then restart the equipment. (Refer to "2.4 Lock-out/Tag-out".)
The sample transfer system cannot be initialized.	Check to make sure that the side doors of the main module or EFEM are not open. (See "2.3 Interlock List".) Check to make sure that the load port panels or rear panels are not open. Opening any of these panels or doors turns off the power of the sample feed system. Be sure to close the side doors and panels.
	Check to make sure that the manual robot controller (inside the EFEM) is not set to the manual mode. Set the manual robot controller to the remote mode ([RMT] is indicated). **CAUTION** When checking the manual robot controller, contact the maintenance personnel. 
	Check to make sure that CDA and vacuum are supplied. Make sure of utility connections. **NOTE:** When checking the CDA, contact the maintenance personnel. 
	If the cause of the problem is unknown, shut down the PC, turn off the main breaker lockout handle of the equipment, then restart the equipment. (Refer to "2.4 Lock-out/Tag-out".)

Troubles	Causes and remedies
The equipment does not generate X-rays.	Check to make sure that the water chiller is turned on. If the software screen shows a CW alarm, cooling water may not be supplied to the X-ray tube. Turn on the water chiller, and check that cooling water is circulated properly.
	Check to make sure that the side doors of the main module or EFEM are not open. (See "2.3 Interlock List".) Check to make sure that the load port panels or rear panels are not open. Opening any of these panels or doors turns off the power of the sample feed system. Be sure to close the side door and panels.
	Check to make sure that the software screen does not shows a CW alarm even though the water chiller is operating and circulating cooling water. For the CW alarm, adjust the flow rate so that the alarms are cancelled. **NOTE:**  When adjusting the flow rate, contact the maintenance personnel.
	Check to make sure that the software screen does not show an FCL alarm. Shut down the PC, turn off the main breaker lockout handle of the equipment, and restart the equipment. (Refer to "2.4 Lock-out/Tag-out".) If this alarm is generated again, the filament in the X-ray tube may be disconnected. **CAUTION**  **When the X-ray tube is replaced, contact our service personnel in charge. Don't touch the X-ray tube.**
	If the software screen shows another alarm or if the cause of the problem is unknown, shut down the PC, turn off the main breaker lockout handle of the equipment, then restart the equipment. (Refer to "2.4 Lock-out/Tag-out".)

9.3 Beam Diagnosis

Troubles	Causes and remedies
The direct beam intensity and position are not as specified.	If the intensity is low, the X-ray optics may be out of adjustment. **NOTE:**  Contact our service personnel in charge for readjustment of the X-ray optics. If the intensity does not improve after the readjustment, the X-ray tube may have reached the end of service life. Check to see if the X-ray tube needs to be replaced.
	If the direct beam position is different, the X-ray optics may be out of adjustment. **NOTE:**  Contact our service personnel in charge for readjustment of the X-ray optics.

9.4 Loadport

Troubles	Causes and remedies
The door of the load port does not open.	Conduct the startup procedure with the software.
The carrier cannot be taken out. The Load/Unload button of the load port does not light.	Conduct the following steps, and also refer to "5.3 Sample Unloading in the Event Emergency".
	Check to make sure that no wafer is left in the equipment. Click **[Unload Wafer]** on the main window of the software to return the wafer to the carrier.
	Click **[Unload Carrier]** on the main window of the software to activate the carrier ejection mode.
	If the **[Unload Wafer]** and **[Unload Carrier]** functions do not operate properly, conduct the startup procedure with the software. If there is a wafer left in the equipment, it is moved to the robot home position. Conduct the wafer ejection operation (**[Unload Carrier]**). If there is no wafer in the equipment, conduct the carrier ejection operation (**[Unload Carrier]**).
	If the software startup procedure fails to complete the ejection operation, exit the software to accomplish the ejection. Restart the software and conduct the startup procedure. If there is a wafer left in the equipment, it is moved to the robot home position. Conduct the wafer ejection operation (**[Unload Carrier]**). If there is no wafer in the equipment, conduct the carrier ejection operation (**[Unload Carrier]**).
	If the above methods fail to complete the ejection operation, conduct the shutdown procedure with the software, exit the software, and turn off the main breaker lockout handle of the equipment accomplish the ejection. (Refer to "2.4 Lock-out/Tag-out".)
The alarm of the load port occurs.	Conduct the startup procedure with the software to reset the load port.

9.5 Wafer Transfer

Troubles	Causes and remedies
The robot hand cannot perform the adsorbing function. **The aligner cannot perform the adsorbing function.**	If the vacuum pipe is connected to the factory facility, check the pressure in the vacuum line. **NOTE:**  Contact the maintenance personnel for checking the vacuum.
A wafer is left inside the equipment.	Click **[Unload Wafer]** on the main window of the software to return the wafer to the carrier. (Refer to "5.3 Sample Unloading in the Event Emergency".)
	Conduct the startup procedure with the software. When the wafer is moved to the robot home position, click **[Unload Wafer]** on the main window of the software. (Refer to "5.3 Sample Unloading in the Event Emergency".)
The bulkhead gates between the main equipment module and EFEM does not open or close.	Check to make sure that CDA is supplied. Check the pressure of CDA on the facility side. **NOTE:**  Contact the maintenance personnel for checking the CDA.
The alarm of the robot occurs.	Shut down the PC, turn off the main breaker lockout handle of the equipment, and restart the equipment. (Refer to "2.4 Lock-out/Tag-out".)

9.6 Sample Alignment

Troubles	Causes and remedies
Sample alignment fails.	Check to make sure that the alignment condition. **NOTE:**  Contact the maintenance personnel for checking the alignment condition in the recipe.
	Check to make sure that the curvature of the sample is not too large.
	Check to make sure that the slit setting in the recipe. **NOTE:**  Contact the maintenance personnel for checking the slit condition in the recipe.

9.7 XRR/XRD Measurement

Troubles	Causes and remedies
The measurement profile intensity is extremely high.	Check to make sure that the slit setting in the recipe. **NOTE:**  Contact the maintenance personnel for checking the slit condition in the recipe.
The measurement profile intensity is extremely low.	Check to make sure that the sample alignment is conducted properly. **NOTE:**  Contact the maintenance personnel for checking the alignment condition in the recipe.
	Check to make sure that the surface/interface roughness is not excessive. If the surface/interface roughness is excessive (several nm or larger), the reflection intensity decreases rapidly, disallowing the observation of oscillations according to film thickness.
The critical angle cannot be fitted.	Check to make sure that the curvature of the sample is not too large. If the curvature of the sample is too large, conduct the sample alignment using the auto focus. **NOTE:**  Contact the maintenance personnel for checking the recipe.
	Alignment of the critical angle of Si can be achieved by setting the 2θ offset (2θ0).
Analysis cannot be performed properly.	Refer to the analysis know-how section in the analysis software manual.

9.8 XRF Measurement

Troubles	Causes and remedies
Analysis result is abnormal.	Check the selection of the recipe.
The measurement result (thickness) is not calculated after the measurement.	The constants of calibration curve are not registered. **NOTE:**  Contact the maintenance personnel for checking the constants of calibration curve.
The measurement result (thickness) has no unit and different digit number.	Enter the unit and the digit number in the XRF analysis software. Refer to the manual of the XRF analysis software. **NOTE:**  Contact the maintenance personnel for checking the unit.
After measuring the standard sample, the data of the standard sample cannot be loaded to the XRF software of creating the calibration curve.	When measuring the standard sample, enter "_C" strings to the comment column. Refer to the manual of the XRF analysis software.
After measuring the standardization sample, the data of the standardization sample cannot be loaded to the XRF standardization software.	When measuring the standardization sample, enter "_S" strings to the comment column. Refer to the manual of the XRF analysis software.

9.9 X-ray Trouble

Troubles	Causes and remedies
The X-ray generation turns off.	Check to make sure that the side door of the equipment, load port panel or rear panel is not open. Opening the side door or panel turns off the power of the X-ray generator. Close the door and panels, and restart.
	Check to make sure that the water chiller has not shut down. If the water chiller does not supply the required amount of cooling water, the X-ray generation stops. Check the software alarms, and circulate cooling water, and restart. **NOTE:**  Contact the maintenance personnel for checking the cooling water.
The X-ray shutter does not open.	**CAUTION**  **Contact the maintenance personnel or our service personnel in charge.** **Don't remove the X-ray tube.**

APPENDIX 1

A1.1 Explanation of XRR (X-ray reflectometry method)

It is well known that the refractivity of materials against X-rays is slightly smaller than 1. Thus, if an X-ray comes in at a very shallow angle, total reflection occurs.

In XRR, the intensity of a reflected X-ray is measured in an angle range close to that for total reflection. At angles close to total reflection, the depth of X-ray invasion to materials is very shallow, at 10 to 100 nm, and thus this configuration is used for analysis of the surface structure and thin-film properties.

XRR can be adopted for either crystalline or non-crystalline materials, provided that the surface or interface is smooth. In particular, XRR has attracted attention as a method capable of estimating the thickness, density, and surface/interface roughness of thin films employed in semiconductor devices.

(1) Capable of estimating multi-layered films without destruction

(2) Capable of estimating film thickness in the range of a few tens to a few thousand Å

(3) Capable of estimating density if the composition of each layer is known

(4) Capable of estimating surface/interface roughness

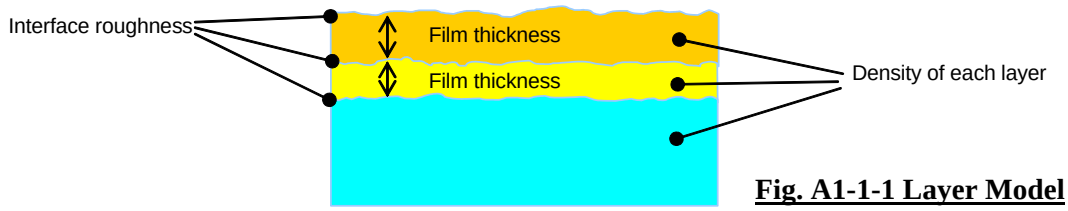


Fig. A1-1-1 Layer Model

(1) Total reflection of X-ray

Refractivity against X-ray

$$n = 1 - \delta - i\beta < 1$$

Snell's law

$$n = \frac{\sin(\pi/2 - \theta)}{\sin(\pi/2 - \theta')}$$

Total reflection occurs if $\theta' < \theta \quad \rightarrow \quad \theta < \theta c \cong \sqrt{2\delta}$

θ_c: Critical angle (2θ = 0.4 (Si..) to 1.0 degree (Ta..))

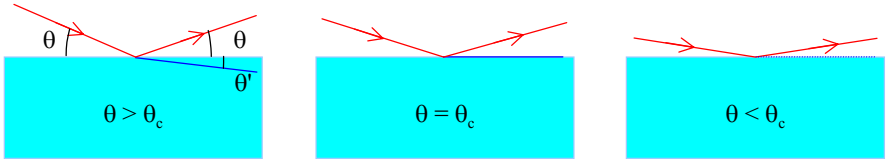
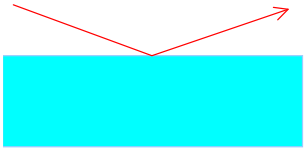


Fig. A1-1-2 Critical Angle

(2) When reflection occurs only on the surface



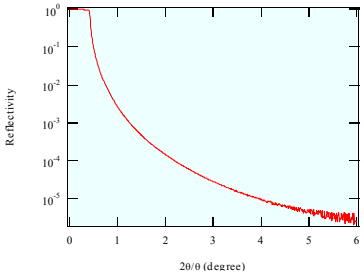
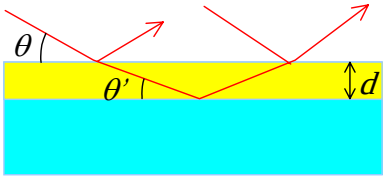


Fig. A1-1-3 Surface Reflection

(3) When the reflected waves from the surface and interface interfere with each other

$$\Delta = 2d \cdot \sin\theta' + 2d\frac{1-n}{\sin\theta'}$$



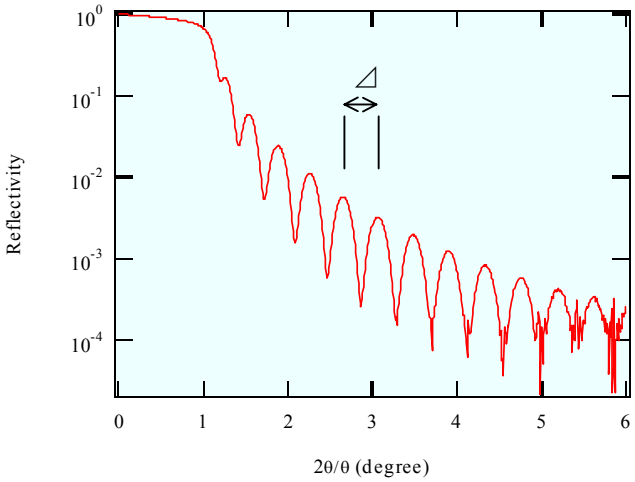


Fig. A1-1-4 Thickness Oscillation

(4) Interpretation of the XRR profile

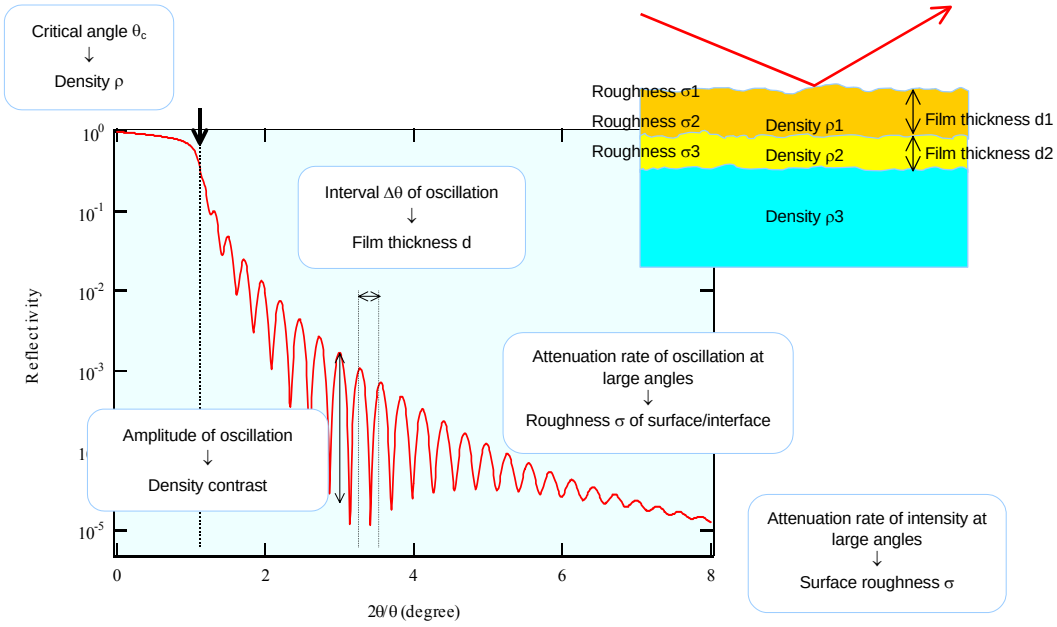
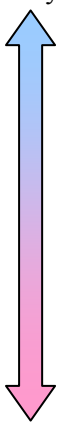
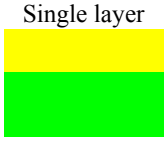
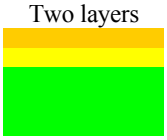
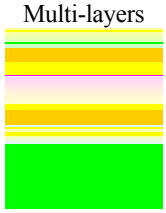


Fig. A1-1-5 XRR Profile

Degree of difficulty in analysis	Analysis contents	Target of analysis/ Film structure
Easy  Difficult	Oscillation interval → Film thickness (roughly estimated from the FFT results) Critical angle → Density (roughly estimated from the critical angle) The accuracy of film thickness, density, and roughness can be improved through fitting analysis. Analysis of film thickness, density, and roughness fitting Analysis is relatively easy, as there are few parameters. Analysis of film thickness, density, and roughness fitting Through the study of various structure models and detailed analysis, one can learn about surface layers, intermediate layers, interface reactions, and interface diffusion. The larger the number of parameters and the less accurate the initial values, the more difficult the analysis.	Single layer  Two layers  Multi-layers 

A1.2 Analysis/Measurement Flow

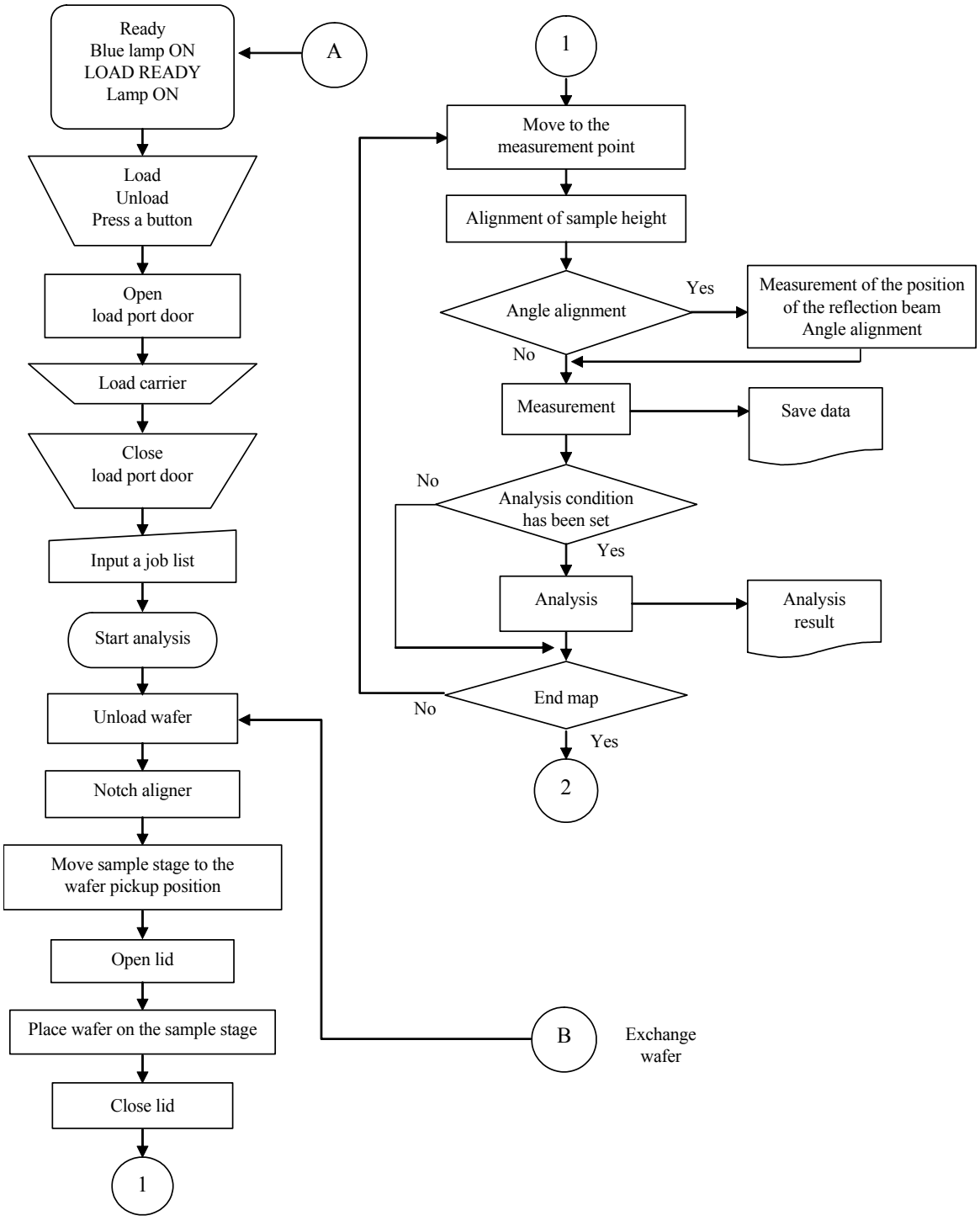


Fig. A1-2-1 Analysis Measurement Flow 1

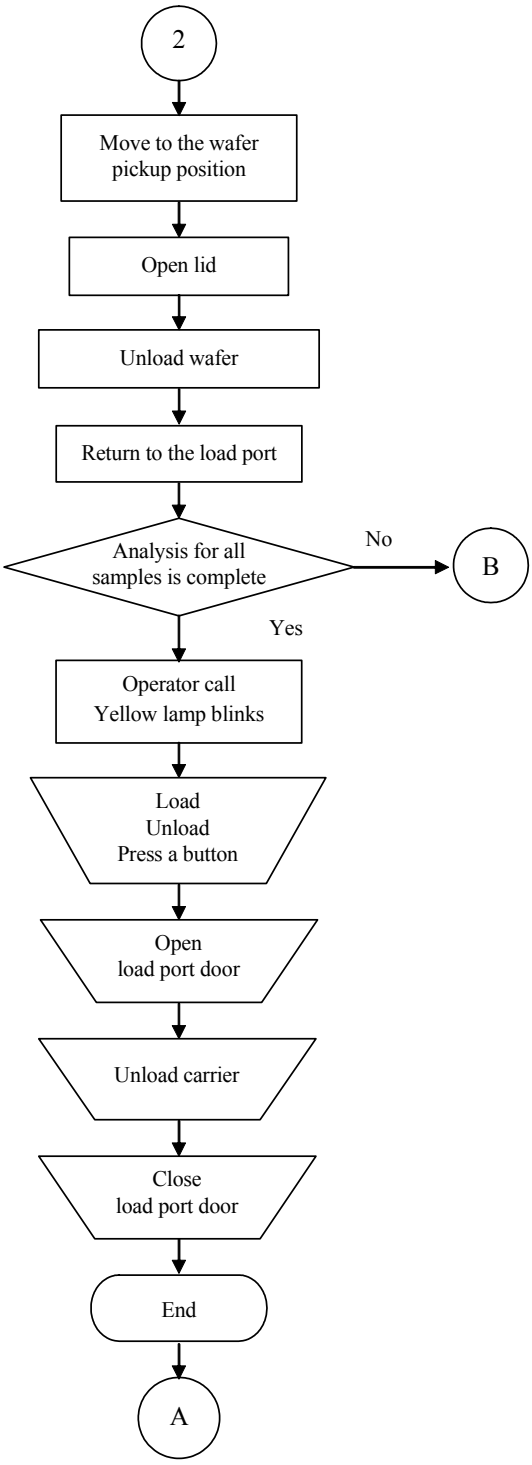


Fig. A1-2-2 Analysis Measurement Flow 2

APPENDIX 2

A2.1 Training for Using Equipment

(1) Training for Operation

We provide the explanation of equipment operating procedures shown in the table below at the time of equipment delivery.

Please discuss the schedule and contents of this training with our service personnel in charge.

We can also provide additional explanation of equipment operation, if necessary. Regarding operation training, contact our service personnel in charge or our company.

Target personnel	Examples of training contents
Operators	* Equipment power ON * Equipment startup procedure * XRR measurement using recipe * XRF measurement using recipe * Optional measurement (XRD, PORE size measurement) using recipe * Equipment shutdown * Daily checks
Engineers	* Above programs designed for operators * Method of producing recipe for XRR measurement * Method of producing recipe for XRF measurement * Method of producing recipe for XRF measurement * Method of producing recipe for optional measurement (XRD,PORE size measurement) * Periodic checks

(2) Training for Maintenance

We provide the explanation of equipment maintenance for your engineers at the time of equipment delivery.
This training can be provided together with the above operation training. Please discuss the schedule and contents of this training with our service personnel in charge.
We can also provide additional explanation of equipment maintenance, if necessary. Regarding maintenance training, contact our service personnel in charge or our company.

Examples of training contents
* Configuration of equipment hardware
* Explanation of interlock
* Troubleshooting
* Explanation of consumables and maintenance parts

APPENDIX 3

A3.1 Power Circuit Diagram

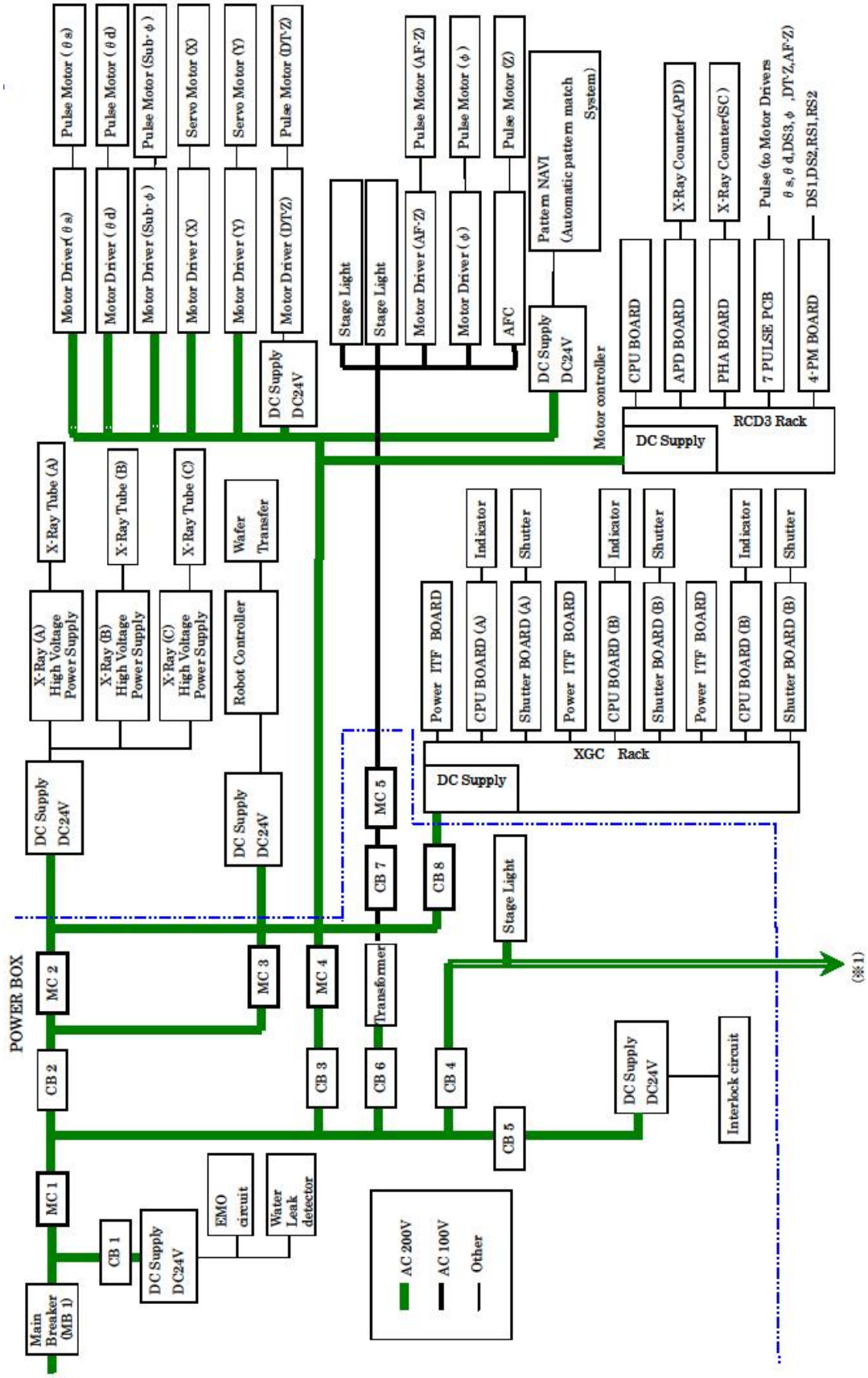


Fig. A3-1-1 Power Circuit Diagram 1

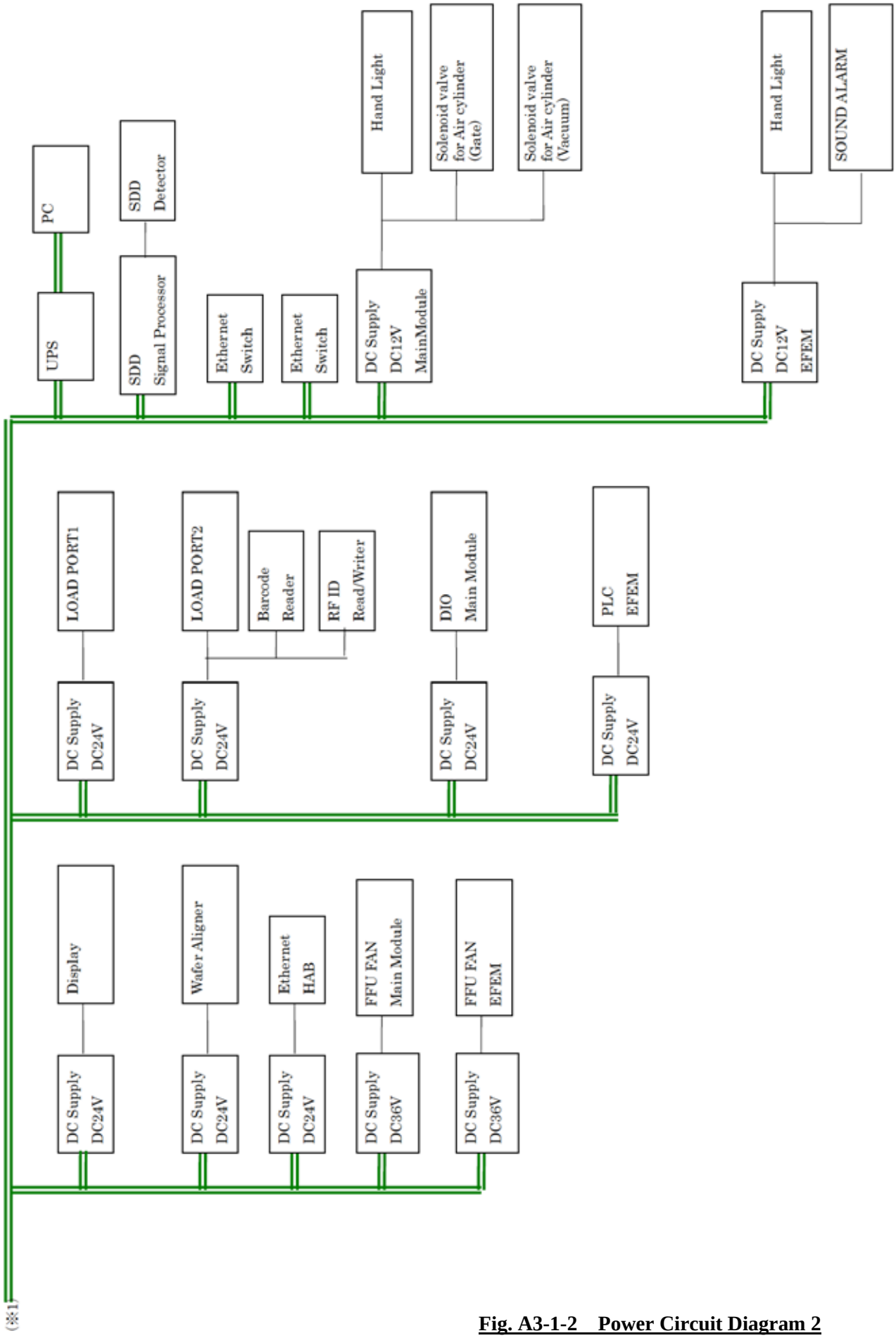


Fig. A3-1-2 Power Circuit Diagram 2

APPENDIX 4

A4.1 List of Material Safety Database Sheet (MSDS)

List of Attached MSDSs

Materials	CAS No.	Purposes	Parts/Assemblies
Beryllium	7440-41-7	Vacuum seal for X-ray window Air seal for detector window	X-ray tube X-ray detector (APD) X-ray detector (SDD)
Lithium	12190-79-3	Built-in Battery	PC Hour meter
Mercury	7439-97-6	Discharge support	Fluorescent lamp
Grease	101316727 113114-19-5 9002-84-0	Mechanical lubricating grease	Actuators
Ethanol	64-17-5	Cleaning the transport line	(Customer's FAB)

A4.2 MSDS of Beryllium

BRUSHWELLMAN
ENGINEERED MATERIALS

MATERIAL SAFETY DATA SHEET - NO. M10

1. CHEMICAL PRODUCT AND COMPANY IDENTIFICATION

Beryllium Solid

SYNONYMS Glucinium
Metallic Beryllium

24-HR. EMERGENCY ASSISTANCE
Transportation Emergency
Call Chemtrec at:
Domestic: (800) 424-9300
International: (703) 527-3887
Other Emergency
Call Brush Wellman at: (800) 862-4118

Revised: 01-13-03
Replaces: MSDS M10 (05-10-02)

CHEMICAL FAMILY Beryllium

CUSTOMER SERVICE
Brush Wellman Inc.
Product Stewardship Department
17876 St. Clair Avenue
Cleveland, Ohio 44110
Phone: (800) 862-4118
Fax: (216) 383-4091
Websites www.brushwellman.com
www.befacts.com

2. COMPOSITION/INFORMATION ON INGREDIENTS

CHEMICAL COMPOSITION (Percent by Weight)

BRUSH WELLMAN PRODUCT		
CONSTITUENTS	CAS Numbers	Beryllium Solid
Beryllium	7440-41-7	100

Hazard Communication regulations of the U.S. Occupational Safety and Health Administration apply to this product.

NOTE: As used in this Material Safety Data Sheet, the term "particulate" refers to dust, mist, fume, fragments, particles and/or powder.

3. HAZARD IDENTIFICATION

3.1 EMERGENCY OVERVIEW

Metallic product which poses little or no immediate hazard in solid form. See label in Section 16. If the material is involved in a fire; pressure-demand self-contained breathing apparatus and protective clothing must be worn by persons potentially exposed to the airborne particulate during or after a fire.

Rigaku

3.2 POTENTIAL HEALTH EFFECTS

Exposure to the elements listed in Section 2 by inhalation, ingestion, and skin contact can occur when melting, casting, dross handling, pickling, chemical cleaning, heat treating, abrasive cutting, welding, grinding, sanding, polishing, milling, crushing, or otherwise heating or abrading the surface of this material in a manner which generates particulate.

Exposure may also occur during repair or maintenance activities on contaminated equipment such as: furnace rebuilding, maintenance or repair of air cleaning equipment, structural renovation, welding, etc.

Particulate depositing on hands, gloves, and clothing, can be transferred to the breathing zone and inhaled during normal hand to face motions such as rubbing of the nose or eyes, sneezing, coughing, etc.

3.2.1. Inhalation

Beryllium: The beryllium in this product is not known to cause acute health effects. Inhaling particulate containing beryllium may cause a serious, chronic lung disease called Chronic Beryllium Disease (CBD) in some individuals. See section 3.2.5 Chronic (long-term health effects).

3.2.2. Ingestion

Ingestion can occur from hand, clothing, food and drink contact with particulate during hand to mouth activities such as eating, drinking, smoking, nail biting, etc.

Beryllium: The health effect of ingestion of beryllium in the form found in this product is unknown.

3.2.3. Skin

Beryllium: Particulate that becomes lodged under the skin has the potential to induce sensitization and skin lesions.

3.2.4. Eyes

Exposure may result from direct contact with airborne particulate or contact to the eye with contaminated hands or clothing. Damage can result from irritation or mechanical injury to the eyes by particulate.

3.2.5. Chronic (long-term health effects)

Beryllium: Inhaling particulate containing beryllium may cause a serious, chronic lung disease called chronic beryllium disease (CBD) in some individuals. Over time lung disease can be fatal. Chronic beryllium disease is a hypersensitivity or allergic condition in which the tissues of the lungs become inflamed. This inflammation, sometimes with accompanying fibrosis (scarring), may restrict the exchange of oxygen between the lungs and the bloodstream. Medical science suggests that CBD may be related to genetic factors.

3.2.6. Carcinogenic References

Beryllium: The International Agency for Research on Cancer (IARC) lists beryllium as a Group 1 – Known Human Carcinogen. The National Toxicology Program (NTP) lists beryllium as known to be human carcinogens. The ACGIH lists beryllium as an A1 – Confirmed Human Carcinogen.

IARC lists beryllium as a known human carcinogen (Group1) and notes that the work environment of workers involved in refining, machining and producing beryllium metal was associated with an increased risk of lung cancer, "the greater excess was in workers hired before 1950 when exposures to beryllium in the work place were relatively uncontrolled and much higher than in subsequent decades"; and "the highest risk for lung cancer being observed among individuals diagnosed with acute beryllium-induced pneumonitis, who represent a group that had the most intense exposure to beryllium." IARC further noted that "Prior to 1950, exposure to beryllium in working environments was usually very high, and concentrations exceeding 1 mg/m3 [1000 micrograms per cubic meter] were not unusual."

3.2.7. Medical Conditions Aggravated by Exposure

Persons with impaired pulmonary function, airway diseases, or conditions such as asthma, emphysema, chronic bronchitis, etc. may incur further impairment if particulate is inhaled. If prior damage or disease to the neurologic (nervous), circulatory, hematologic (blood), or urinary (kidney) systems has occurred, proper screening or examinations should be conducted on individuals who may be exposed to further risk where handling and use of this material may cause exposure.

Beryllium: The effects of chronic beryllium disease on the lungs and heart are additive to the effects of other health conditions.

3.3 POTENTIAL ENVIRONMENTAL EFFECTS

See Ecological Information (Section 12)

4. FIRST AID MEASURES

4.1 FIRST AID PROCEDURES

INHALATION: Breathing difficulty caused by inhalation of particulate requires immediate removal to fresh air. If breathing has stopped, perform artificial respiration and obtain medical help.

INGESTION: Induce vomiting immediately as directed by medical personnel. Never give anything by mouth to an unconscious person.

SKIN: Thoroughly wash skin cuts or wounds to remove all particulate debris from the wound. Seek medical attention for wounds that cannot be thoroughly cleansed. Treat skin cuts and wounds with standard first aid practices such as cleansing, disinfecting and covering to prevent wound infection and contamination before continuing work. Obtain medical help for persistent irritation. Material accidentally implanted or lodged under the skin must be removed.

EYES: Immediately flush eyes with plenty of water for at least 15 minutes, lifting lower and upper eyelids occasionally. Get medical attention immediately.

4.2 NOTE TO PHYSICIANS

Treatment of Chronic Beryllium Disease: There is no known treatment which will cure chronic beryllium disease. Prednisone or other corticosteroids are the most specific treatment currently available. They are directed at suppressing the immunological reaction and can be effective in diminishing signs and symptoms of chronic beryllium disease. In cases where steroid therapy has had only partial or minimal effectiveness, other immunosuppressive agents, such as cyclophosphamide, cyclosporine, or methotrexate, have been used. These latter agents remain investigational. Further, in view of the potential side effects of all the immunosuppressive medications, including steroids such as prednisone, they should be used only under the direct care of a physician. In general, these medications should be reserved for cases with significant symptoms and/or significant loss of lung function. Other symptomatic treatment, such as oxygen, inhaled steroids or bronchodilators, may be prescribed by some physicians and can be effective in selected cases.

Rigaku

The decision about when and with what medication to treat is a judgment situation for individual physicians. For the most part, treatment is reserved for those persons with symptoms and measurable loss of lung function. The value of starting oral steroid treatment, before signs or symptoms are evident, remains a medically unresolved issue.

The effects of continued low exposure to beryllium are unknown for individuals who are sensitized to beryllium or who have a diagnosis of chronic beryllium disease. It is generally recommended that persons who are sensitized to beryllium or who have CBD terminate their occupational exposure to beryllium.

5. FIRE FIGHTING MEASURES

Flash Point	Not Applicable to Solids
Explosive Limits	Not Applicable to Solids
Extinguishing Media	Only in powder or other finely divided form does this material present a special fire problem. To extinguish a metal powder fire, use Class D fire extinguishing powder.
Unusual Fire and Explosion Hazards	Do not use water to extinguish fires around operations involving molten metal due to the potential for steam explosions. In addition, water may disassociate when in contact with burning metal particulate or chips releasing flammable hydrogen gas which could burn and result in an explosion. Ventilation duct work which has accumulated a fine coating of this material as a particulate on its internal surface poses a potentially serious fire hazard. Extinguish using Class D fire extinguisher media and shut down or isolate the affected portion of the ventilation system. Because of this potential risk, sources of ignition such as flame, spark from machining of other materials, welding spark, etc. must not be allowed to enter the ventilation duct work. Also, duct work must be made of non-combustible material. See Section 8 for further information regarding personal protective measures.
Special Fire Fighting Procedures	Pressure-demand self-contained breathing apparatus must be worn by firefighters or any other persons potentially exposed to the particulate released during or after a fire.

6. ACCIDENTAL RELEASE MEASURES

STEPS TO BE TAKEN IF MATERIAL IS RELEASED OR SPILLED

If this material is a particulate, establish a restricted entry zone based on the severity of the spill. Persons entering the restricted zone must wear adequate respiratory protection and protective clothing appropriate for the severity of the spill (see Section 8). Cleanup spills with a vacuum system utilizing a high efficiency particulate air (HEPA) filtration system followed by wet cleaning methods. Special precautions must be taken when changing filters on HEPA vacuum cleaners used to clean up hazardous materials. Be careful to minimize airborne generation of particulate and avoid contamination of air and water. Depending upon the quantity of material released into the environment, the incident may be required to be reported to the National Response Center at (800) 424-8802 as well as the State Emergency Response Commission and Local Emergency Planning Committee.

7. HANDLING AND STORAGE

7.1 HANDLING

Particulate may enter the body through cuts, abrasions or other wounds on the surface of the skin. Wear gloves when handling parts with loose surface particulate or sharp edges.

7.2 STORAGE

Store in a dry area.

8. EXPOSURE CONTROLS, PERSONAL PROTECTION

8.1 VENTILATION AND ENGINEERING CONTROLS

Whenever possible, the use of local exhaust ventilation or other engineering controls is the preferred method of controlling exposure to airborne particulate. Where utilized, exhaust inlets to the ventilation system must be positioned as close as possible to the source of airborne generation. Avoid disruption of the airflow in the area of a local exhaust inlet by equipment such as a man-cooling fan. Check ventilation equipment regularly to ensure it is functioning properly. Provide training on the use and operation of ventilation to all users. Use qualified professionals to design and install ventilation systems.

8.2 WORK PRACTICES

Develop work practices and procedures that prevent particulate from coming in contact with worker skin, hair, or personal clothing. If work practices and/or procedures are ineffective in controlling airborne exposure or visual particulate from deposition on skin, hair, or clothing, provide appropriate cleaning/washing facilities. Procedures should be written that clearly communicate the facility's requirements for protective clothing and personal hygiene. These clothing and personal hygiene requirements help keep particulate from being spread to non-production areas or from being taken home by the worker. Never use compressed air to clean work clothing or other surfaces.

Fabrication processes may leave a residue of particulate on the surface of parts, products or equipment that could result in employee exposure during subsequent material handling activities. As necessary, clean loose particulate from parts between processing steps. As a standard hygiene practice, wash hands before eating or smoking.

To prevent exposure, remove surface scale or oxidation formed on cast or heat treated products in an adequately ventilated process prior to working the surface.

8.3 WET METHODS

Machining operations conducted under a flood of liquid coolant require complete hooded containment and local exhaust ventilation. Openings into the hood must be baffled to prevent release of fast moving particulate. The cycling through a machine of liquid lubricant/coolant containing finely divided beryllium particulate in suspension can result in the concentration building to a point where the particulate may become airborne during use. Prevent coolant from splashing onto floor areas, external structures or operators' clothing. Utilize a coolant filtering system to remove particulate from the coolant.

8.4 RESPIRATORY PROTECTION

When airborne exposures exceed or have the potential to exceed the occupational limits shown in Section 8.13, approved respirators must be used as specified by an Industrial Hygienist or other qualified professional. Respirator users must be medically evaluated to determine if they are physically capable of wearing a respirator. Quantitative and/or qualitative fit testing and respirator training must be satisfactorily completed by all personnel prior to respirator use. Users of tight fitting respirators must be clean shaven on those areas of the face where the respirator seal contacts the face. Exposure to unknown concentrations of particulate requires the wearing of a pressure-demand airline respirator or pressure-demand self-contained breathing apparatus (SCBA). Use pressure-demand airline respirators when performing jobs with high potential exposures such as changing filters in a baghouse air cleaning device.

8.5 OTHER PROTECTIVE EQUIPMENT

Protective overgarments or work clothing must be worn by persons who may become contaminated with particulate during activities such as machining, furnace rebuilding, air cleaning equipment filter changes, maintenance, furnace tending, etc. Contaminated work clothing and overgarments must be managed in a controlled manner to prevent secondary exposure to workers of third parties, to prevent the spread of particulate to other areas, and to prevent particulate from being taken home by workers.

8.6 PROTECTIVE GLOVES

Wear gloves to prevent contact with particulate or solutions. Wear gloves to prevent metal cuts and skin abrasions during handling.

8.7 EYE PROTECTION

Wear safety glasses, goggles, face shield, or welder's helmet when risk of eye injury is present, particularly during melting, casting, machining, grinding, welding, powder handling, etc.

8.8 HOUSEKEEPING

Use vacuum and wet cleaning methods for particulate removal from surfaces. Be certain to de-energize electrical systems, as necessary, before beginning wet cleaning. Use vacuum cleaners with high efficiency particulate air (HEPA). Do not use compressed air, brooms, or conventional vacuum cleaners to remove particulate from surfaces as this activity can result in elevated exposures to airborne particulate. Follow the manufacturer's instructions when performing maintenance on HEPA filtered vacuums used to clean hazardous materials.

8.9 MAINTENANCE

During repair or maintenance activities the potential exists for exposures to particulate in excess of the occupational standards. Under these circumstances, protecting workers can require the use of specific work practices or procedures involving the combined use of ventilation, wet and vacuum cleaning methods, respiratory protection, decontamination, special protective clothing, and when necessary, restricted work zones.

8.10 WELDING

In accordance with OSHA regulation 29 CFR 1910.252 welding of materials containing beryllium is regulated as follows: Welding or cutting indoors, outdoors, or in confined spaces involving beryllium containing base or filler metals shall be done using local exhaust ventilation and pressure-demand airline respirators unless atmospheric tests under the most adverse conditions have established that the workers' exposure is within the acceptable concentrations defined by 29 CFR 1910.1000. In all cases, workers in the immediate vicinity of the welding or cutting operations shall be protected as necessary by local exhaust ventilation or airline respirators.

8.11 CORROSION PROTECTION

Beryllium is corrosion-resistant in air and water up to 600°C. This is attributed to the formation of an adherent oxide layer on the surface.

The presence of salts in water, particularly chloride, dramatically accelerates the corrosion of beryllium. This corrosion can be further accelerated (galvanic corrosion) if beryllium is in contact with a less reactive metal. Contrarily, beryllium can be protected from corrosion by contact with a more reactive metal (anodic protection).

Generally, some corrosion protection should be applied to beryllium. Salts from handling beryllium without gloves along with humidity in the air are sufficient to cause "finger print" corrosion on a bare beryllium part. A chromate conversion coating is an effective protection for non-severe service.

For applications where beryllium is exposed to salt spray or mist, an integral coating is needed to prevent corrosion. The conversion coating alone will not protect beryllium in salt spray applications. Conversion coating in combination with anodic protection with manganese or magnesium has been effective in protecting beryllium brake components on aircraft carrier based planes. Electroless nickel, epoxy paint and other integral coatings are effective corrosion barriers in salt spray applications.

8.12 EXPOSURE CHARACTERIZATION

Determine exposure to airborne particulate by air sampling in the employee breathing zone, work area, and department. Utilize an Industrial Hygienist or other qualified professional to specify the frequency and type of air sampling. Develop and utilize a sampling strategy which identifies the extent of exposure variation and provides statistical confidence in the results. Conduct an exposure risk assessment of processes to determine if conditions or situations exist which dictate the need for additional controls or improved work practices. Make air sample results available to employees.

8.13 MEDICAL SURVEILLANCE

Beryllium: Medical surveillance for beryllium health effects includes (1) skin examination, (2) respiratory history, (3) examination of the lungs, (4) lung function tests (FVC and FEV1), and (5) periodic chest x-ray. In addition, a specialized, specific, immunological blood test, the beryllium blood lymphocyte proliferation test (BLPT), is available to assist in the diagnosis of beryllium related reactions. Individuals who have an abnormal BLPT are normally referred to a lung specialist for additional specific tests to determine if chronic beryllium disease is present. Note: Substantial inter- and intra-laboratory disagreement exists among the laboratories that conduct this test. The BLPT does not at this time meet the criteria for a screening test. Despite its limitations however, the BLPT remains a useful disease surveillance tool.

8.14 RISK FACTORS

Specific genetic factors have been identified and have been shown to increase an individual's susceptibility to CBD. Medical testing is available to detect genetic factors in individuals.

8.15 OCCUPATIONAL EXPOSURE LIMITS

CONSTITUENTS	OSHA*			ACGIH*		NIOSH RTECS NUMBER
	PEL	CEILING	PEAK	TLV	TLV-STEL	
Beryllium	0.002	0.005	0.025	0.002	0.01	DS1750000

*ALL CONCENTRATIONS ARE IN MILLIGRAMS PER CUBIC METER OF AIR
(at the concentrations noted above, these constituents may not be visible to the human eye)

A leading scientific body recommending occupational standards is the American Conference of Governmental Industrial Hygienists (ACGIH). The ACGIH recommends standards for all listed substances. The ACGIH defines a threshold limit value (standard) as follows: "Threshold Limit Values refer to airborne concentrations of substances and represent conditions under which it is believed that nearly all workers may be repeatedly exposed day after day without adverse health effects. Because of wide variation in individual susceptibility, however, a small percentage of workers may experience discomfort from some substances at concentrations at or below the threshold limit; a smaller percentage may be affected more seriously by aggravation of a pre-existing condition or by development of an occupational illness." "Individuals may also be hypersusceptible or otherwise unusually responsive to some industrial chemicals because of genetic factors, age, personal habits (smoking, alcohol, or other drugs), medication, or previous exposures. Such workers may not be adequately protected from adverse health effects from certain chemicals at concentrations at or below the threshold limits."

ACGIH	=	American Conference of Governmental Industrial Hygienists
OSHA	=	Occupational Safety and Health Administration
PEL	=	Eight-Hour Average Permissible Exposure Limit (OSHA)
CEILING	=	Not To Be Exceeded Except For Peak Limit (OSHA)
PEAK	=	30-Minute Maximum Duration Concentration Above Ceiling Limit (OSHA)
TLV	=	Eight-Hour Average Threshold Limit Value (ACGIH)
TLV-STEL	=	15-Minute Short Term Exposure Limit (ACGIH)
CAS	=	Chemical Abstract Service
NIOSH	=	National Institute For Occupational Safety and Health
RTECS	=	Registry of Toxic Effects of Chemical Substances
NA	=	Not Applicable

Brush Wellman recommends following good industrial hygiene practice which includes reducing airborne exposures to the lowest feasible level for all constituents in this product.

9. PHYSICAL AND CHEMICAL PROPERTIES

PHYSICAL PROPERTIES

Boiling Point (°F):	5378	Radioactivity:	Not Applicable
Evaporation Rate:	Not Applicable	Solubility:	None
Freezing Point (°F):	Not Applicable	Sublimes At (°F):	Not Applicable
Odor:	None	Vapor Density (Air = 1):	Not Applicable
pH:	Not Applicable	Vapor Pressure (mmHg):	Not Applicable
Physical State:	Solid	% Volatiles By Volume:	None
Color:	Gray Metallic	Melting Point (°F):	2345
Density (lb/in3):	0.067	Atomic Number	4
Atomic Weight	9.01	Molecular Weight	9.01

10. STABILITY AND REACTIVITY

General Reactivity	This Material is Stable
Incompatibility (materials to avoid)	Avoid contact with mineral acids and strong bases which generate hydrogen gas. Hydrogen gas can be an explosion hazard.
Hazardous Decomposition Products	None under normal conditions of use.
Hazardous Polymerization	Will not occur

11. TOXICOLOGICAL INFORMATION

For questions concerning toxicological information, write to: Medical Director, Brush Wellman Inc., 14710 West Portage River South Road, Elmore, Ohio 43416-9502.

Rigaku

12. ECOLOGICAL INFORMATION

This material can be recycled; contact your Sales Representative.

13. DISPOSAL CONSIDERATIONS

13.1 BYPRODUCT RECYCLING

When recycled (used in a process to recover metals), this material is not classified as hazardous waste under federal law. Seal particulate or particulate containing materials inside two plastic bags, place in a DOT approved container, and label appropriately.

13.2 SOLID WASTE MANAGEMENT

When spent products are declared solid wastes (no longer recyclable), they must be labeled, managed and disposed of, in accordance with federal, state and local requirements. This material is not classified a hazardous waste under federal law.

The U.S. Environmental Protection Agency has classified beryllium powder (P015) as a hazardous waste under the Resource Conservation and Recovery Act (RCRA). In Section 40 CFR 261.33(e) of RCRA, beryllium powder is considered hazardous when it is in the form of a "discarded commercial chemical product, off-specification species, container residue and spill residue, thereof." This designation only applies to commercially pure products or manufacturing intermediates in which beryllium is the "sole active ingredient." Due to the limited scope of this definition, we believe the only form of beryllium to which it applies is waste commercially pure metallic beryllium powder.

Beryllium scrap, chips, and powder are normally recycled as by-products and are not classified a waste. In cases where this is not justified, seal any off-specification metallic beryllium powder in two plastic bags and then place in a DOT container approved for flammable solids. If being disposed, the outer container must be labeled with the appropriate EPA hazardous waste label and DOT hazard warning label(s) and shipped under a uniform hazardous waste manifest to an approved hazardous waste management facility. Dispose of dust collector filters contaminated with metallic beryllium powder following the above procedure, with the exception of the hazardous waste manifest and hazardous waste container label.

14. TRANSPORT INFORMATION

There are no U.S. Department of Transportation hazardous material regulations which apply to the packaging and labeling of this product as shipped by Brush Wellman.

Hazard Communication regulations of the U.S. Occupational Safety and Health Administration require this product be labeled.

15. REGULATORY INFORMATION

15.1 UNITED STATES FEDERAL REGULATIONS

15.1.1. Occupational Safety and Health Administration (OSHA)

Air contaminants, 29 CFR 1910.1000
Hazard Communication Standard, 29 CFR 1910.1200

15.1.2. Environmental Protection Agency (EPA)

AMBIENT AIR EMISSIONS: Beryllium-containing materials are subject to the National Emission Standard for Beryllium as promulgated by EPA (40 CFR 61, Subpart C). The National Emission Standard for beryllium is 0.01 micrograms per cubic meter (30 day average) in ambient air for those production facilities which have been qualified to be regulated through ambient air monitoring. Other facilities must meet a 10 gram per 24-hour total site emission limit. Most process air emission sources will require an air permit from a local and/or state air pollution control agency. The use of air cleaning equipment may be necessary to achieve the permissible emission. Tempered makeup air should be provided to prevent excessive negative pressure in a building. Direct recycling of cleaned process exhaust air is not recommended. Plant exhausts should be located so as not to re-enter the plant through makeup air or other inlets. Regular maintenance and inspection of air cleaning equipment and monitoring of operating parameters is recommended to ensure adequate efficiency is maintained.

WASTEWATER: Wastewater regulations can vary considerably. Contact your local and state governments to determine their requirements.

TOXIC SUBSTANCES CONTROL ACT: Component(s) of this material is/are listed on the TSCA Chemical Substance Inventory of Existing Chemical Substances

SARA TITLE III REPORTING REQUIREMENTS: On February 16, 1988 the U.S. Environmental Protection Agency (EPA) issued a final rule that implements the requirements of the Superfund Amendments and Reauthorization Act (SARA) Title III, Section 313 (53) Federal Register 4525. Title III is the portion of SARA concerning emergency planning and community right-to-know issues. Section 313 covers annual emission reporting on specific chemicals which are manufactured, processed or used at certain U.S. Industrial facilities.

This Brush Wellman product is reportable under the Section 313.

You may obtain additional information by calling the EPA SARA Title III Hotline at 1-800-535-0202 (or 703 412 9810).

15.2 STATE REGULATIONS

Beryllium

- Is listed on the following state right to know lists: California, New Jersey, Florida, Pennsylvania, Minnesota and Massachusetts.
- The following statements are made in order to comply with the California State Drinking Water Act - Warning: This product contains BERYLLIUM, a chemical known to the state of California to cause cancer.
- California No Significant Risk Level: CAS# 7440-41-7: No significant risk level = 0.1 ug/day

15.3 CANADA

Constituent	DSL/NDSL	WHMIS Classification	Ingredient Disclosure List
Beryllium	Yes/No	D2A,D2B	Yes

Rigaku

16. OTHER INFORMATION

Following is the label which accompanies this product during shipment.

M10

Beryllium Solid

WARNING

INHALING DUST OR FUMES MAY CAUSE CHRONIC BERYLLIUM DISEASE, A SERIOUS CHRONIC LUNG DISEASE, IN SOME INDIVIDUALS. CANCER HAZARD. OVER TIME, LUNG DISEASE AND CANCER CAN BE FATAL. TARGET ORGAN IS PRIMARILY THE LUNG.

READ THE MATERIAL SAFETY DATA SHEET (MSDS) ON FILE WITH YOUR EMPLOYER BEFORE WORKING WITH THIS MATERIAL.

Overexposure to beryllium by inhalation may cause chronic beryllium disease, a serious chronic lung disease.

- If processing or recycling produces airborne dust, fumes, or mists, use exhaust ventilation or other controls designed to prevent exposure to workers. Examples of such activities include melting, machining, welding, grinding, abrasive sawing, sanding and polishing. Any activity which abrades the surface of this material can generate airborne dust.
- The Occupational Safety and Health Administration (OSHA) has set mandatory limits on occupational exposures.
- Beryllium metal, in solid form and as contained in finished products presents no special health risks.
- Sold for manufacturing purposes only. This product can be recycled; contact your sales representative.

The Occupational Safety and Health Administration requires employers to provide training in the proper use of this product.

For further information, please telephone or write to: Product Stewardship Department, Brush Wellman Inc., 17876 St. Clair Avenue, Cleveland, Ohio 44110, telephone: (800) 862-4118, www.brushwellman.com. For transportation emergency call Chemtrec at (800) 424-9300.

M10

*Label may vary in size
*Label color (light gray edge with black lettering)

This MSDS has been revised following the guidelines outlined in the American National Standard for Hazardous Industrial Chemicals -"Material Safety Data Sheets - Preparation." Z400.1-1998

MSDS Status: Revision to Carcinogenic Reference in Section 3

IMPORTANT: If you have any questions or require additional information regarding the materials described in this Material Safety Data Sheet, please telephone or write to the Product Stewardship Department at the location given on page 1. Additional product safety information, such as Safety Facts, is available from your sales representative or at www.brushwellman.com or www.befacts.com.

A4.3 MSDS of Lead

Material Safety Data Sheet

Company Name : Shin-Kobe Electric Machinery Co., Ltd.
Address : Nihonbashi Honmachi 8-7 OG Tokyo building, Chuou-ku, Tokyo
Section in Charge : CSR Department
Person in charge : Yuzaburo Ishikawa
Telephone Number : +81-(0)3-5695-6126
FAX Number : +81-(0)3-5695-6142
Urgent Contact : Quality Assurance Department, Nabari Factory, Shin-Kobe ElectricMachinery Co., Ltd.
Telephone Number : +81-(0)595-64-2230
FAX Number : +81-(0)595-64-2239

Preparation Date : October 4, 2000
Reference Number : MSN-3217012 Revision Date : April 21, 2005

Product name (chemical name, brand name, etc.) : Small-sized valve regulated lead-acid battery (HP, HV, HF, HC, LHM, KV series)

Identification of materials

Distinction of single products and mixtures : mixtures
Chemical name : Small-sized valve regulated lead-acid battery (HP, HV, HF, HC, LHM, KV series)
United nations number : class 8 2800 (Battery, non-spillable)

Name of hazardous ingredients	Lead and its compounds	Sulfuric acid
Hazardous material content	About 70%	About 20%
Official gazette notice reference number	-	1-430 (Law Concerning Examination and Regulation of Manufacture and Handling of Chemical Substances)
CAS NO.	7439-92-1	7664-93-9
United Nations classification and United Nations number	Class 5.1 1872	Class 8 2796

- Each of the above hazardous materials is mentioned in the Safety Data Sheet.

Attention at the end of life of the battery

Lead which is the main material of the storage battery is to be recycled. Please bring the spent battery into the place of the purchase or the places specified by the manufacturer when discarding it.

When the user dispose of the battery by himself or herself, it shall be noted that the "Waste Disposal and Public Cleansing Law" applies. When you dispose of the battery, insulate it so that its terminal part may not short circuit. If insulation isn't done, explosion or fire may be caused.

Attention in transport

(1) Don't carry the battery by the up-down reverse posture. Or liquid leakage may be caused.
(2) Don't give the battery an unusual vibration or shock during the conveyance.
(3) Avoid, as general rules, the transport of the battery built in the equipment.
(4) Don't carry the battery by use of its terminals and lead lines.

Applicable statute

JIS C 8702 Small-sized valve regulated lead-acid battery

A4.4 MSDS of Lithium

Page 1 of 3

MATERIAL SAFETY DATA SHEET

SANYO Batteries
SANYO Energy
2055 Sanyo Ave.
San Diego, CA 92154

Telephone No.: (619) 661-4888
www.sanyobatteries.com
In case of emergency contact:
CHEMTREC at (800) 424-9300

Date of Preparation: 6/23/03

Section I – Product Identification

Product Name: Lithium Ion Battery

Model: Cylindrical and Prismatic Type Cells

Chemical System: Lithium Ion

Designated for Recharge:

_X_ Yes ___No

Section II – Composition / Information on Ingredients

IMPORTANT NOTE: The battery cell should not be opened or exposed to heat because exposure to the following ingredients contained within could be harmful under some circumstances.

Chemical Name	CAS No.	PEL	TLV
Lithium Cobaltate ($LiCoO_2$)	12190-79-3	None Established	None Established
Graphite (C)	7782-42-5	2.5 mg/m³ (as dust)	2.5 mg/m³ (as dust)
Organic Solvent		None Established	None Established
Lithium Salt		None Established	None Established
Polyvynilidene difluoride (PVdF)	24937-79-9	None Established	None Established

Weight of lithium per cell: 0g

Section III – Physical Data

Specific Gravity: (H_20=1): LiC_0O_2:4.95, Graphite:2.09~2.2
Melting Point: (ºC): LiC_0O_2 about 1130 C
Appearance and Odor: LiC_0O_2 is a black, odorless powder.
C is a black, odorless powder.
Organic solvent is a colorless or light yellow liquid.
Lithium salt is a white, crystalline and odorless powder.

The information and recommendations set forth are made in good faith and believed to be accurate as of the date of preparation. SANYO ENERGY CORP. makes no warranty, expressed or implied, with respect to this information and disclaims all liabilities from reliance on it.

Section IV — Fire and Explosion Hazard Data

Extinguishing Media:	Water
Flammable Limits:	Not available
Special Fire Fighting Procedure:	In case of fire in an adjacent area, use water, CO_2 or dry chemical extinguishers if cells are packed in their original containers since the fuel of the fire is basically paper products. For bulk quantities of unpackaged cells use LITH-X (Graphite Base). In this case, do not use water.

Section V - Reactivity Data

Stability:	Stable
Conditions to Avoid:	Do not heat, disassemble or overcharge.
Hazardous Decomposition or By-products:	N/A

Hazardous polymerization will not occur.

Section VI - Health Hazard Data

Routes of Entry:	Inhalation	Yes
	Skin	Yes
	Ingestion	Yes

Health Hazards (Acute and Chronic):

These chemicals are contained in a sealed can. Risk of exposure occurs only if the battery is mechanically or electrically abused. The most likely risk is an acute exposure when the gas release vent works. Organic solvent has slight toxicity and can irritate skin and eyes. Lithium salt is irritating to skin, eyes and mucous membranes and should be avoided.

Carcinogenicity:

NTP: None IARC Monograph: None OSHA Regulated: None

Medical Conditions Generally Aggravated by Exposure:

An acute exposure will not generally aggravate any medical condition.

Emergency and First Aid Procedures:

In case of skin contact with contents of battery, flush immediately with water. For eye contact, flush with copious amounts of water for 15 minutes. Do not inhale leaked material. If irritation persists, get medical help.

Section VII - Precautions for Safe Handling and Use

Steps to be Taken in Case Material is Released or Spilled:

The preferred response is to leave the area and allow the batteries to cool and the vapors to dissipate. Avoid skin and eye contact or inhalation of vapors. Remove spilled liquid with absorbent and incinerate.

Waste Disposal Method:

Dispose in accordance with appropriate regulations. Open cells should be treated as hazardous waste.

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Precautions to be Taken in Handling and Storing:
Avoid mechanical or electrical abuse.

Other Precautions:
Batteries may explode or cause burns, if disassembled, crushed or exposed to fire or high temperatures. Do not short or install with incorrect polarity.

Section VIII - Control Measure

Respiratory Protection (Specify Type):	Not necessary under conditions of normal use.
Ventilation:	Not necessary under conditions of normal use.
Protective Gloves:	Not necessary under conditions of normal use.
Eye Protection:	Not necessary under conditions of normal use.
Other Protective Clothing or Equipment:	Not necessary under conditions of normal use.

Section IX - Recycling and Disposal

SANYO encourages battery recycling. Lithium ion batteries are safe for disposal in the normal municipal waste stream since they are not defined by the federal government as hazardous waste. However, lithium ion batteries are recyclable. For information contact Kinsbursky Brothers Inc. at (800)548-8797 or see their website at www.kinsbursky.com.

DO NOT INCINERATE or subject battery cells to temperatures in excess of 212°F. Such treatment can cause cell rupture.

Section X - Transportation

Sanyo sealed Lithium Ion batteries comply with all applicable shipping regulations as prescribed by industry and legal standards which includes compliance with the UN Recommendations on the Transport of Dangerous Goods; IATA Dangerous Goods Regulations, 44th Edition, 2003, Special Provisions A45, and applicable U.S. DOT regulations for the safe transport of Lithium Ion batteries.

Each Sanyo cell or battery has been tested under provisions of the UN Manual of Tests and Criteria, Part III, Sub-section 38.3.

The information and recommendations set forth are made in good faith and believed to be accurate as of the date of preparation. SANYO ENERGY CORP. makes no warranty, expressed or implied, with respect to this information and disclaims all liabilities from reliance on it.

A4.5 MSDS of Mercury

Material Safety Data Sheet

Section 1. Product and Company Identification

Product Name Mercury

Product Code MX0405

Manufacturer EMD Chemicals Inc.
P.O. Box 70
480 Democrat Road
Gibbstown, NJ 08027
Prior to January 1, 2003 EMD Chemicals Inc. was EM Industries, Inc. or EM Science, Division of EM Industries, Inc.

Effective Date 6/18/2003

For More Information Call

856-423-6300 Technical Service
Monday-Friday: 8:00 AM - 5:00 PM

In Case of Emergency Call

800-424-9300 CHEMTREC (USA)
613-996-6666 CANUTEC (Canada)
24 Hours/Day: 7 Days/Week

Synonym Quicksilver

Material Uses Analytical reagent.

Chemical Family Element.

Section 2. Composition and Information on Ingredients

Component	CAS #	% by Weight
Mercury	7439-97-6	100

Section 3. Hazards Identification

Physical State and Appearance Liquid.

Emergency Overview

DANGER!
MAY BE FATAL IF INHALED OR SWALLOWED.
CAUSES RESPIRATORY TRACT, EYE AND SKIN IRRITATION.
MAY CAUSE EYE AND SKIN BURNS.
HARMFUL IF ABSORBED THROUGH SKIN.
CONTAINS MATERIAL WHICH CAUSES DAMAGE TO THE FOLLOWING ORGANS: KIDNEYS, GASTROINTESTINAL TRACT, RESPIRATORY TRACT, SKIN, CENTRAL NERVOUS SYSTEM, EYE, LENS OR CORNEA.
MAY BE HARMFUL TO ENVIRONMENT IF RELEASED IN LARGE AMOUNTS.
VERY TOXIC TO AQUATIC ORGANISMS.
WARNING: This product contains a chemical(s) known to the State of California to cause birth defects or other reproductive harm.

Routes of Entry Absorbed through skin. Dermal contact. Eye contact. Inhalation. Ingestion.

Potential Acute Health Effects

Eyes Hazardous in case of eye contact (corrosive, irritant). May cause burns. Inflammation of the eye is characterized by redness, watering, and itching.

Skin Hazardous in case of skin contact (permeator, corrosive, irritant). Skin contact may produce burns. Skin inflammation is characterized by itching, scaling, reddening, or, occasionally, blistering.

Inhalation Extremely hazardous in case of inhalation. May be fatal if inhaled. Hazardous in case of inhalation (lung irritant).

Ingestion Extremely hazardous in case of ingestion. May be fatal if swallowed.

Potential Chronic Health Effects

Carcinogenic Effects This material is not known to cause cancer in animals or humans.

Additional information See Toxicological Information (section 11)

Medical Conditions Aggravated by Overexposure: Repeated or prolonged contact with spray mist may produce chronic eye irritation and severe skin irritation. Repeated or prolonged exposure to spray mist may produce respiratory tract irritation leading to frequent attacks of bronchial infection. Repeated exposure to a highly toxic material may produce general deterioration of health by an accumulation in one or many human organs.

Section 4. First Aid Measures

Eye Contact Check for and remove any contact lenses. In case of contact, immediately flush eyes with plenty of water for at least 15 minutes. Get medical attention immediately.

Skin Contact In case of contact, immediately flush skin with plenty of water for at least 15 minutes while removing contaminated clothing and shoes. Cover the irritated skin with an emollient. Wash clothing before reuse. Thoroughly clean shoes before reuse. Get medical attention immediately.

Inhalation If inhaled, remove to fresh air. If not breathing, give artificial respiration. If breathing is difficult, give oxygen. Get medical attention immediately.

Ingestion If swallowed, do not induce vomiting unless directed to do so by medical personnel. Never give anything by mouth to an unconscious person. Loosen tight clothing such as a collar, tie, belt or waistband. Get medical attention immediately.

Section 5. Fire Fighting Measures

Flammability of the Product Non-flammable.

Auto-ignition Temperature Not applicable.

Flash Points Not applicable.

Flammable Limits Not applicable.

Products of Combustion Not available.

Fire Hazards in Presence of Various Substances Not applicable.

Explosion Hazards in Presence of Various Substances

Risks of explosion of the product in presence of static discharge: No.

Risks of explosion of the product in presence of mechanical impact: No.

Fire Fighting Media and Instructions Not applicable.

Protective Clothing (Fire) Not applicable.

Special Remarks on Fire Hazards Not available.

Special Remarks on Explosion Hazards Not available.

Section 6. Accidental Release Measures

Small Spill and Leak Absorb with an inert material and put the spilled material in an appropriate waste disposal.

Large Spill and Leak Stop leak if without risk. Absorb with DRY earth, sand or other non-combustible material. Do not get water inside container. Do not touch spilled material. Use water spray curtain to divert vapor drift. Use water spray to reduce vapors. Prevent entry into sewers, basements or confined areas; dike if needed. Call for assistance on disposal. Be careful that the product is not present at a concentration level above TLV. Check TLV on the MSDS and with local authorities.

Spill Kit Information The following EMD Chemicals Inc. SpillSolv ® absorbent is recommended for this product: SX1350 Mercury Treatment Kit

Section 7. Handling and Storage

Handling Avoid contact with eyes, skin and clothing. Do not ingest. Do not breathe vapor or mist. Keep container closed. Use only with adequate ventilation. Wash thoroughly after handling.

Storage Keep container in a cool, well-ventilated area.

Section 8. Exposure Controls/Personal Protection

Engineering Controls Provide exhaust ventilation or other engineering controls to keep the airborne concentrations of vapors below their respective occupational exposure limits. Ensure that eyewash stations and safety showers are proximal to the work-station location.

Personal Protection

Eyes Face shield.

Body Full suit.

Respiratory Vapor respirator. Be sure to use an approved/certified respirator or equivalent. Wear appropriate respirator when ventilation is inadequate.

Hands Gloves.

Feet Boots.

Protective Clothing (Pictograms)



Personal Protection in Case of a Large Spill Splash goggles. Full suit. Vapor respirator. Boots. Gloves. A self-contained breathing apparatus should be used to avoid inhalation of the product. Suggested protective clothing might not be sufficient; consult a specialist BEFORE handling this product.

Product Name	Exposure Limits
Mercury	**AUVA (Austria, 1995).** Spitzenbegrenzung: 0.5 mg/m3 1 times per shift, 30 minute(s). Spitzenbegrenzung: 0.05 ppm 1 times per shift, 30 minute(s). TWA: 0.05 mg/m3 8 hour(s). TWA: 0.005 ppm 8 hour(s). **Belgium Minister of Labour (Belgium, 1998). Skin** VL: 0.025 mg/m3 8 hour(s). **BAUA (Germany, 1997).** Spitzenbegrenzung: 0.32 mg/m3 Spitzenbegrenzung: 0.04 ppm TWA: 0.08 mg/m3 8 hour(s). TWA: 0.01 ppm 8 hour(s). **DK-Arbejdstylsinet (Denmark, 1996). Skin** GV: 0.025 mg/m3 8 hour(s). **Tyterveyslaitos (Finland, 1998). Skin** TWA: 0.05 mg/m3 8 hour(s). **INRS (France, 1996). Skin** VME: 0.05 mg/m3 8 hour(s). **National Authority for Occupational Safety/Health (Ireland, 1999).** OEL: 0.025 mg/m3 8 hour(s). **Arbeidsinspectie (Netherlands, 1999).** TGG 15 min: 0.5 mg/m3 15 minute(s). TGG 8 uur: 0.05 mg/m3 8 hour(s). **N-Arbeidstylsinet (Norway, 1996). Sensitizer skin, Sensitizer inhalation** AN: 0.05 mg/m3 8 hour(s). **AFS (Sweden, 1996).** NGV: 0.03 mg/m3 8 hour(s). **EH40-OES (United Kingdom (UK), 1997).** TWA: 0.025 mg/m3 8 hour(s). **ACGIH (United States, 1994). Skin** TWA: 0.03 mg/m3 8 hour(s). Form: Inorganic **OSHA Final Rule (United States, 1989). Skin** TWA: 0.05 mg/m3 8 hour(s). Form: Vapor **OSHA Transitional Rule (United States, 1993).** CEIL: 1 MG10M3

Section 9. Physical and Chemical Properties

Odor Not available.

Color Silvery. Grey.

Physical State and Appearance Liquid.

Molecular Weight 200.59 g/mole

Molecular Formula Hg

pH	Not applicable.
Boiling/Condensation Point	356.69°C (674°F)
Melting/Freezing Point	-38.82°C (-37.9°F)
Critical Temperature	1461.9°C (2663.4°F)
Specific Gravity	13.55 (Water = 1)
Vapor Pressure	Not available.
Vapor Density	Not available.
Odor Threshold	Not available.
Evaporation Rate	Not available.
LogKow	Not available.
Solubility	Insoluble in water.

Section 10. Stability and Reactivity

Stability and Reactivity	The product is stable.
Conditions of Instability	Not available.
Incompatibility with Various Substances	Not available.
Rem/Incompatibility	Not available.
Hazardous Decomposition Products	Mercury vapor
Hazardous Polymerization	Will not occur.

Section 11. Toxicological Information

RTECS Number: Mercury OV4550000

Toxicity	LD50: Not available. LC50: Not available.
Chronic Effects on Humans	Not available.
Acute Effects on Humans	Hazardous in case of eye contact (corrosive, irritant). May cause burns. Inflammation of the eye is characterized by redness, watering, and itching. Hazardous in case of skin contact (permeator, corrosive, irritant). Skin contact may produce burns. Skin inflammation is characterized by itching, scaling, reddening, or, occasionally, blistering. Extremely hazardous in case of inhalation. May be fatal if inhaled. Hazardous in case of inhalation (lung irritant). Extremely hazardous in case of ingestion. May be fatal if swallowed.
Synergetic Products (Toxicologically)	Not available.
Irritancy	Draize Test: Not available.
Sensitization	Not available.
Carcinogenic Effects	This material is not known to cause cancer in animals or humans.
Toxicity to Reproductive System	Tests on laboratory animals for reproductive effects are cited in Registry of Toxic Effects on Chemical Substances (RTECS).
Teratogenic Effects	Not available.
Mutagenic Effects	Tests on laboratory animals for mutagenic effects are cited in Registry of Toxic Effects of Chemical Substances (RTECS).

Section 12. Ecological Information

Ecotoxicity	Not available.
BOD5 and COD	Not available.
Toxicity of the Products of Biodegradation	The products of degradation are less toxic than the product itself.

Section 13. Disposal Considerations

EPA Waste Number	U151 D009

Treatment Specifed Technology - Contact your local permitted waste disposal site (TSD) for permissible treatment sites. Always contact a permitted waste disposal (TSD) to assure compliance with all current local, state, and Federal Regulations..

Section 14. Transport Information

DOT Classification
Proper Shipping Name: MERCURY
Hazard Class: 8
UN number: UN2809
Packing Group: III
RQ: 1 lbs. (0.4536 kg)

TDG Classification Not available.

IMO/IMDG Classification
Proper Shipping Name: MERCURY
Hazard Class: 8
UN number: UN2809
Packing Group: III
RQ: 1

ICAO/IATA Classification Not available.

Section 15. Regulatory Information

U.S. Federal Regulations TSCA 8(b) inventory: Mercury

SARA 302/304/311/312 extremely hazardous substances: No products were found.
SARA 302/304 emergency planning and notification: No products were found.
SARA 302/304/311/312 hazardous chemicals: Mercury
SARA 311/312 MSDS distribution - chemical inventory - hazard identification: Mercury: Immediate (Acute) Health Hazard, Delayed (Chronic) Health Hazard
SARA 313 toxic chemical notification and release reporting: Mercury

Clean Water Act (CWA) 307: Mercury

Clean Water Act (CWA) 311: No products were found.

Clean air act (CAA) 112 accidental release prevention: No products were found.

Clean air act (CAA) 112 regulated flammable substances: No products were found.

Clean air act (CAA) 112 regulated toxic substances: No products were found.

WHMIS (Canada) Class D-1A: Material causing immediate and serious toxic effects (VERY TOXIC).
CLASS E: Corrosive liquid.
CEPA DSL: Mercury

This product has been classifed in accordance with the hazard criteria of the Controlled Product Regulations and the MSDS contains all required information.

International Regulations

EINECS Mercury 231-106-7

DSCL (EEC) R37/38- Irritating to respiratory system and skin.
R41- Risk of serious damage to eyes.

International Lists Australia (NICNAS): Mercury

Korea (TCCL): Mercury

Philippines (RA6969): Mercury
China: No products were found.

State Regulations Massachusetts RTK: Mercury
New Jersey: Mercury
California prop. 65: This product contains the following ingredients for which the State of California has found to cause cancer, birth defects or other reproductive harm, which would require a warning under the statute: Mercury
California prop. 65: This product contains the following ingredients for which the State of California has found to cause birth defects which would require a warning under the statute: Mercury

Section 16. Other Information



Association (U.S.A.)

Specific Hazard

Changed Since Last Revision

+

Notice to Reader

The statements contained herein are based upon technical data that EMD Chemicals Inc. believes to be reliable, are offered for information purposes only and as a guide to the appropriate precautionary and emergency handling of the material by a properly trained person having the necessary technical skills. Users should consider these data only as a supplement to other information gathered by them and must make independent determinations of suitability and completeness of information from all sources to assure proper use, storage and disposal of these materials and the safety and health of employees and customers and the protection of the environment. EMD CHEMICALS INC. MAKES NO REPRESENTATION OR WARRANTY OF ANY KIND, EXPRESS OR IMPLIED, INCLUDING MERCHANTABILITY OR FITNESS FOR A PARTICULAR USE, WITH RESPECT TO THE INFORMATION HEREIN OR THE PRODUCT TO WHICH THE INFORMATION REFERS.

A4.6 MSDS of Mechanical Lubricating Grease

Material Safety Data Sheet

SECTION I – Material Identity
SECTION II – Manufacturer's Information
SECTION III – Physical/Chemical Characteristics
SECTION IV – Fire and Explosion Hazard Data
SECTION V – Reactivity Data
SECTION VI – Health Hazard Data
SECTION VII – Precautions for Safe Handling and Use
SECTION VIII – Control Measures
SECTION IX – Label Data
SECTION X – Transportation Data
SECTION XI – Site Specific/Reporting Information
SECTION XII – Ingredients/Identity Information

SECTION I – Material Identity

Item Name	
Part Number/Trade Name	MULTEMP PS NO 2-A 07-350
National Stock Number	9150PS2A
CAGE Code	KYODO
Part Number Indicator	A
MSDS Number	193523
HAZ Code	B

SECTION II – Manufacturer's Information

Manufacturer Name	KYODO YUSHI CO LTD
Street	DENTSU KOSAN DAI-8 BLDG
City	GINZA, CHUO-KU
Country	JA
Zip Code	2-16-7
Emergency Phone	03-3543-5813

MSDS Preparer's Information

Date MSDS Prepared/Revised	18SEP96
Active Indicator	Y

Alternate Vendors

SECTION III – Physical/Chemical Characteristics

Appearance/Odor	WHITE PASTE; SLIGHT ODOR
Boiling Point	NA
Melting Point	190 C
Vapor Pressure	NA
Specific Gravity	0.92
Solubility in Water	NEGLIGIBLE
Container Type	R
Container Pressure Code	1
Temperature Code	4

Product State Code	S

SECTION IV – Fire and Explosion Hazard Data

Flash Point	215
Flash Point Method	SCC
Lower Explosion Limit	NA
Upper Explosion Limit	NA
Extinguishing Media	DRY CHEMICAL, WATER FOG, CO2, FOAM, SAND/EARTH
Special Fire Fighting Procedures	DENSE SMOKE. FIRE FIGHTER WEAR APPROVED SCBA. DO NOT USE WATER EXCEPT FOG

SECTION V – Reactivity Data

Stability	YES
Stability Conditions to Avoid	AVOID OVER-HEATING
Materials to Avoid	STRONG OXIDIZERS SUCH AS HYDROGEN PEROXIDE, BROMINE, & CHROMIC ACID
Hazardous Decomposition Products	CARBON MONOXIDE & DIOXIDE, OXIDE OF NITROGEN
Hazardous Polymerization	NO
Polymerization Conditions to Avoid	WILL NOT OCCUR

SECTION VI – Health Hazard Data

Route of Entry: Skin	U
Route of Entry: Ingestion	U
Route of Entry: Inhalation	U
Health Hazards – Acute and Chronic	{EYES}
Emergency/First Aid Procedures	{EYES} IMMEDIATELY FLUSH W/ WATER FOR AT LEAST 15 MIN. {SKIN} REMOVE EXCESS W/ CLOTH OR PAPER & WASH THOROGHLY W/ SOAP & WATER. {INGEST} CONSULT PHYSICIAN. DO NOT INDUCE VOMITING {INHALE} KEEP VICTIM WARM & QUIET. REMOVE TO FRESH AIR

SECTION VII – Precautions for Safe Handling and Use

Steps if Material Released/Spilled	TRANSFER BULK OF MIXTURE INTO ANOTHER CONTAINER. ABSORB RESIDUE W/ AN INERT MATERIAL SUCH AS EARTH, SAND, & VERMICULITE. SWEEP UP & DISPOSE SOLID WASTE IN ACCORDANCE W/ LOCAL, STATE & FED REGS
Waste Disposal Method	DISPOSE OF IN ACCORDANCE W/ STATE, LOCAL & FED REGS. INCINIRATE IN ACCORD. W/ APPLICABLE REGS. MATERIAL MAY BE RECOVERED & RECYCLED
Handling and Storage Precautions	KEEP CONTAINER CLOSED UNTIL READY FOR USE. STORAGE AWAY FROM FIRE SOURCE OR SUNLIGHT & IN COOL DRY AREA
Other Precautions	DO NOT USE PRESSUE TO EMPTY CONTAINER. WHEN EMPTY, CONTAINER MAY HAVE VAPOR OR PRODUCT RESIDUE. DO NOT CUT, PUNCTURE OR WELD ON OR NEAR THE DRUM

SECTION VIII – Control Measures

Respiratory Protection	GOOD VENTILATION SHOULD BE SUFFICIENT
Ventilation	GOOD GENERAL VENT. SHOULD BE SUFFICIENT
Protective Gloves	RUBBER OR PLASTIC OIL RESISTANT
Eye Protection	CHEMICAL SAFETY GOGGLES & IF HANDLED HOT, FULL FACE SHIELD
Other Protective Equipment	NONE

SECTION IX – Label Data

Protect Eye	NO
Protect Skin	NO
Protect Respiratory	NO
Chronic Indicator	UNKNOWN
Contact Code	UNKNOWN

Fire Code	UNKNOWN
Health Code	UNKNOWN
React Code	UNKNOWN

SECTION X – Transportation Data

SECTION XI – Site Specific/Reporting Information

Volatile Organic Compounds (P/G)	0
Volatile Organic Compounds (G/L)	0

SECTION XII – Ingredients/Identity Information

Ingredient #	01
Ingredient Name	*REFINED MINERAL OIL
CAS Number	101316727
Percent	25

Material Safety Data Sheet

Issued 15-Feb-1994 Revised (7.1) 13-Dec-2002

Section1: Chemical Product / Company Identification

Trade name **DEMNUM ™ Grease L, LR Series**
L-65, L-100, L-200, LR-65, LR-200

Synonym Perfluoropolytrimethyleneoxide grease

Company identification
Manufacturer DAIKIN INDUSTRIES, LTD.CHEMICAL DIVISION:
Umeda Center Bldg., 4-12, Nakazaki-Nishi2-chome, Kita-Ku, Osaka, JAPAN
Phone: (+81) 6-6373-4349 Fax: (+81) 6-6373-4389
Supplier in EU DAIKIN CHEMICAL EUROPE GmbH
ImmermannStr.65 d, 40210 Düsseldorf, GERMANY
Phone: (+49) 211-1640-834. Fax: (+49) 211-1640-734,
Supplier in US DAIKIN AMERICA, INC.
20 Olympic Drive, Orangeburg, New York 10962
Phone: +1-800-365-9570
Emergency telephone
Company +81-6-6373-4349, +49-211-179 225 0, +1-845-365-9500

Section 2: Composition / information on ingredients

Name	Amount	CAS Number
Perfluoropolytrimethyleneoxide	80-20	113114-19-5
PTFE	20-80	9002-84-0

Section 3: Hazard identification

EMERGENCY OVERVIEW Nonflammable.

Potential Health Effects
Ingestion This product can be considered practically non-toxic when swallowed.
Eye Contact Direct contact with the solution may cause irritation to the eyes.
No damage is expected.
Skin Contact This product is not expected to cause skin irritation.
Inhalation The inhalation hazard potential for this product is considered low.
Avoid prolonged inhalation of vapors.

WARNING:
Vapors and fumes liberated during hot processing with this material may cause flu-like symptoms (chills, fever, and sometimes cough) that may not occur until several hours after exposure and typically pass within about 36 to 48 hours.

Carcinogenicity Information:
None of the components present in this material at concentrations equal to or greater than 1% is listed by IARC, NTP, OSHA or ACGIH as a carcinogen.

Rigaku

DEMNUM ™ Grease L, LR Series

Section 4: First aid measures

Eyes Contact	Wash thoroughly with large amounts of water for at least 15 minutes (remove contact lenses if easily possible). Consult an oculist.
Inhalation	If the decomposition gas inhaled, move immediately to fresh air and consult a physician.
Skin Contact	Wash thoroughly with large amounts of water and soap before drying.
Ingestion	Rinse mouth. Refer for medical attention.

SECTION 5: Fire-fighting measures

General Information	Non-flammable. Wear self-contained breathing apparatus (SCBA) and full protective gear. Use water spray to cool fire exposed containers. During a fire, irritating and highly toxic gases may be generated by thermal decomposition or combustion.
Extinguishing Media	Powder, alcohol-resistant foam, carbon dioxide.
WARNING:	TOXIC FLUORINE COMPOUNDS ARE EVOLVED IN FIRE.

SECTION 6: Accidental release measures

General Information	Use proper personal protective equipment as indicated in Section 8.
Spills/Leaks	Absorb spill with inert material (e.g. sand or earth). Then place in suitable container. Do not flush to sewer.

SECTION 7: Handling and storage

Handling	Wear suitable protective clothing (see section 8) Use in well ventilated areas. As there is a possibility for inhaling poisonous decomposition gas form smoking a cigarette to which compound may be adhered, "no smoking" practice should be maintained in a work place and after handling materials, wish face and hands thoroughly. We recommend to use these materials bellow 260 ^{o}C under good ventilation.
Storage	Should be a no-smoking zone Store in a dry, cool place. Keep the container tightly sealed during storage.

SECTION 8: Exposure controls / personal protection

Exposure Limits

HF	TLV (as F): 3ppm; (ceiling values)(ACGIH 1999) MAK: 3ppm; 2.5mg/m^3, BAT 7mg/g creatinine (1999) MAK as STEL: 6ppm, 5mg/m^3 (1999)
COF_2	TLV: 2ppm; 5.4mg/m^3 (as TWA); 5ppm; 13mg/m^3 (as STEL) (ACGIH 1997)

Engineering Controls:

Use local exhaust ventilation facilities.

If user operations generate fume, use ventilation to keep exposure to airborne contaminants below the exposure limit.

Personal Protective Equipment

Respiratory protection	Wear a gas mask or ventilated mask.
Hand protection	Wear appropriate gloves.
Eye protection	Wear protective glasses (goggles).
Skin protection	Wear protective clothing and boots as required. Contaminated clothing should be thoroughly cleaned before re-use.

DEMNUM ™ Grease L, LR Series

SECTION 9: Physical and chemical properties

Appearance	White opaque
Odor	None
pH	N.ap
Boiling point/ range	Extremely high
Flash point	None
Explosive properties	No data
Oxidising properties	No data
Vapour pressure	Negligible
Relative density	No data
Solubility	
- water solubility	Insoluble
- fat solubility	No data
Partition coefficient	N.ap
Viscosity	No data
Vapour density	Heavier than air
Evaporation rate	No data

SECTION 10: Stability and reactivity

Chemical Stability	Stable under normal temperatures and pressures.
Conditions to Avoid	Ignition sources, excess heat.
Decomposition	PTFE slowly decompose from 260 °C, emit rapidly toxic gases (HF, COF_2) above 380 °C.
Wearing	These materials may react with other materials known to catalyze these reactions include, Ti-alloy, Al_2O_3 at lower temperature.

SECTION 11: Toxicological information

ACUTE TOXICITY DATA
< Perfluoropolytrimethyleneoxide>

Acute oral	rat	LD_{50}>2g/kg
Acute dermal	rat	LD_{50}>2g/kg
28-day repeated oral	rat	NOEL=1.3g/kg /day
Acute irritation/corrosion	dermal:albino rabbit	not
Acute irritation/corrosion	eye:albino rabbit	not
Sensitization	guinea pig	not (maximization test)
Mutation	Bacterial reverse mutation:	negative
	Chromosomal aberration:	negative

NOEL=no observed effect level

When heated for a long time, a very small quantity of hydrogen fluoride (HF), carbonyl fluoride(COF_2) is generated. Further the higher temperature, the larger it will increase. Follow safe industrial hygiene practices and wear proper protective equipment when handling this compound.

(as HF or COF_2)
Burning sensation. Cough. Dizziness. Headache. Laboured breathing. Nausea. Shortness of breath. Sore throat. Vomiting. Symptoms may be delayed.
Inhalation of this gas or vapour may cause lung oedema.

DEMNUM ™ Grease L, LR Series

SECTION 12: Ecological information

< Perfluoropolytrimethyleneoxide>

Biodegradability	not degraded (the closed bottle test)	
Acute toxicity	daphnia magna:	not affected
Semi-acute toxicity	zebra fish:	not affected
Effect on the growth	alga *Selenastrum*	NOEL=102m g/L
Effect on the respiration rate	activated sludge	NOEC=>1000mg/L

NOEC: no observed effect concentration

SECTION 13: Disposal considerations

Comply with Federal, State and Local regulations concerning health and environment.
This material can be disposed by using landfill or by incineration.
In case of incineration, mix with flammable material and incinerate in an industrial or commercial facility which has the function of standing the acid.

SECTION 14: Transport information

Shipping Information
Not regulated as a hazardous material by DOT, IMO, or IATA.

SECTION 15: Regulatory information

European Labeling in Accordance with EC Directive

Hazard Symbols	-
Risk Phrases	-
Safety Phrases	15: Keep away from heat. 20/21: When using, do not eat, drink or smoke.

SECTION 16: Other information

International Regulations

US (TSCA):	Listed on the Toxic substances Control Act-Section 8(b) Chemical Inventory.
EU:	DAIKIN CHEMICAL EUROPE GmbH has ELINCS number.
Japan (ENCS):	All components are listed on.

This product is not designed, manufactured, or intended for medical uses, including implantation to the body or other applications in direct contact with body fluids or tissues.
Do not use for non-industrial applications.

The information in this Material Safety Data Sheet (MSDS) is believed to be correct as of the date issued. The information does not relate to use in combination with any other material or in any process.

DAIKIN INDUSTRIES, LTD.CHEMICAL DIVISION: TOXICOLOGY & REGULATORY AFFEARS
Homepage: http://www.daikin.co.jp/chm/

A4.7 MSDS of Ethanol

Material Safety Data Sheet
Ethanol, Absolute

ACC# 89308

Section 1 - Chemical Product and Company Identification

MSDS Name: Ethanol, Absolute
Catalog Numbers: NC9602322
Synonyms: Ethyl Alcohol; Ethyl Alcohol Anhydrous; Ethyl Hydrate; Ethyl Hydroxide; Fermentation Alcohol; Grain Alcohol; Methylcarbinol; Molasses Alcohol; Spirits of Wine.
Company Identification:
Fisher Scientific
1 Reagent Lane
Fair Lawn, NJ 07410
For information, call: 201-796-7100
Emergency Number: 201-796-7100
For CHEMTREC assistance, call: 800-424-9300
For International CHEMTREC assistance, call: 703-527-3887

Section 2 - Composition, Information on Ingredients

CAS#	Chemical Name	Percent	EINECS/ELINCS
64-17-5	Ethanol	ca.100	200-578-6

Section 3 - Hazards Identification

EMERGENCY OVERVIEW

Appearance: colorless clear liquid. Flash Point: 16.6 deg C.
Warning! Causes severe eye irritation. **Flammable liquid and vapor.** Causes respiratory tract irritation. This substance has caused adverse reproductive and fetal effects in humans. May cause central nervous system depression. May cause liver, kidney and heart damage. Causes moderate skin irritation.
Target Organs: Kidneys, heart, central nervous system, liver.

Potential Health Effects
Eye: Causes severe eye irritation. May cause painful sensitization to light. May cause chemical conjunctivitis and corneal damage.
Skin: Causes moderate skin irritation. May cause cyanosis of the extremities.
Ingestion: May cause gastrointestinal irritation with nausea, vomiting and diarrhea. May cause systemic toxicity with acidosis. May cause central nervous system depression, characterized by excitement, followed by headache, dizziness, drowsiness, and nausea. Advanced stages may cause collapse, unconsciousness, coma and possible death due to respiratory failure.
Inhalation: Inhalation of high concentrations may cause central nervous system effects characterized by nausea, headache, dizziness, unconsciousness and coma. Causes respiratory tract irritation. May cause narcotic effects in high concentration. Vapors may cause dizziness or suffocation.
Chronic: May cause reproductive and fetal effects. Laboratory experiments have resulted in mutagenic effects. Animal studies have reported the development of tumors. Prolonged exposure may cause liver, kidney, and heart damage.

Section 4 - First Aid Measures

Eyes: Get medical aid. Gently lift eyelids and flush continuously with wate r.
Skin: Get medical aid. Wash clothing before reuse. Flush skin with plenty of soap and water.
Ingestion: Do not induce vomiting. If victim is conscious and alert, give 2-4 cupfuls of milk or water. Never give anything by mouth to an unconscious person. Get medical aid.
Inhalation: Remove from exposure and move to fresh air immediately. If not breathing, give artificial respiration. If breathing is difficult, give oxygen. Get medical aid. Do NOT use mouth-to-mouth resuscitation.
Notes to Physician: Treat symptomatically and supportively. Persons with skin or eye disorders or liver, kidney, chronic respiratory diseases, or central and peripheral nervous sytem diseases may be at increased risk from exposure to this substance.
Antidote: None reported.

Section 5 - Fire Fighting Measures

General Information: Containers can build up pressure if exposed to heat and/or fire. As in any fire, wear a self-contained breathing apparatus in pressure-demand, MSHA/NIOSH (approved or equivalent), and full protective gear. Vapors may form an explosive mixture with air. Vapors can travel to a source of ignition and flash back. Will burn if involved in a fire. Flammable Liquid. Can release vapors that form explosive mixtures at temperatures above the flashpoint. Use water spray to keep fire-exposed containers cool. Containers may explode in the heat of a fire.
Extinguishing Media: For small fires, use dry chemical, carbon dioxide, water spray or alcohol-resistant foam. For large fires, use water spray, fog, or alcohol-resistant foam. Use water spray to cool fire-exposed containers. Water may be ineffective. Do NOT use straight streams of water.
Flash Point: 16.6 deg C (61.88 deg F)
Autoignition Temperature: 363 deg C (685.40 deg F)
Explosion Limits, Lower:3.3 vol %
Upper: 19.0 vol %
NFPA Rating: (estimated) Health: 2; Flammability: 3; Instability: 0

Section 6 - Accidental Release Measures

General Information: Use proper personal protective equipment as indicated in Section 8.
Spills/Leaks: Absorb spill with inert material (e.g. vermiculite, sand or earth), then place in suitable container. Remove all sources of ignition. Use a spark-proof tool. Provide ventilation. A vapor suppressing foam may be used to reduce vapors.

Section 7 - Handling and Storage

Handling: Wash thoroughly after handling. Use only in a well-ventilated area. Ground and bond containers when transferring material. Use spark-proof tools and explosion proof equipment. Avoid contact with eyes, skin, and clothing. Empty containers retain product residue, (liquid and/or vapor), and can be dangerous. Keep container tightly closed. Keep away from heat, sparks and flame. Avoid ingestion and inhalation. Do not pressurize, cut, weld, braze, solder, drill, grind, or expose empty containers to heat, sparks or open flames.
Storage: Keep away from heat, sparks, and flame. Keep away from sources of ignition. Store in a tightly closed container. Keep from contact with oxidizing materials. Store in a cool, dry, well-ventilated area away from incompatible substances. Flammables-area. Do not store near perchlorates, peroxides, chromic acid or nitric acid.

Section 8 - Exposure Controls, Personal Protection

Engineering Controls: Use explosion-proof ventilation equipment. Facilities storing or utilizing this material should be equipped with an eyewash facility and a safety shower. Use adequate general or local exhaust ventilation to keep airborne concentrations below the permissible exposure limits.
Exposure Limits

Chemical Name	ACGIH	NIOSH	OSHA - Final PELs
Ethanol	1000 ppm TWA	1000 ppm TWA; 1900 mg/m3 TWA 3300 ppm IDLH	1000 ppm TWA; 1900 mg/m3 TWA

OSHA Vacated PELs: Ethanol: 1000 ppm TWA; 1900 mg/m3 TWA
Personal Protective Equipment
Eyes: Wear appropriate protective eyeglasses or chemical safety goggles as described by OSHA's eye and face protection regulations in 29 CFR 1910.133 or European Standard EN166.
Skin: Wear appropriate protective gloves to prevent skin exposure.
Clothing: Wear appropriate protective clothing to prevent skin exposure.
Respirators: A respiratory protection program that meets OSHA's 29 CFR 1910.134 and ANSI Z88.2 requirements or European Standard EN 149 must be followed whenever workplace conditions warrant a respirator's use.

Section 9 - Physical and Chemical Properties

Physical State: Clear liquid
Appearance: colorless
Odor: Mild, rather pleasant, like wine or whis
pH: Not available.
Vapor Pressure: 59.3 mm Hg @ 20 deg C

Vapor Density: 1.59
Evaporation Rate: Not available.
Viscosity: 1.200 cP @ 20 deg C
Boiling Point: 78 deg C
Freezing/Melting Point:-114.1 deg C
Decomposition Temperature: Not available.
Solubility: Miscible.
Specific Gravity/Density:0.790 @ 20–C
Molecular Formula:C2H5OH
Molecular Weight:46.0414

Section 10 - Stability and Reactivity

Chemical Stability: Stable under normal temperatures and pressures.
Conditions to Avoid: Incompatible materials, ignition sources, excess heat, oxidizers.
Incompatibilities with Other Materials: Strong oxidizing agents, acids, alkali metals, ammonia, hydrazine, peroxides, sodium, acid anhydrides, calcium hypochlorite, chromyl chloride, nitrosyl perchlorate, bromine pentafluoride, perchloric acid, silver nitrate, mercuric nitrate, potassium-tert-butoxide, magnesium perchlorate, acid chlorides, platinum, uranium hexafluoride, silver oxide, iodine heptafluoride, acetyl bromide, disulfuryl difluoride, tetrachlorosilane + water, acetyl chloride, permanganic acid, ruthenium (VIII) oxide, uranyl perchlorate, potassium dioxide.
Hazardous Decomposition Products: Carbon monoxide, irritating and toxic fumes and gases, carbon dioxide.
Hazardous Polymerization: Will not occur.

Section 11 - Toxicological Information

RTECS#:
CAS# 64-17-5: KQ6300000
LD50/LC50:
CAS# 64-17-5:
Draize test, rabbit, eye: 500 mg Severe;
Draize test, rabbit, eye: 500 mg/24H Mild;
Draize test, rabbit, skin: 20 mg/24H Moderate;
Inhalation, mouse: LC50 = 39 gm/m3/4H;
Inhalation, rat: LC50 = 20000 ppm/10H;
Oral, mouse: LD50 = 3450 mg/kg;
Oral, rabbit: LD50 = 6300 mg/kg;
Oral, rat: LD50 = 7060 mg/kg;
Oral, rat: LD50 = 9000 mg/kg;
Carcinogenicity:
CAS# 64-17-5: Not listed by ACGIH, IARC, NTP, or CA Prop 65.

Epidemiology: Ethanol has been shown to produce fetotoxicity in the embryo or fetus of laboratory animals. Prenatal exposure to ethanol is associated with a distinct pattern of congenital malformations that have collecetively been termed the "fetal alcohol syndrome".
Teratogenicity: Oral, Human - woman: TDLo = 41 gm/kg (female 41 week(s) after conception) Effects on Newborn - Apgar score (human only) and Effects on Newborn - other neonatal measures or effects and Effects on Newborn - drug dependence.
Reproductive Effects: Intrauterine, Human - woman: TDLo = 200 mg/kg (female 5 day(s) pre-mating) Fertility - female fertility index (e.g. # females pregnant per # sperm positive females; # females pregnant per # females mated).
Neurotoxicity: No information available.
Mutagenicity: DNA Inhibition: Human, Lymphocyte = 220 mmol/L.; Cytogenetic Analysis: Human, Lymphocyte = 1160 gm/L.; Cytogenetic Analysis: Human, Fibroblast = 12000 ppm.; Cytogenetic Analysis: Human, Leukocyte = 1 pph/72H (Continuous).; Sister Chromatid Exchange: Human, Lymphocyte = 500 ppm/72H (Continuous).
Other Studies: Standard Draize Test(Skin, rabbit) = 20 mg/24H (Moderate) Standard Draize Test: Administration into the eye (rabbit) = 500 mg (Severe).

Section 12 - Ecological Information

Ecotoxicity: Fish: Rainbow trout: LC50 = 12900-15300 mg/L; 96 Hr; Flow-through @ 24-24.3–CFish: Rainbow trout: LC50 = 11200 mg/L; 24 Hr; Fingerling (Unspecified)Bacteria: Phytobacterium phosphoreum: EC50 = 34900 mg/L; 5-30 min; Microtox test When spilled on land it is apt to volatilize, biodegrade, and leach into the ground water, but no data on the rates of these processes could be found. Its fate in ground water is unknown. When released into water it will volatilize and probably biodegrade. It would not be expected to adsorb to sediment or bioconcentrate in fish.
Environmental: When released to the atmosphere it will photodegrade in hours (polluted urban atmosphere) to an estimated range of 4 to 6 days in less polluted areas. Rainout should be significant.

Physical: No information available.
Other: No information available.

Section 13 - Disposal Considerations

Chemical waste generators must determine whether a discarded chemical is classified as a hazardous waste. US EPA guidelines for the classification determination are listed in 40 CFR Parts 261.3. Additionally, waste generators must consult state and local hazardous waste regulations to ensure complete and accurate classification.
RCRA P-Series: None listed.
RCRA U-Series: None listed.

Section 14 - Transport Information

	US DOT	Canada TDG
Shipping Name:	Not reviewed.	No information available.
Hazard Class:		
UN Number:		
Packing Group:		

Section 15 - Regulatory Information

US FEDERAL

TSCA
CAS# 64-17-5 is listed on the TSCA inventory.
Health & Safety Reporting List
None of the chemicals are on the Health & Safety Reporting List.
Chemical Test Rules
None of the chemicals in this product are under a Chemical Test Rule.
Section 12b
None of the chemicals are listed under TSCA Section 12b.
TSCA Significant New Use Rule
None of the chemicals in this material have a SNUR under TSCA.
CERCLA Hazardous Substances and corresponding RQs
None of the chemicals in this material have an RQ.
SARA Section 302 Extremely Hazardous Substances
None of the chemicals in this product have a TPQ.
SARA Codes
CAS # 64-17-5: acute, chronic, flammable.
Section 313 No chemicals are reportable under Section 313.
Clean Air Act:
This material does not contain any hazardous air pollutants.
This material does not contain any Class 1 Ozone depletors.
This material does not contain any Class 2 Ozone depletors.
Clean Water Act:
None of the chemicals in this product are listed as Hazardous Substances under the CWA.
None of the chemicals in this product are listed as Priority Pollutants under the CWA.
None of the chemicals in this product are listed as Toxic Pollutants under the CWA.
OSHA:
None of the chemicals in this product are considered highly hazardous by OSHA.
STATE
CAS# 64-17-5 can be found on the following state right to know lists: California, New Jersey, Pennsylvania, Minnesota, Massachusetts.

California Prop 65
WARNING: This product contains Ethanol, a chemical known to the state of California to cause developmental reproductive toxicity.
California No Significant Risk Level: None of the chemicals in this product are listed.

European/International Regulations
European Labeling in Accordance with EC Directives
Hazard Symbols:
F
Risk Phrases:
R 11 Highly flammable.

Safety Phrases:

S 16 Keep away from sources of ignition - No smoking.
S 33 Take precautionary measures against static discharges.
S 7 Keep container tightly closed.
S 9 Keep container in a well-ventilated place.

WGK (Water Danger/Protection)

CAS# 64-17-5: 0

Canada - DSL/NDSL

CAS# 64-17-5 is listed on Canada's DSL List.

Canada - WHMIS

This product has a WHMIS classification of B2, D2A.

Canadian Ingredient Disclosure List

CAS# 64-17-5 is listed on the Canadian Ingredient Disclosure List.

Section 16 - Additional Information

MSDS Creation Date: 7/27/1999
Revision #4 Date: 3/18/2003

The information above is believed to be accurate and represents the best information currently available to us. However, we make no warranty of merchantability or any other warranty, express or implied, with respect to such information, and we assume no liability resulting from its use. Users should make their own investigations to determine the suitability of the information for their particular purposes. In no event shall Fisher be liable for any claims, losses, or damages of any third party or for lost profits or any special, indirect, incidental, consequential or exemplary damages, howsoever arising, even if Fisher has been advised of the possibility of such damages.

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Specifications Subject to Change without Notice

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