Rigaku

Metal Film Monitor

MFM65

(Model : MFM65S2RFFFTFT)

Instruction Manual

2. Maintenance 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.

USA

Rigaku Americas Corporation
9009 New Trails Drive
The Woodlands, TX 77381
USA

Tel : +1-281-363-1033
Fax: +1-281-364-3628
URL:http://www.Rigaku.com

JAPAN

Rigaku Corporation
Semiconductor Instruments Division
3-9-12 Matsubara-cho,
Akishima-shi,
Tokyo 196-8666, JAPAN

Tel : +81-42-545-8102
Fax: +81-42-54-0310
URL:http://www.rigaku.co.jp

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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.
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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.



Contents

1. OVERVIEW 1

2. SAFETY 2
2.1 Hazards and Risks 2
2.2 Hazard Indications 5
2.3 Interlock List 9
2.4 Lock-out / Tag-out 11
2.5 EMO 12
2.6 Maintenance Keys 12

3. CONFIGURATION 13
3.1 MFM65 External Figure 13
3.2 MFM65 Configuration Block Diagram 16
3.3 Functions 17
3.4 Software Configuration 18
3.5 Hardware Specifications 19
3.6 Explanation of Software 21
3.7 Utility Specifications 22

4. START UP 26

5. SHUTDOWN 27

6. DAILY CHECKS 28

7. DAILY ANALYSIS 29

8. EDIT RECIPE 30
8.1 Display the Edit Recipe Screen 30
8.2 Edit Recipe 31
8.2.1 Process Recipe 32
8.2.2 Analysis recipe 34
8.2.3 Wafer map recipe 40
8.2.4 Pattern map recipe 42

9. MANUAL OPERATION 50
9.1 Operation in the Chart Screen 51
9.2 [EFEM] Control 52
9.3 [Optics1] ~ [Optics3]Control 54
9.4 [Manual] Control 55
9.5 [Sequence Test] Control 57
9.6 [MFM Status] Control 58

10. SETUP 59
10.1 EFEM Settings 60
10.2 Optics Setup 61

11. DATA LOG 64

12. ALARMS 66

13. ROUTINE CHECKUP LIST 67
13.1 Checking cooling water, CDA and vacuum 69
13.2 Cleaning of the transport line 70

14. MAINTENANCE 71
14.1 Power Box 71
14.2 Using the handy light 72
14.3 Utility Adjustment 73
14.4 Exchanging Parts 74
14.4.1 Cooling Water 74
14.4.2 UPS Battery 75
14.4.3 Accessories of PC 76

15. TROUBLE SHOOTING 77
15.1 Electric Power 77
15.2 Startup 78
15.3 Beam Diagnosis 80
15.4 Loadport 81
15.5 Wafer Transfer 82
15.6 Sample Alignment 83
15.7 XRR/XRD Measurement 84
15.8 XRF Measurement 85
15.9 X-ray Trouble 86

APPENDIX 1 87
A1.1 Consumables and Maintenance Parts 87
A1.2 Disposing the Equipment and parts 89

APPENDIX 2 90
A2.1 Explanation of XRR (X-ray reflectometry method) 90
A2.2 Analysis/Measurement Flow 93

APPENDIX 3 95
A3.1 Training for Using Equipment 95

APPENDIX 4 96
A4.1 Power Circuit Diagram 96
A4.2 EMO Circuit 98

APPENDIX 5 99
A5.1 List of Material Safety Database Sheet (MSDS) 99
A5.2 MSDS of Beryllium 100
A5.3 MSDS of Lead 111
A5.4 MSDS of Lithium 112
A5.5 MSDS of Mercury 115
A5.6 MSDS of Mechanical Lubricating Grease 121
A5.7 MSDS of Ethanol 128

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1. OVERVIEW

This manual describes the user's maintenance of the MFM65 system (model RRMWSFT Model).

Maintenance items except for descriptions in this manual should be performed by RIGAKU service personnel in charge.

General information about the MFM65 system and its operation is found in a separate Operations Manual.

NOTE : 

If the MFM65 system is modified without consulting RIGAKU, the system may not satisfy the systems specifications, and RIGAKU does not warrant the modified 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 potential hazards and risks as follows.

(1) X-ray Hazards

WARNING



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

WARNING



When performing maintenance inside the access panels where electrical hazard has any potential of causing personal injury or damage to the system, strictly follow **lock-out/tag-out** procedure of the instrument before starting the maintenance work.

(Refer to "2.4 Lock-out/Tag-out".)

Some electrical charge may remain in the capacitor of the HV transformer, and electric shock may occur when the HV cable contacts are touched during cleaning.

Do not disconnect the HV cables of the X-ray generators, and contact Rigaku Service personnel.

If any fuse blows or if a thermal relay trips frequently in the instrument, its peripherals, or main power supply, then stop using the equipment. Turn the power off, and lock and tag the power in the "Off" position from the main Power Box, **Contact trained maintenance personnel or the Rigaku Service center**.

(3) Laser Hazards

NOTE



This instrument uses a wafer aligner which is an FDA Class 1 laser product (λ : 780 nm, Pmax. : 1.7 mW, Mode : Continuous).

The MFM65 system has no risk of laser exposure during normal operation because this system has a complete enclosure shield for laser light and interlock to avoid laser exposure.

(Refer to “2.3 Interlock List”.)

(4) Mechanical Hazards

WARNING



Be sure that the power switch is off when maintenance within the equipment is attempted. However, during the adjustment of some components, the power must be on. In this case, take due care to avoid injury from mechanical parts.



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

NOTE



When heavy parts or units are removed, for example a PC or an X-ray tube shield, lift these objects with a coordinated effort by 2 or more persons.

(5) Material Hazards

WARNING



Metal beryllium foil is used for the windows of X-ray tubes and X-ray detectors (APD, SDD). Solid beryllium usually has no influence on human health, but evidence exists that the person who inhales the beryllium powder or vapor risks a possibility of serious injury or death. Do not scratch, polish, and chemically clean beryllium foil, nor bake up to temperature so as to generate vapor or powder. In case that beryllium window is ruptured, do not touch chips of the beryllium window, and **contact Rigaku Service personnel.**

Then dispose them according to local regulations.

(Refer to the attached MSDS.)

WARNING



Lead is used in the sealed maintenance-free built-in battery of the UPS.

Do not break up the battery when it is replaced.

Dispose of batteries according to local regulations.

(Refer to the attached MSDS.)

WARNING



Mechanical lubricating grease is used in this equipment.

This grease usually has no influence on human health, but dispose according to regulations and local regulations.

(Refer to the attached MSDS.)

WARNING



Other toxic substances in the MFM65 system are lithium compound and mercury compound.

A lithium compound is used in the built-in batteries of X-ray hour meter and PC.

A mercury compound is used in the fluorescent light for maintenance.

These materials usually have no influence on human health, but dispose of them according to local regulations.

(Refer to the attached MSDS.)

WARNING



Ethanol of the customer's FAB may be used to clean the transfer line by the maintenance personnel.

(Refer to the attached MSDS.)

(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

CAUTION



A halogen lamp is used in the light unit for pattern recognition.

Do not touch before cooling.

Wear safety gloves, when lamp exchanging this lamp.

(8) Trip Hazards

CAUTION



The PC rack in the left lower side of the main module can be pulled out for the maintenance.

Take care not to trip over it.

2.2 Hazard Indications

(1) Labels for hazard indications

The MFM65 system has the following labels for hazard indications.

1	X-ray Hazard



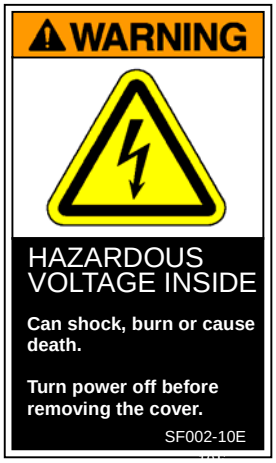
2	X-ray Hazard



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

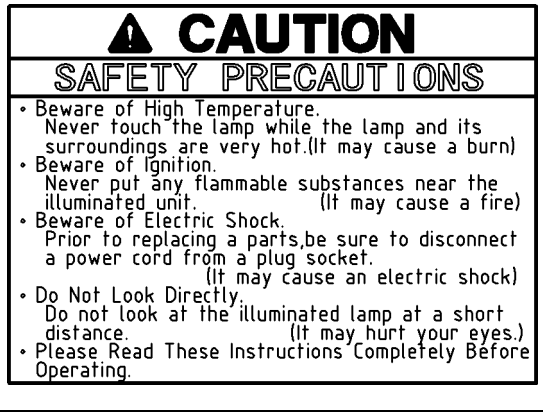


Fig. 2-2-2 Hazard Labels 2

The locations of the hazard indication labels are shown in the following figure.

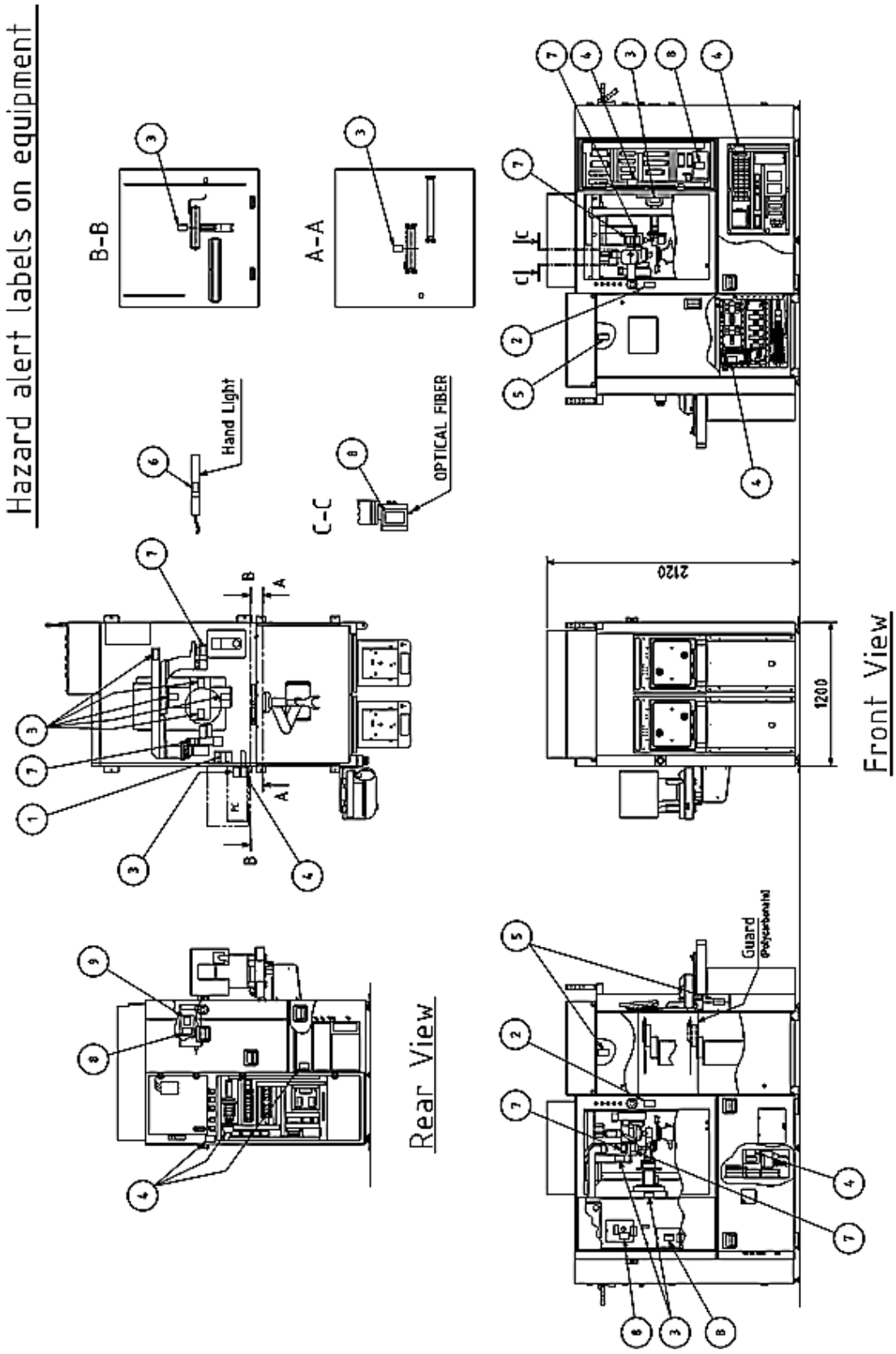
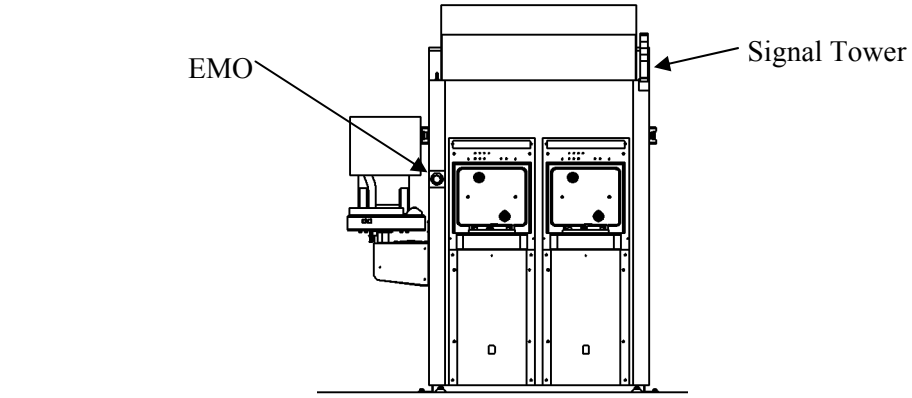
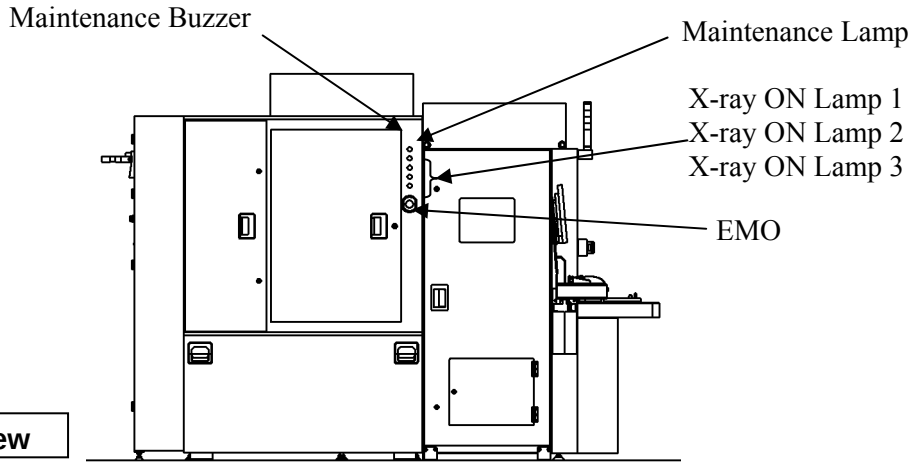


Fig. 2-2-3 Locations of Hazard Indication Labels

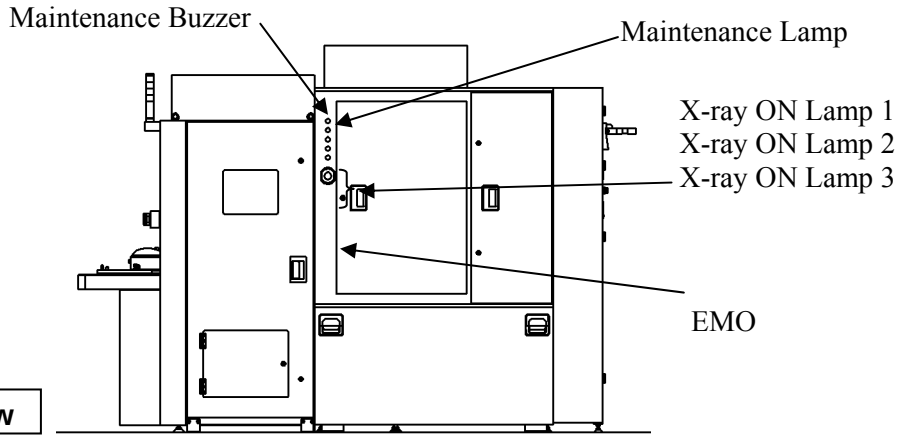
(2) Signal Towers and Buzzers



Front View



Left View



Right View

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 “A4.1 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.

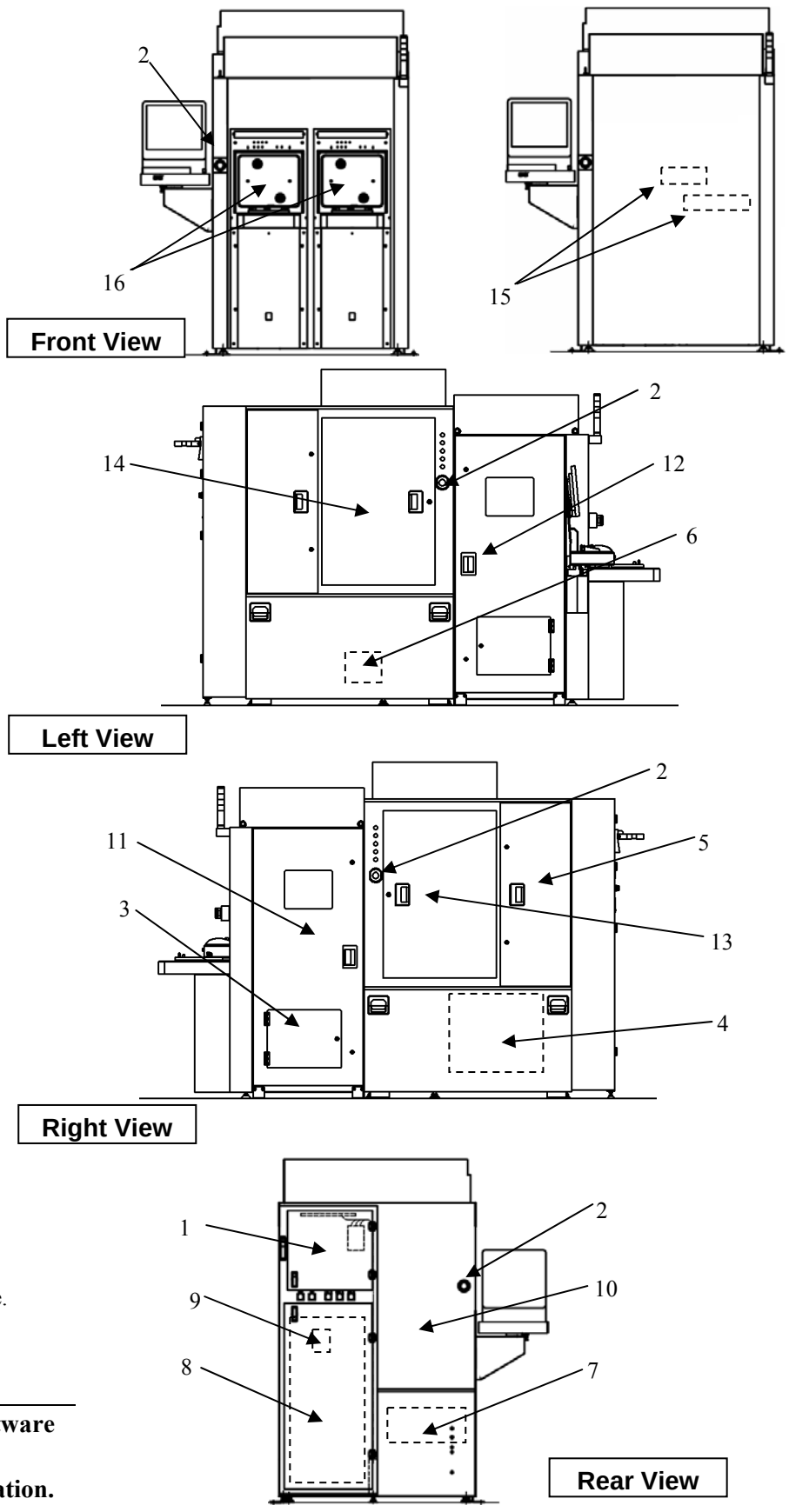


Fig. 2-3-1 Interlock Locations

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

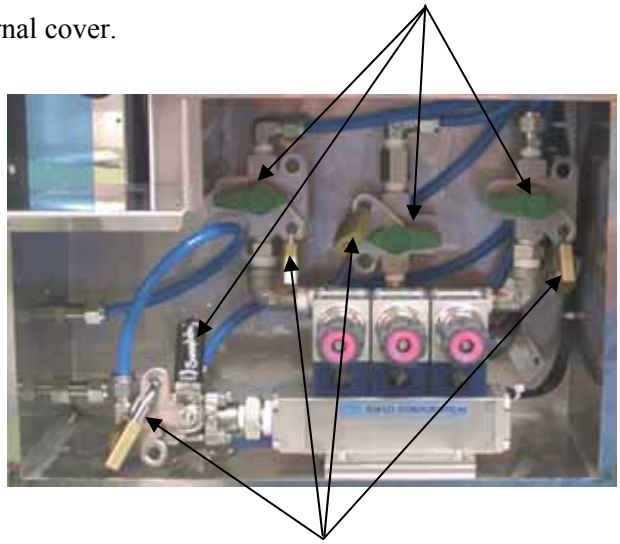
Fig. 2-4-1 Lock-out Handle

(2) The cooling water lock-out

1. Open the lower panel on the left side.
2. Remove the internal cover.

.

3. Close the bulbs



4. Lock-out the bulbs.

Fig. 2-4-2 Water Lock-out

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 the 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]

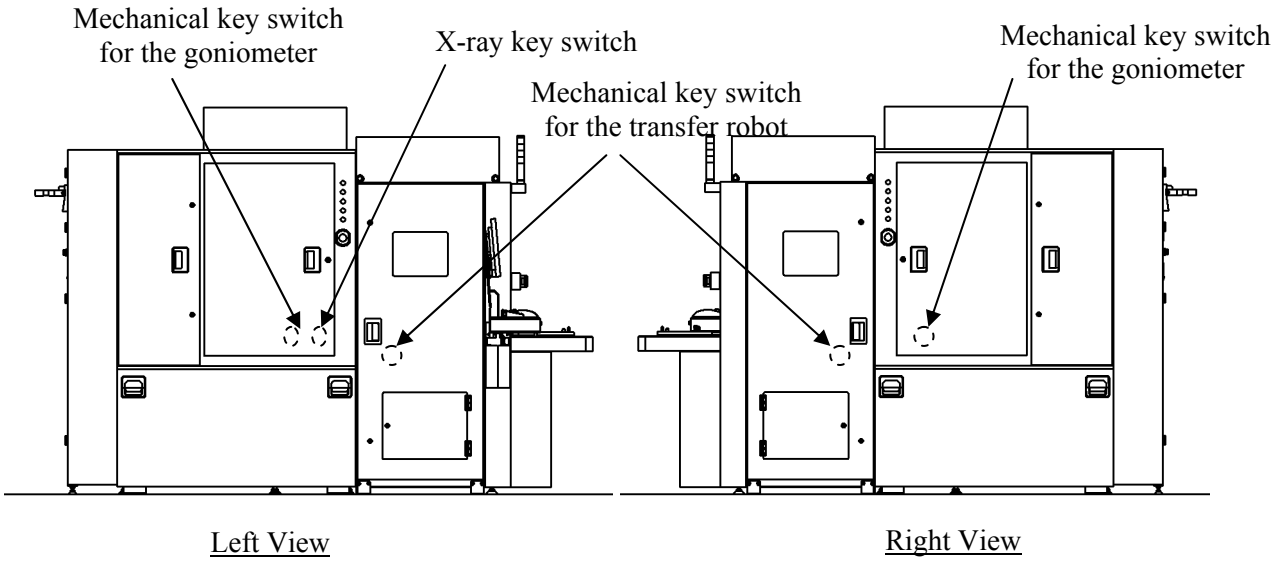


Fig. 2-6-1 Maintenance Key Locations

3. CONFIGURATION

3.1 MFM65 External Figure

[External Figure]

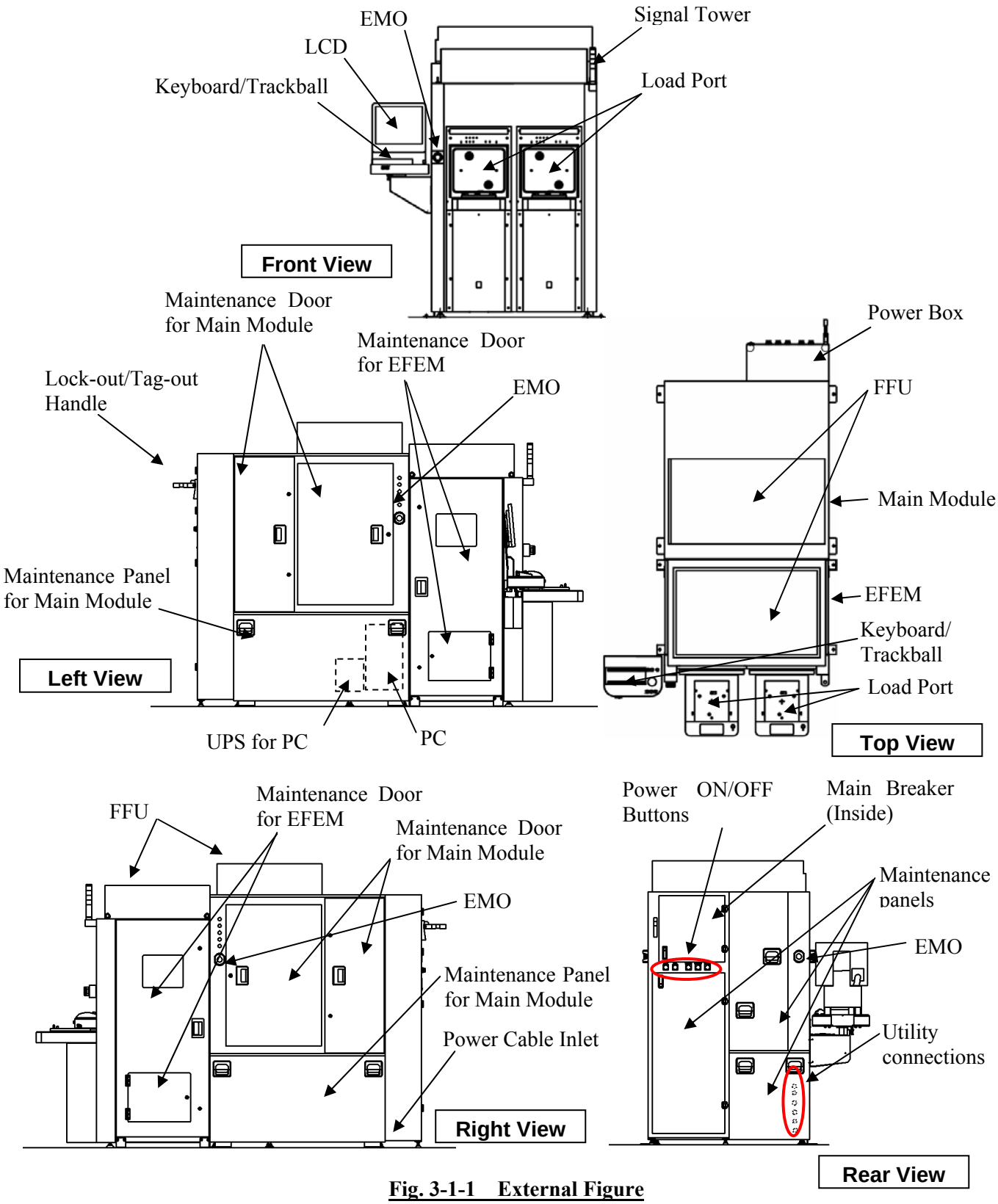
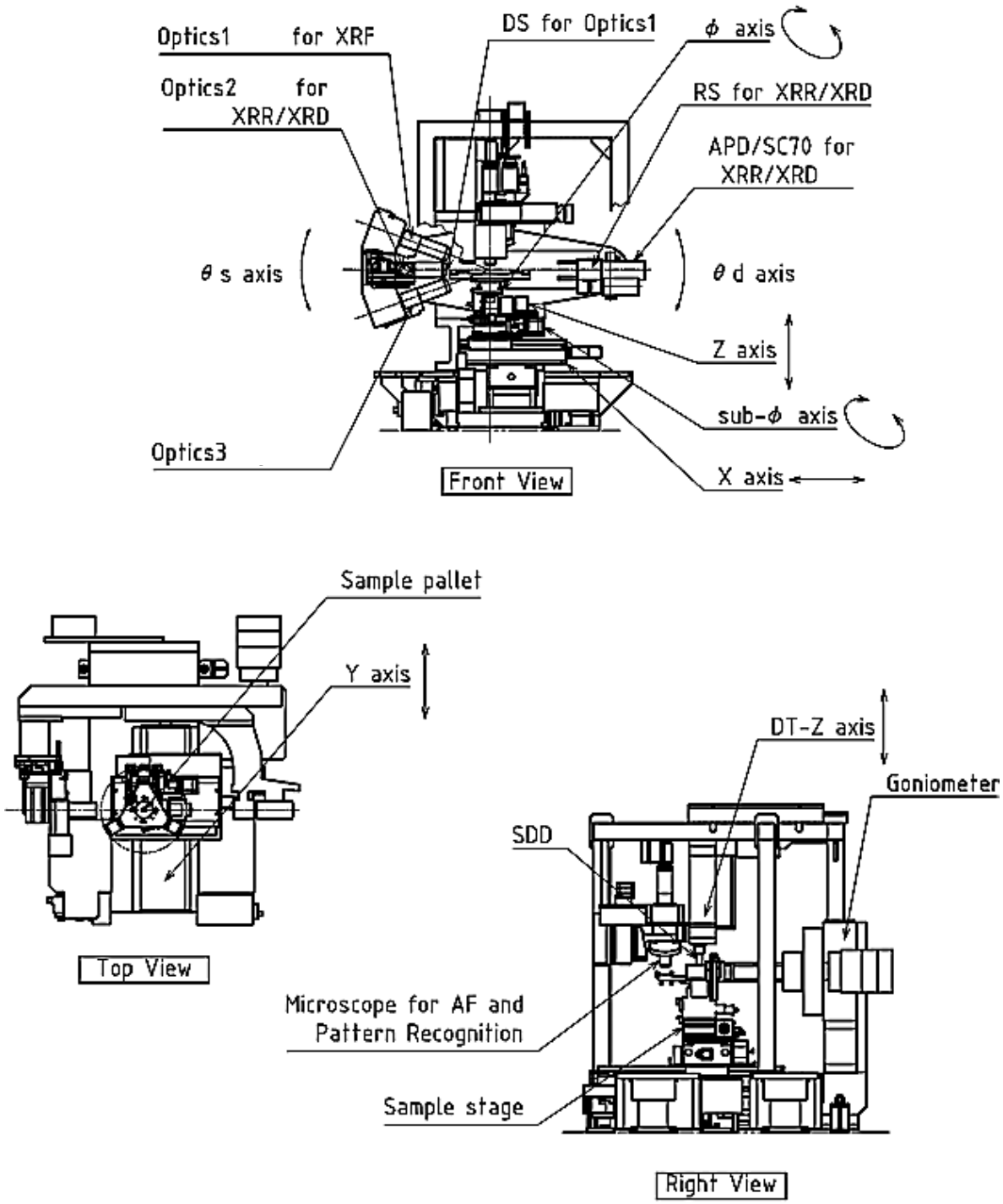


Fig. 3-1-1 External Figure

[Goniometer Figure]



[EFEM Figure]

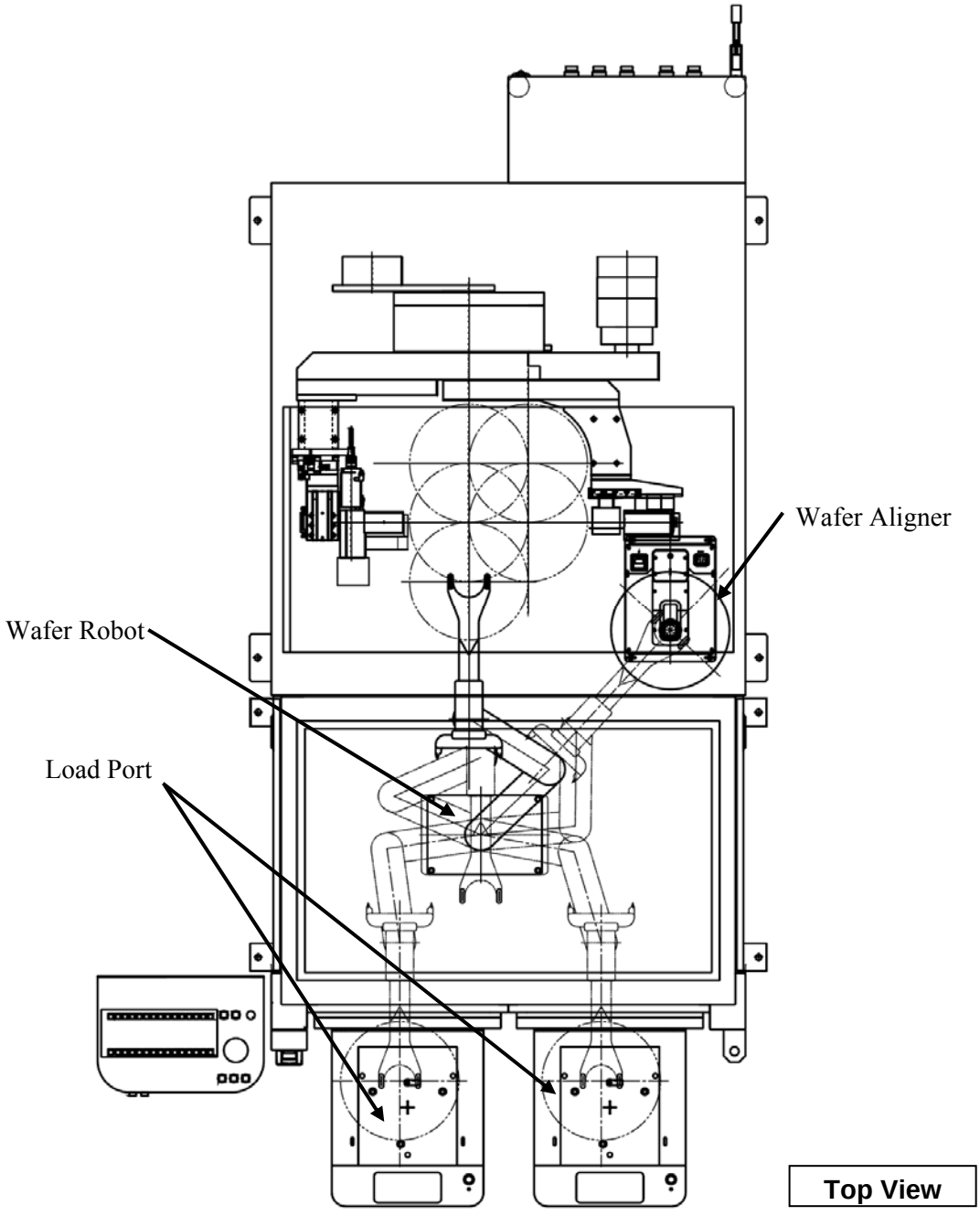


Fig. 3-1-3 EFEM Figure

3.2 MFM65 Configuration Block Diagram

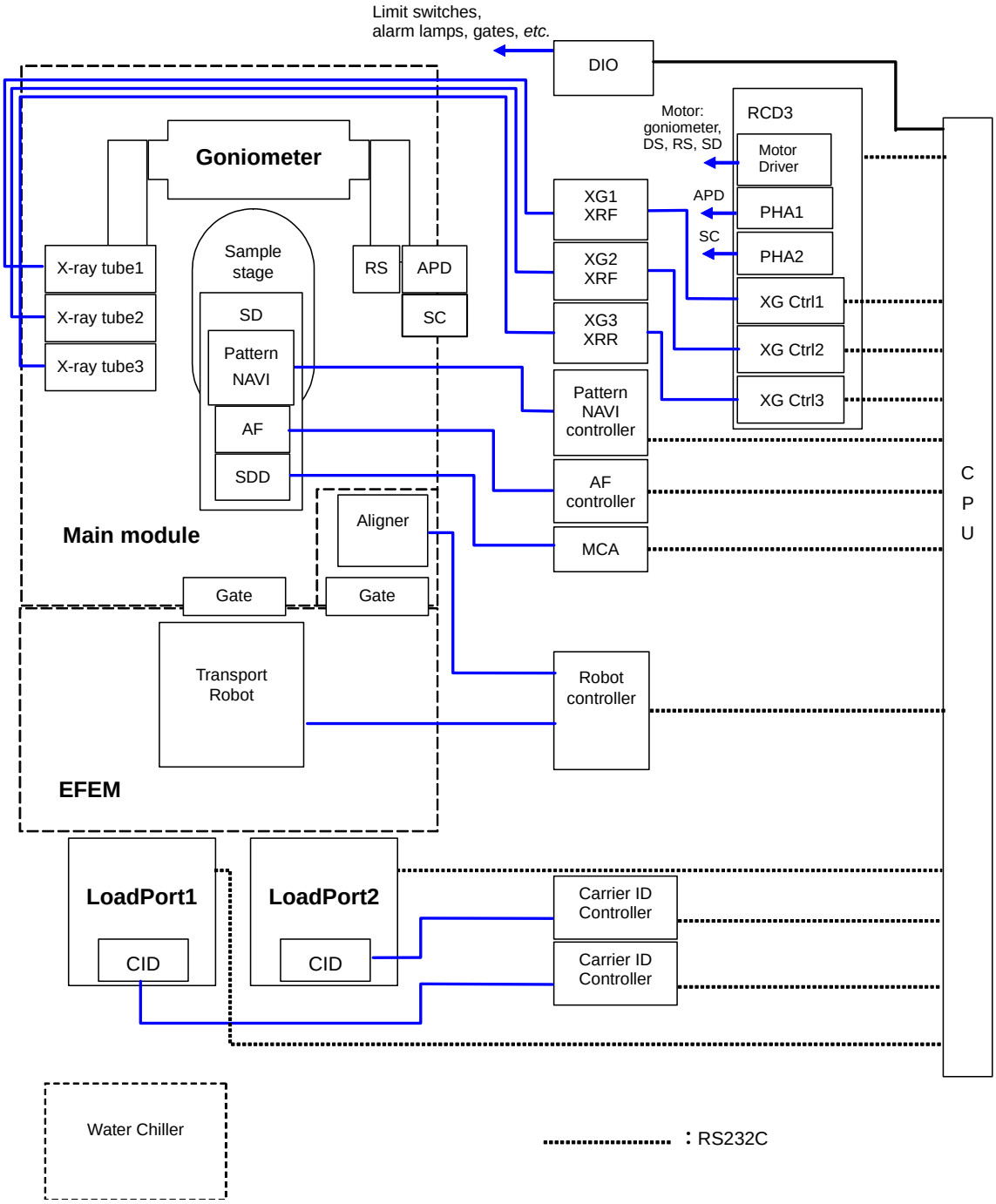


Fig. 3-2-1 Configuration Block Diagram

NOTE : Refer to the “A4.1 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 (0 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 XRF1	Mo target sealed tube 25 W 4-corner CMF mirror
	X-ray source For XRF2	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

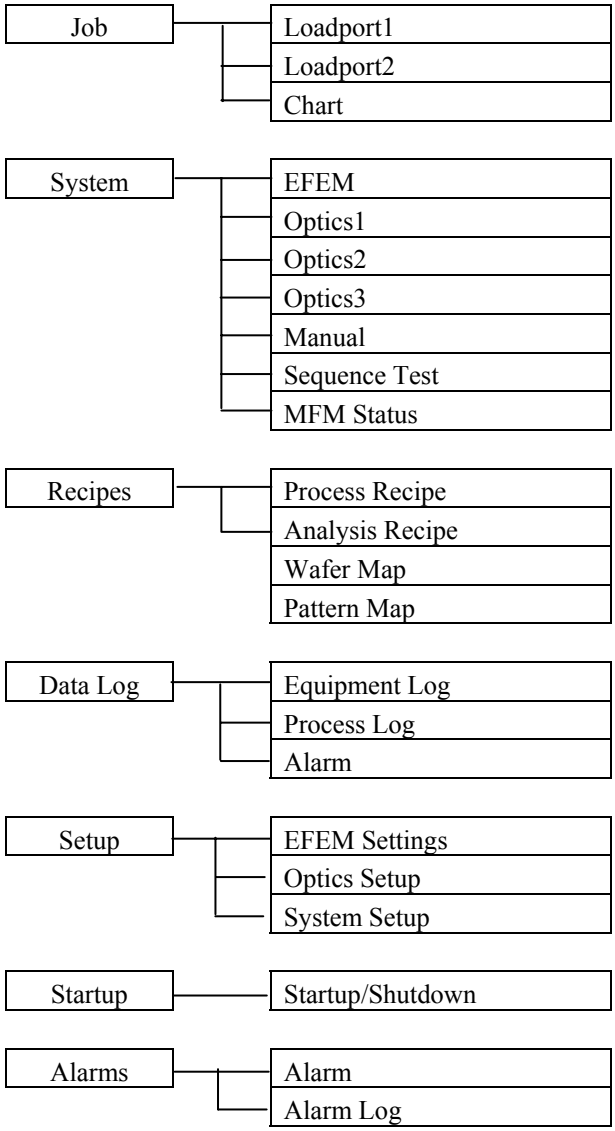


Fig. 3-4-1 Software Block Diagram

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 (XRF)	
Maximum power	40 W (50 kV, 0.8 mA)
Target	**Cr** (Max. 125 W, (40 kV, 0.3 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	**Au** (Max. 20 W, (50 kV, 0.4 mA))
Focus size on tube target	ϕ40 μm
Alignment mechanism	Manual alignment for X-ray tube position.
X-ray Generator 3 (Optional 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	ϕ85 μm
Alignment mechanism	Manual alignment for X-ray tube position.
Incident Optics 1 (XRF)	
Monochromator	Four-corner multi-layer mirror unit
X-ray beam size	ϕ40 μm
Alignment mechanism	Fine adjustment with screws (manual operation)
Incident Optics 2 (XRF)	
Monochromator	Four-corner multi-layer mirror unit
X-ray beam size	ϕ40 μm
Alignment mechanism	Fine adjustment with screws (manual operation)
Incident Optics 3 (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)
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)	– 5 to 60 degrees 0.001 degree/step
θd axis (Detector mounted)	– 5 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)	0 to 300 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.
	Optics3	Sets x-ray power for optics 3.
	Manual	Operates actuators of this equipment manually.
	Sequence Test	Tests the sequence of recipes.
	MFM Status	Displays the equipment conditions visually.
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.

3.7 Utility Specifications

Power Supply						
		Volt.	**Phase**	**Frequency**	**Amp.**	**Remarks**
(1)	**Main module**	208 V	3	60 Hz	20 A	
(2)	**Water chiller**	208 V	1	60 Hz	10A	
(3)	**CPU, Controller**	Supplied through main module after stepping down. Power for CPU is supplied by means of a UPS.				
(4)	**Grounding**	Less than 10 ohm. Independent.				
(5)	**Other Specifications**	Frequency stability ±1% Voltage stability ±10% No surge or noise from other tool connected in the same power line. (Ampere Interrupting Capacity (AIC) of the main interrupting circuit > 10,000 A) The power cable to the main breaker : AWG4 4C (R22-8) (3 lines for the 208 V phases and 1 line for grounding.)				
Cooling Water						
Primary		**Pressure**	**Flow rate**	**Connector**		**Remarks**
(1)	**Water chiller**	0.1 – 0.5 MPa	7 L/min	3/8” SUS joint		20 – 25 ºC
Secondary		**Pressure**	**Flow rate**	**Temp.**		**Remarks**
(2)	**X-ray tube**	0.1 – 0.5 MPa	> 1.5 L/min	24 ºC		(Internal connections)
Gas (Air)						
		Pressure	**Flow rate**	**Connector**		**Remarks**
(1)	**Compressed Dry Air**	0.5 – 0.7 MPa	1 L/min	1/4” SUS joint		For air cylinder operations
Vacuum						
		Pressure	**Flow rate**	**Connector**		**Remarks**
(1)	**Vacuum**	-80 kPa	20 L/min	3/8” SUS joint		For wafer transfer and chuck
Air Exhaust						
		Pressure	**Flow rate**	**Connector**		**Remarks**
(1)	**Air**	-----	-----	1/4” SUS joint		For air cylinder exhaust. (Connect, if necessary.)
LAN Cable						
		Remarks				
(1)	**Host Communication**	The length of a LAN calbe should be 20m or shorter. When a LAN cable longer than 20m is necessary, a HUB should joint LAN calbels to relay each cable.				

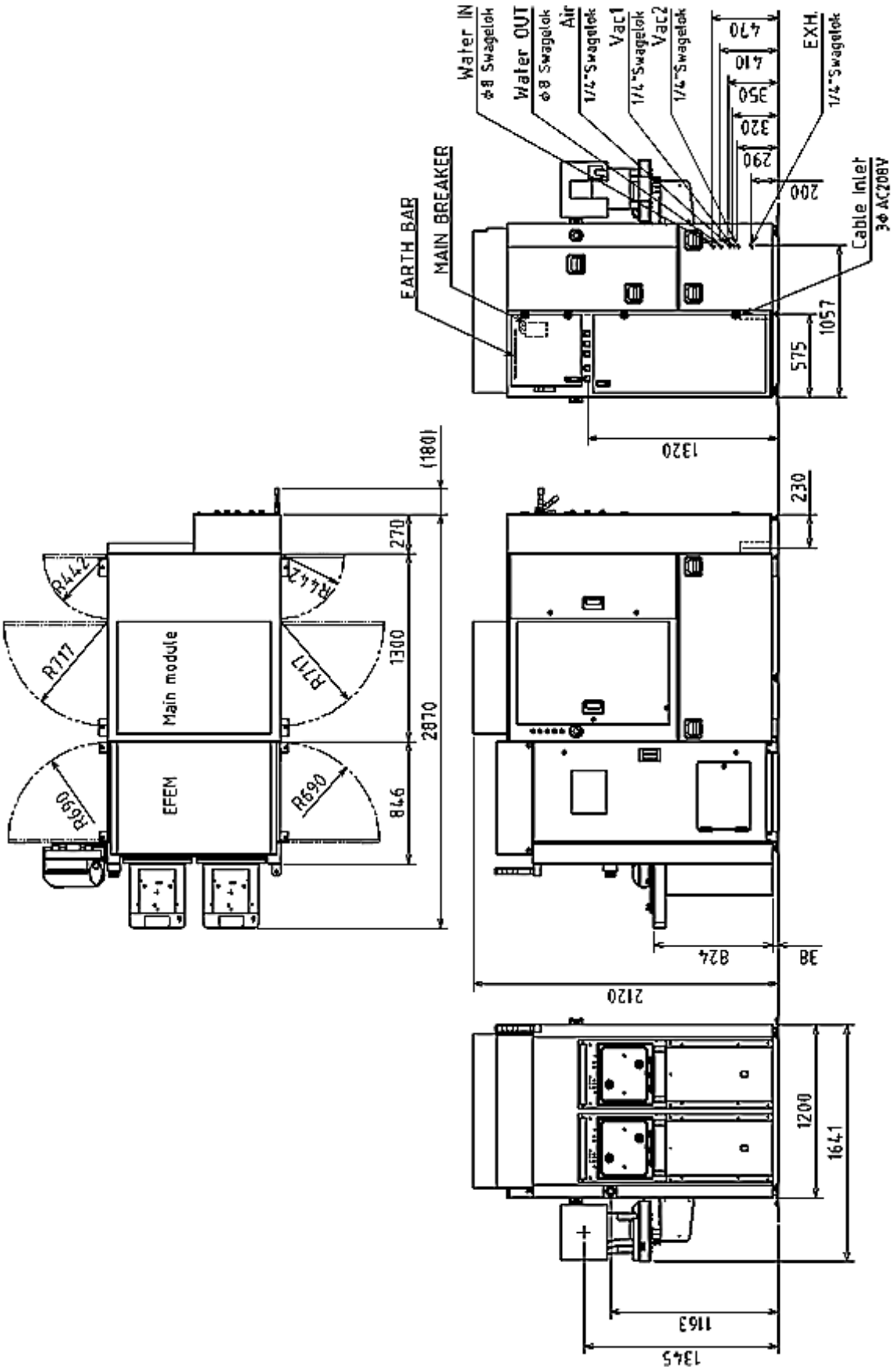


Fig. 3-7-1 Utility Figure



Fig. 3-7-2 Cable Inlet

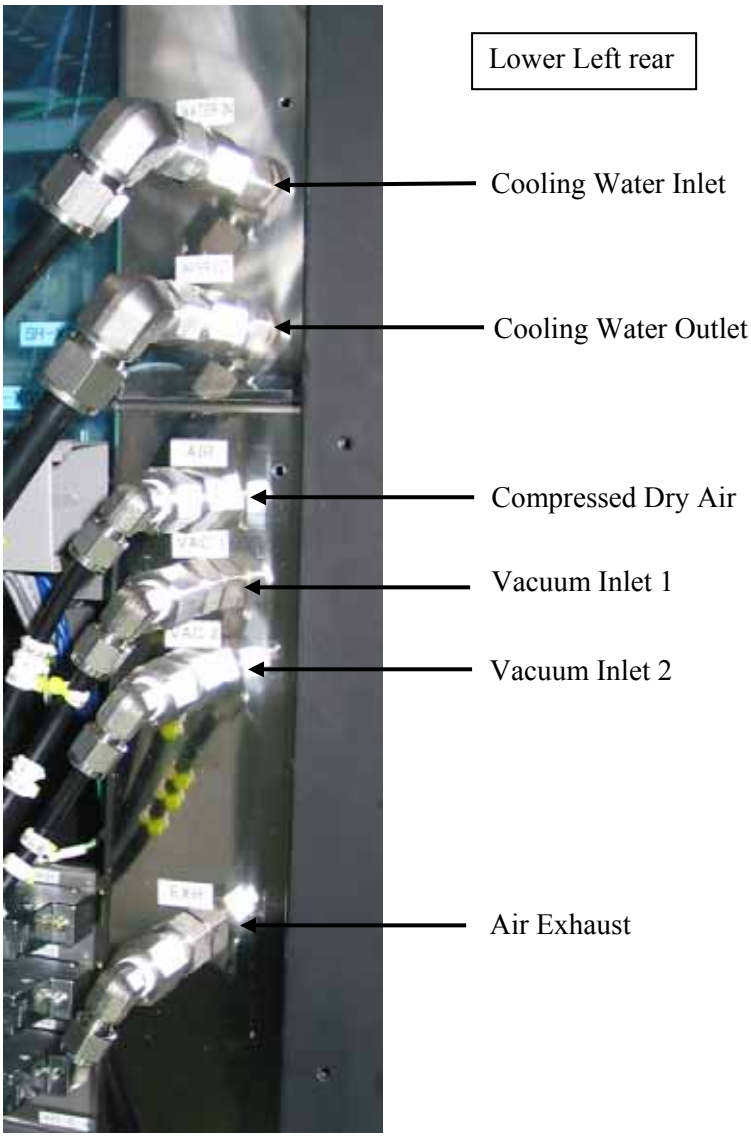


Fig. 3-7-3 Hose Inlet

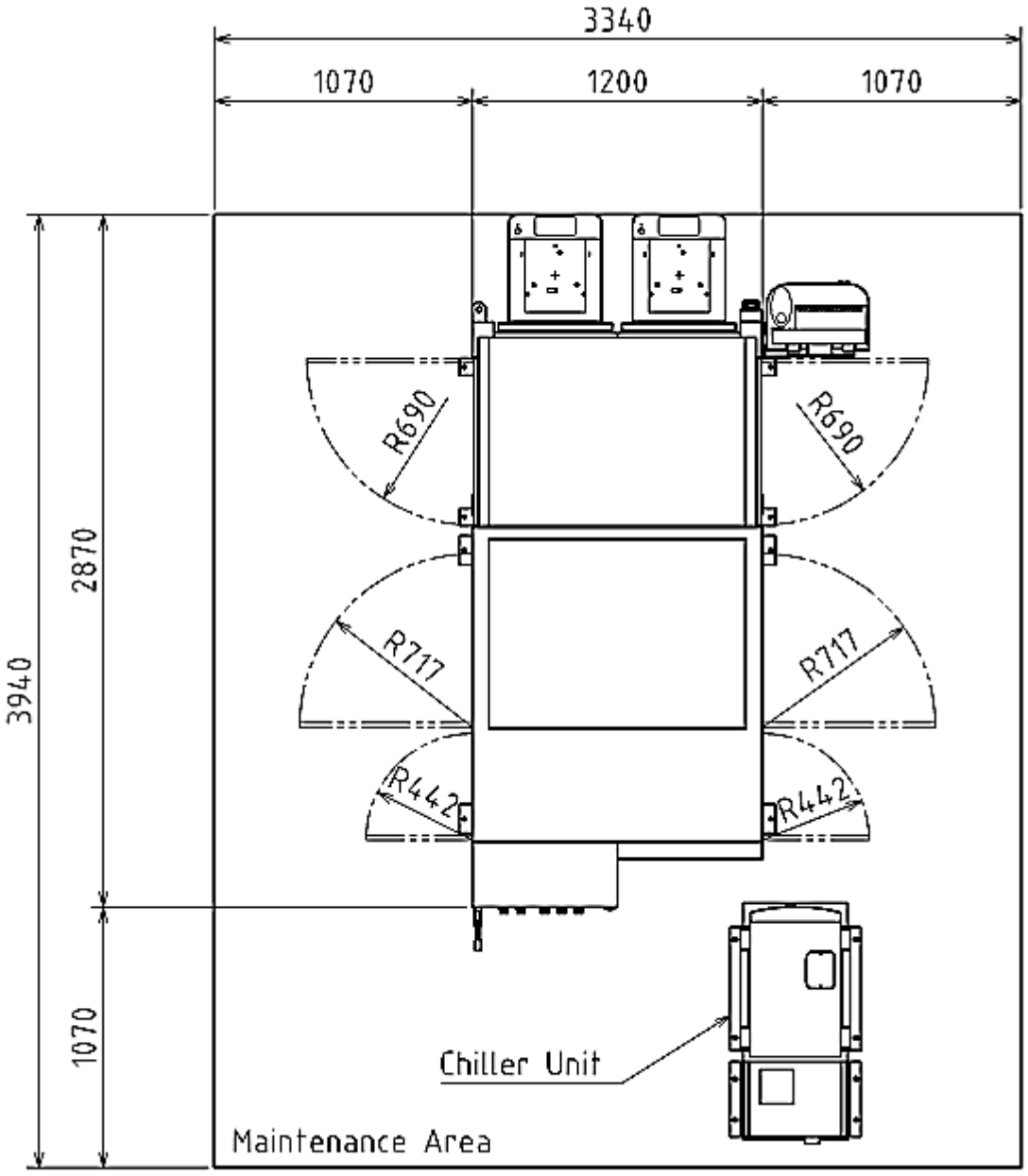


Fig. 3-7-4 Layout Figure

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

See the operation manual for details.

5. SHUTDOWN

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

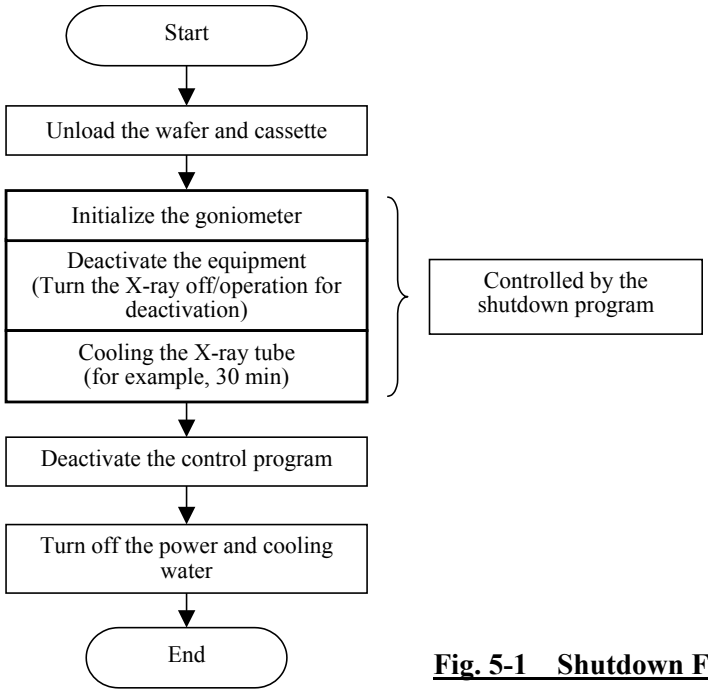


Fig. 5-1 Shutdown Flow

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.

See the operation manual for details.

6. DAILY CHECKS

Check the following points in daily operation:

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

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

(3) Measure the check sample.

Others,

(4) Check for unusual noise or odor.

See the operation manual for details.

7. DAILY ANALYSIS

The [Jobs]-[job] sub navigation button is available for the daily analysis in the measurement software. About the daily analysis, see the operation manual.

8. EDIT RECIPE

In this equipment, measurement conditions and data analysis conditions can be selected by selecting a recipe.

This function enables measurement conditions and mapping conditions to be selected and edited.

Use the off-line utility software program "XRR: GXRR software", "XRF: XRFbatch software" or "XRD: XRDbatch software", when creating each data process condition.

(See each software's manual.)

(1) XRR Measurement Condition

(2) XRF Measurement Condition

(3) XRD Measurement Condition

(4) Wafer Mapping Condition

(5) Pattern Mapping Condition

8.1 Display the Edit Recipe Screen

Click **[Recipes]** among the navigation buttons.

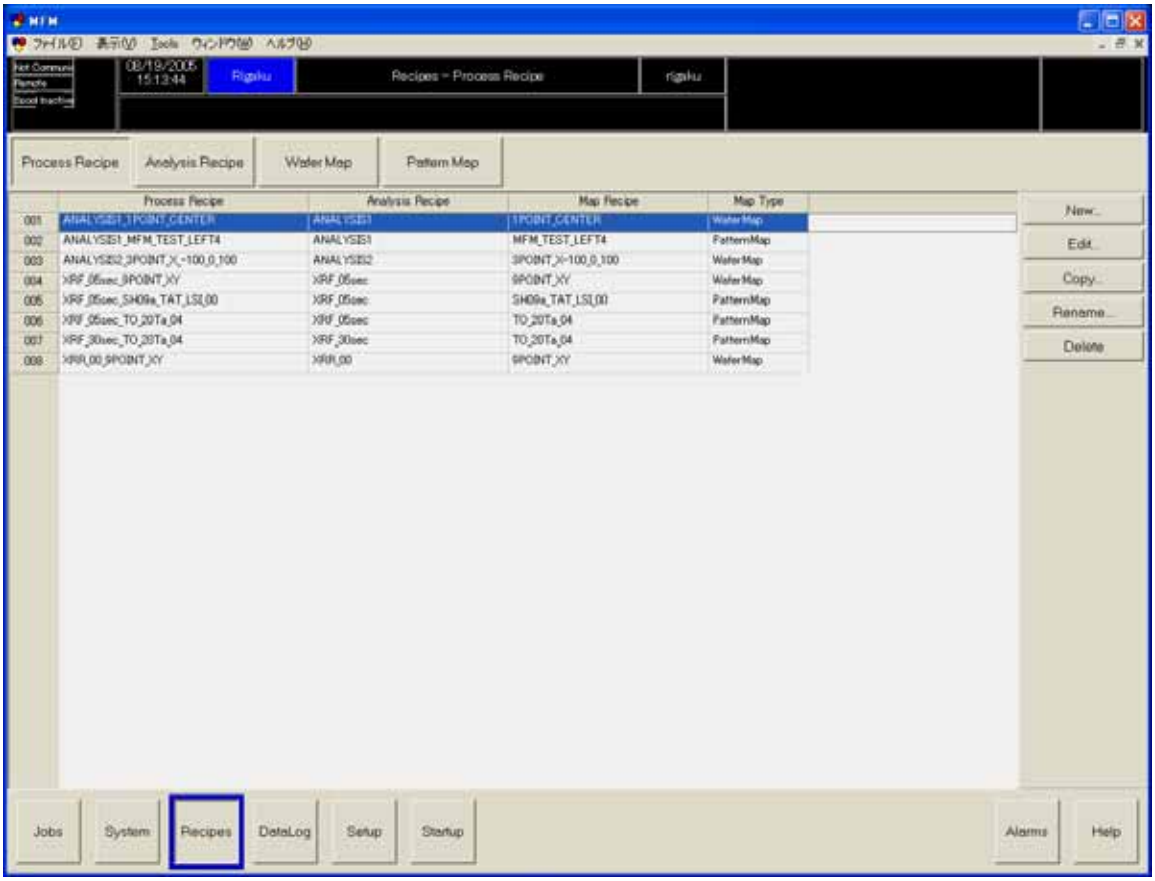


Fig. 8-1-1 Edit Recipe

8.2 Edit Recipe

There are four kinds of recipes in this software as below.

(1)	Process recipe	This recipe is specified and executed in Jobs. This recipe consists of an existing analysis recipe and an existing map recipe which is a wafer map recipe or pattern map recipe.
(2)	Analysis recipe	XRR/XRF/XRD measurement and data process conditions at an arbitrary point on a wafer.
(3)	Wafer map recipe	Measurement points on a non-patterned wafer. A point is specified by the x-y or r-ϕ coordinates on a wafer.
(4)	Pattern map recipe	Measurement points on a patterned wafer. A point is specified by the pattern recognition process.

8.2.1 Process Recipe

Click **[Process Recipe]** among the sub-navigation buttons.

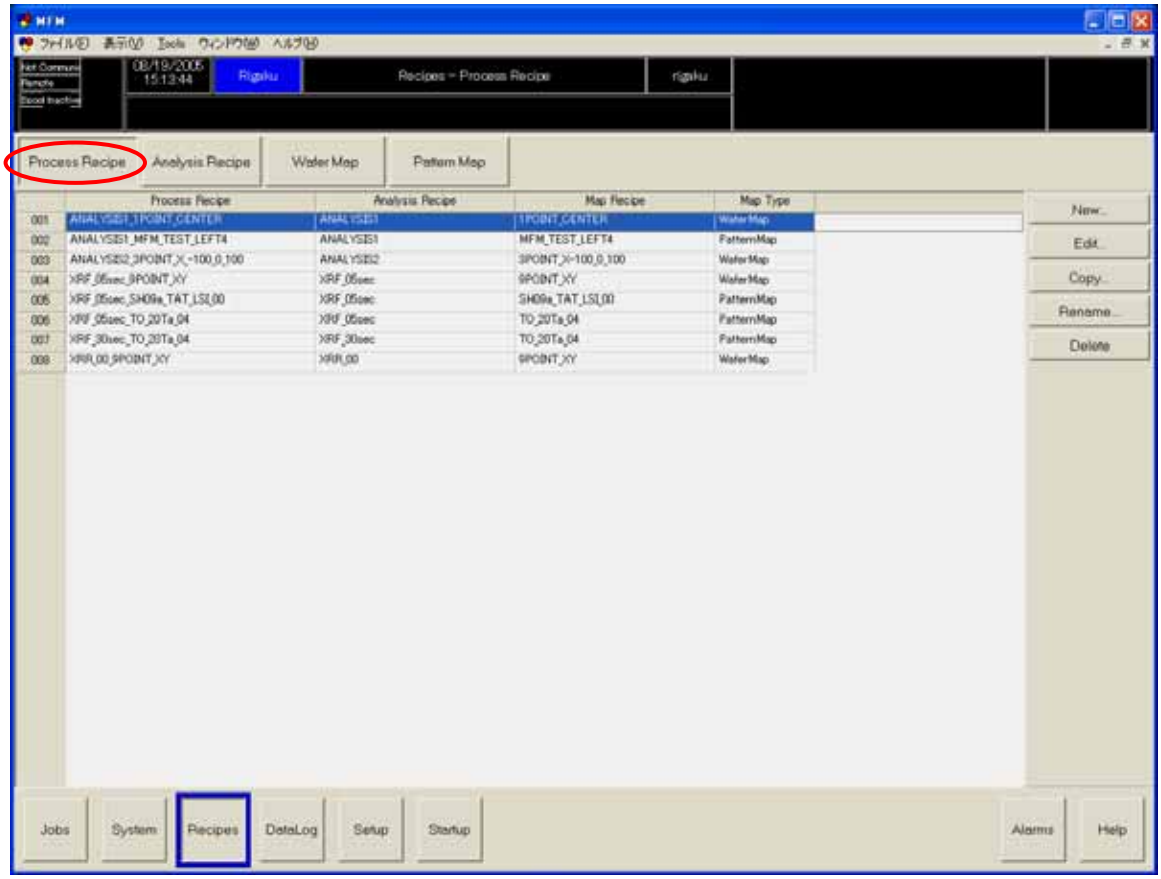


Fig. 8-2-1 Process Recipe Button

Items	Contents	Notes
New	Create a new recipe.	See the following dialog box.
Edit	Edit an existing recipe.	See the following dialog box.
Copy	Copy the specified recipe in the table.	
Rename	Rename the specified recipe in the table.	
Delete	Delete the specified recipe in the table.	

When clicking **[New]** or **[Edit]** button, the following **"Create Process Recipe"** dialog box appears.

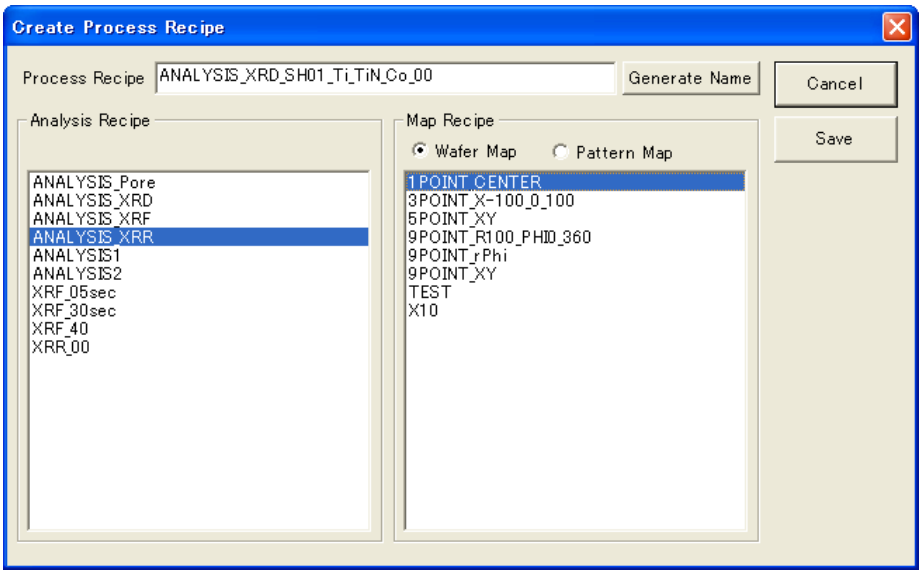


Fig. 8-2-2 Create Process Recipe dialog box

Items	Contents	Notes
Process Recipe	Enter the name of process recipe.	
Generate Name		
Analysis Recipe	Choose an analysis recipe in the list box.	
Map Recipe	Choose a map recipe in the list box.	
Wafer Map	Wafer map recipes are displayed into the list box.	(Radio button)
Pattern Map	Pattern map recipes are displayed into the list box.	(Radio button)
Save	Save the process recipe.	

NOTE : Click the [Save] button, when editing is completed.

If the dialog box is closed without clicking on this button, the recipe is not changed.

8.2.2 Analysis recipe

Click **[Analysis Recipe]** among the sub-navigation buttons.

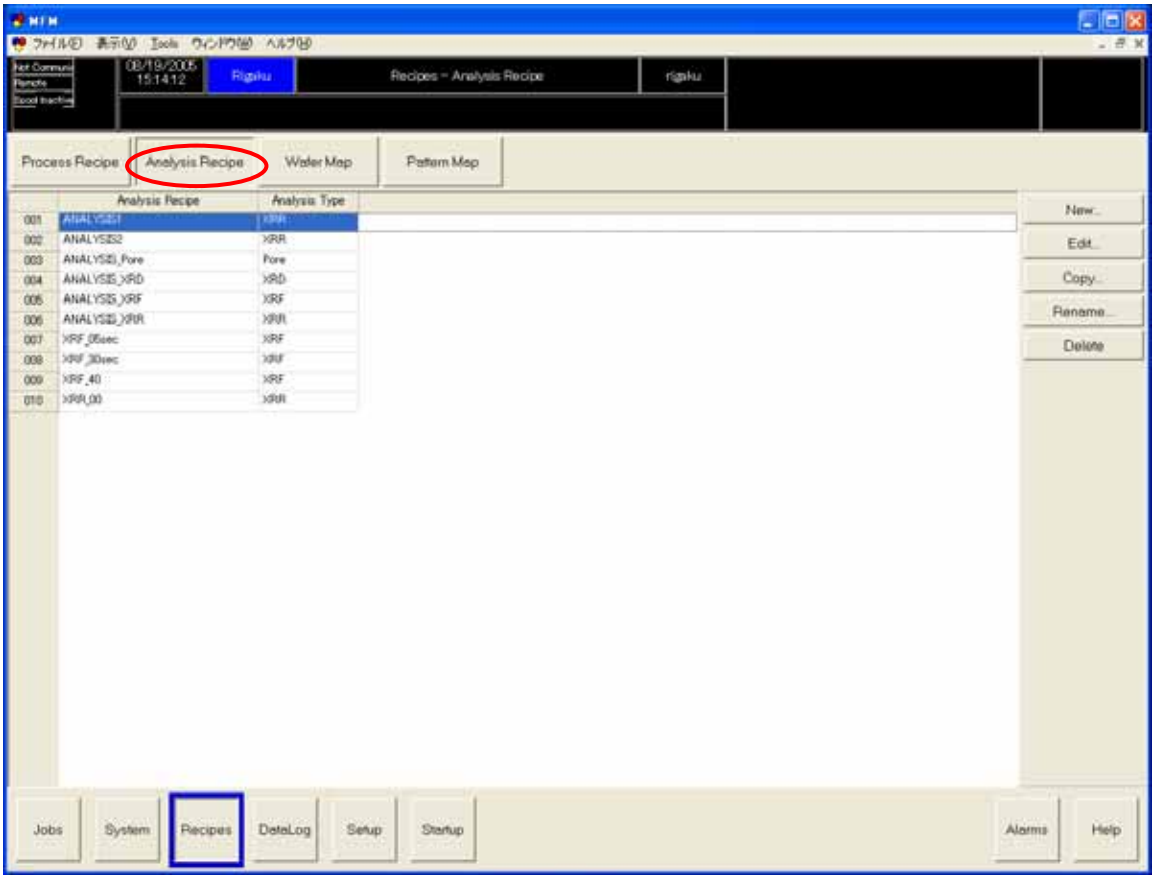


Fig. 8-2-3 Analysis Recipe Button

Items	Contents	Notes
New	Create a new recipe.	See the following dialog box.
Edit	Edit an existing recipe.	See the following dialog box.
Copy	Copy the specified recipe in the table.	
Rename	Rename the specified recipe in the table.	
Delete	Delete the specified recipe in the table.	

When clicking **[New]** or **[Edit]** button, the following **"Create Analysis Recipe"** dialog box appears.

(1) XRR Recipe

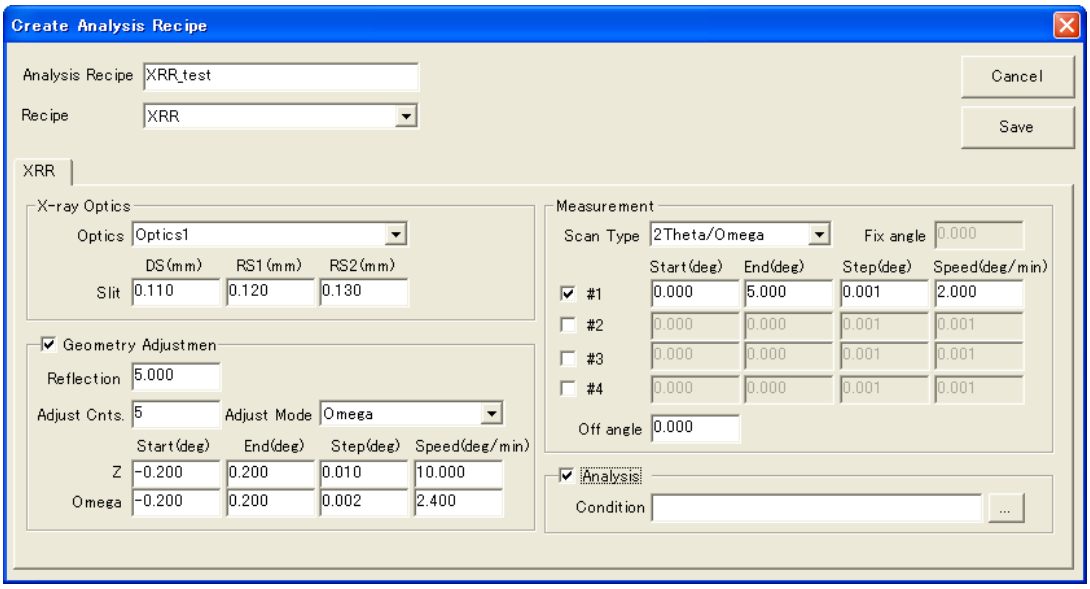


Fig. 8-2-4 Create Analysis Recipe (XRR) dialog box

Items	Contents	Notes
Analysis Recipe	Enter the name of analysis recipe.	
Recipe	Choose **[XRR]** to create XRR analysis recipe.	
Optics	Choose **[Optics2]** for XRR measurements.	
Slit	Enter slit width (**[DS]**, **[RS1]**, **[RS2]**).	Approx. 0.1~0.2mm
Geometry Adjustment	Check this box for XRR measurements.	
Reflection	Enter smaller angle than the critical angle of sample.	Approx. 0.3 degrees
Adjust Cnts.	Enter the number of adjustments.	1 or 2 times
Adjust Mode	Choose **[Omega]** for XRR measurements.	
Z	Enter scan conditions of z axis. (**[Start]**, **[End]**, **[Step]**, **[Speed]**) **[Start]** and **[End]** are relative positions from the current position.	If **[Adjust Mode]** is chosen **[Omega]**, these values are ignored.
Omega	Enter scan conditions of omega axis. (**[Start]**, **[End]**, **[Step]**, **[Speed]**) **[Start]** and **[End]** are relative positions from the current position.	**[Start]** : -0.1 ~ -0.2 **[End]** : 0.1 ~ 0.2 **[Step]** : 0.001 ~ 0.002 **[Speed]** : 1 ~ 2
Scan Type	Choose **[2Theta/Omega]** for XRR measurements.	
Fix Angle	Not used for XRR measurements.	
#1 ~ #4	Enter scan conditions of **[Scan Type]**. (**[Start]**, **[End]**, **[Step]**, **[Speed]**) **[Start]** and **[End]** are relative positions from the adjustment position. If dividing scan region, check and enter **[#2]** ~ **[#4]**.	All **[Step]** are same value.

Items	Contents	Notes
Off angle	Enter **0.0** for XRR measurements.	
Analysis	When performing auto analysis of XRR profile, check this box.	
Condition	Specify an existing recipe file by creating GXRR software.	**[…]** button is available to specify.
Save	Save the analysis recipe.	

NOTE : Click the [Save] button, when editing is completed.



If the dialog box is closed without clicking on this button, the recipe is not changed.

(2) XRF Recipe

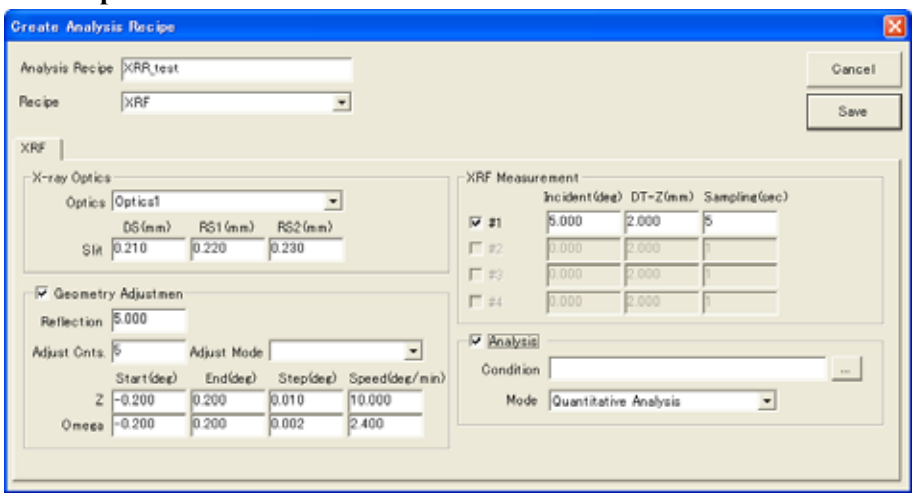


Fig. 8-2-5 Create Analysis Recipe (XRF) dialog box

Items	Contents	Notes
Analysis Recipe	Enter the name of analysis recipe.	
Recipe	Choose **[XRF]** to create XRF analysis recipe.	
Optics	Choose **[Optics1]** or **[Optics2]** for XRR measurements.	
Slit	Not used for XRF measurements.	
Geometry Adjustment	Uncheck this box for XRF measurements.	
Reflection	Not used for XRF measurements.	
Adjust Cnts.	Not used for XRF measurements.	
Adjust Mode	Not used for XRF measurements.	
Z	Not used for XRF measurements.	
Omega	Not used for XRF measurements.	
#1 ~ #4	Check **[#1]** and Enter counting conditions. (**[Incident]**, **[DT-Z]**, **[Sampling]**) **[Incident]** and **[DT-Z]** are relative positions from the adjustment position.	
Analysis	When performing auto analysis of XRF profile, check this box.	
Condition	Specify an existing recipe file by creating XRFbatch software.	**[…]** button is available to specify.
Mode	Choose **[Quantitative analysis]** for XRF analysis.	
Save	Save the analysis recipe.	

NOTE : Click the [Save] button, when editing is completed.

If the dialog box is closed without clicking on this button, the recipe is not changed.

(3) XRD Recipe

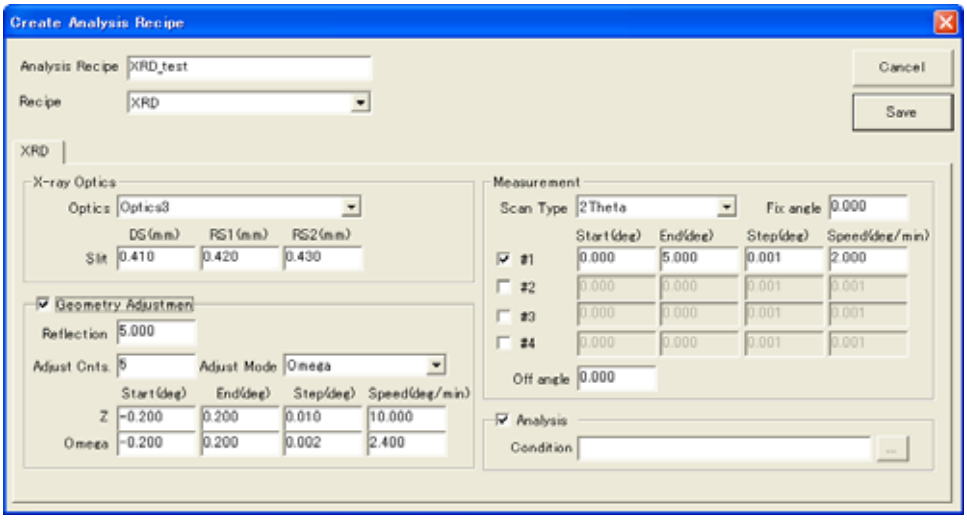


Fig. 8-2-6 Create Analysis Recipe (XRD) dialog box

Items	Contents	Notes
Analysis Recipe	Enter the name of analysis recipe.	
Recipe	Choose **[XRD]** to create XRD analysis recipe.	
Optics	Choose **[Optics2]** for XRD measurements.	
Slit	Enter slit width (**[DS]**, **[RS1]**, **[RS2]**).	Approx. 0.1~0.2mm
Geometry Adjustment	Check this box for XRD measurements.	
Reflection	Enter smaller angle than the critical angle of sample.	Approx. 0.3 degrees
Adjust Cnts.	Enter the number of adjustments.	1 or 2 times
Adjust Mode	Choose **[Omega]** for XRD measurements.	
Z	Enter scan conditions of z axis. (**[Start]**, **[End]**, **[Step]**, **[Speed]**) **[Start]** and **[End]** are relative positions from the current position.	If **[Adjust Mode]** is chosen **[Omega]**, these values are ignored.
Omega	Enter scan conditions of omega axis. (**[Start]**, **[End]**, **[Step]**, **[Speed]**) **[Start]** and **[End]** are relative positions from the current position.	**[Start]** : -0.1 ~ -0.2 **[End]** : 0.1 ~ 0.2 **[Step]** : 0.001 ~ 0.002 **[Speed]** : 1 ~ 2
Scan Type	Choose scan axis (2Theta/Omega, 2Theta, Omega) for XRD measurements.	**[2Theta/Omega]** is default.
Fix Angle	When **[Scan Type]** is chosen **[2Theta]**, this angle means **[Omega]**. When **[Scan Type]** is chosen **[Omega]**, this angle means **[2Theta]**. When **[Scan Type]** is chosen **[2Theta/Omega]**, this angle is ignored.	

Items	Contents	Notes
#1 ~ #4	Enter scan conditions of **[Scan Type]**. (**[Start]**, **[End]**, **[Step]**, **[Speed]**) **[Start]** and **[End]** are relative positions from the adjustment position. If dividing scan region, check and enter **[#2]** ~ **[#4]**.	All **[Step]** are same value.
Off angle	Enter **0.0** for XRR measurements.	
Analysis	When performing auto analysis of XRD profile, check this box.	
Condition	Specify an existing recipe file by creating XRDbatch software.	**[…]** button is available to specify.
Save	Save the analysis recipe.	

NOTE : Click the [Save] button, when editing is completed.



If the dialog box is closed without clicking on this button, the recipe is not changed.

8.2.3 Wafer map recipe

Click **[Wafer Map]** among the sub-navigation buttons.

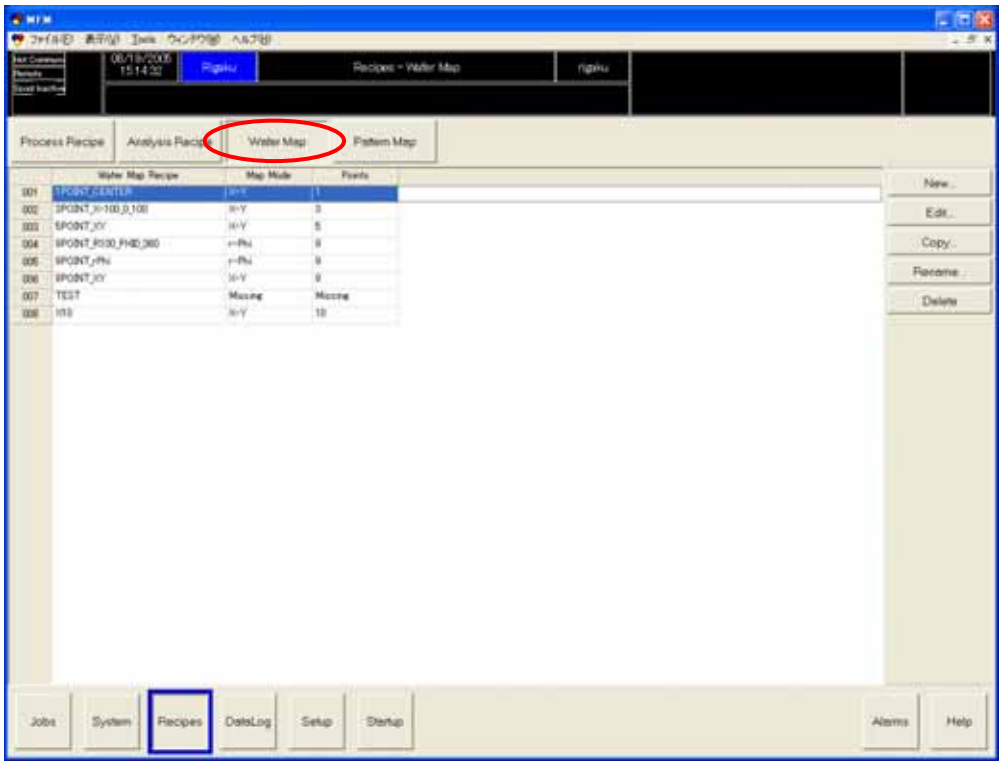


Fig. 8-2-7 Wafer Map Button

Items	Contents	Notes
New	Create a new recipe.	See the following dialog box.
Edit	Edit an existing recipe.	See the following dialog box.
Copy	Copy the specified recipe in the table.	
Rename	Rename the specified recipe in the table.	
Delete	Delete the specified recipe in the table.	

When clicking **[New]** or **[Edit]** button, the following **"Edit Wafer Map"** dialog box appears.

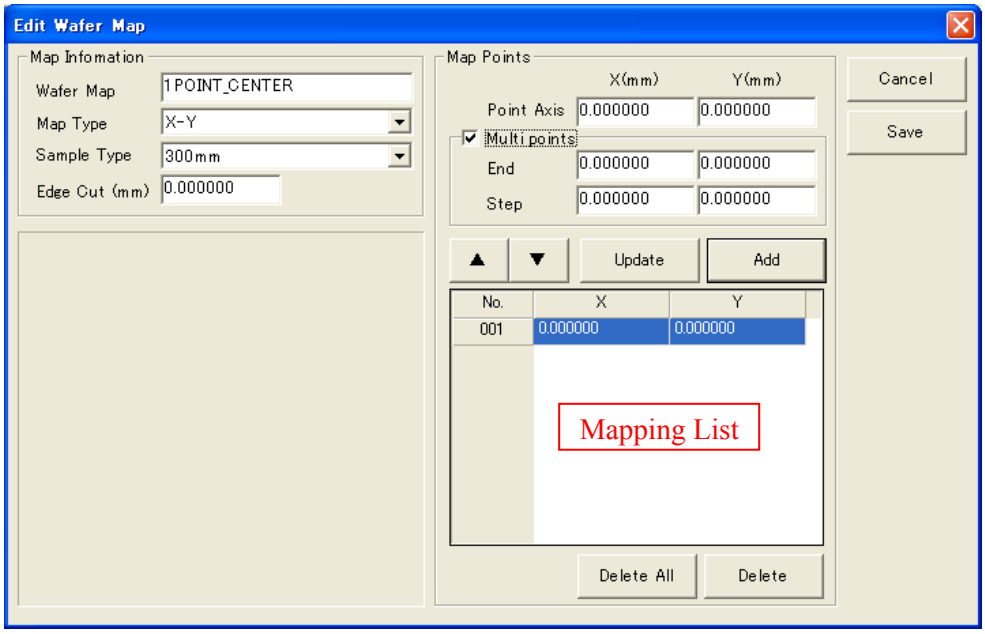


Fig. 8-2-8 Edit Wafer Map dialog box

Items	Contents	Notes
Wafer Map	Enter the name of wafer map recipe.	
Map Type	Choose an axis type, X-Y or R-θ.	
Sample Type	Choose wafer size, 300mm or 200mm.	
Edge Cut	Enter the edge cut of the wafer.	
Point Axis	Enter the axis of measurement point.	
Multi Points	Check this box, when specifying regular plural points.	
End	Enter the axis of end point.	
Step	Enter the step between **[Point Axis]** to **[End]**.	
▲▼	Move the specified line in the mapping list to upper or lower side.	▲ : To upper side ▼ : To lower side
Update	Replace the specified line in the mapping list to the **[Point Axis]**.	
Add	Add the specified map points to the mapping list.	
Delete All	Delete all contents in the mapping list.	
Delete	Delete the specified line in the mapping list.	
Save	Save the wafer map recipe.	

NOTE : Click the [Save] button, when editing is completed.

If the dialog box is closed without clicking on this button, the recipe is not changed.

8.2.4 Pattern map recipe

Click **[Wafer Map]** among the sub-navigation buttons.

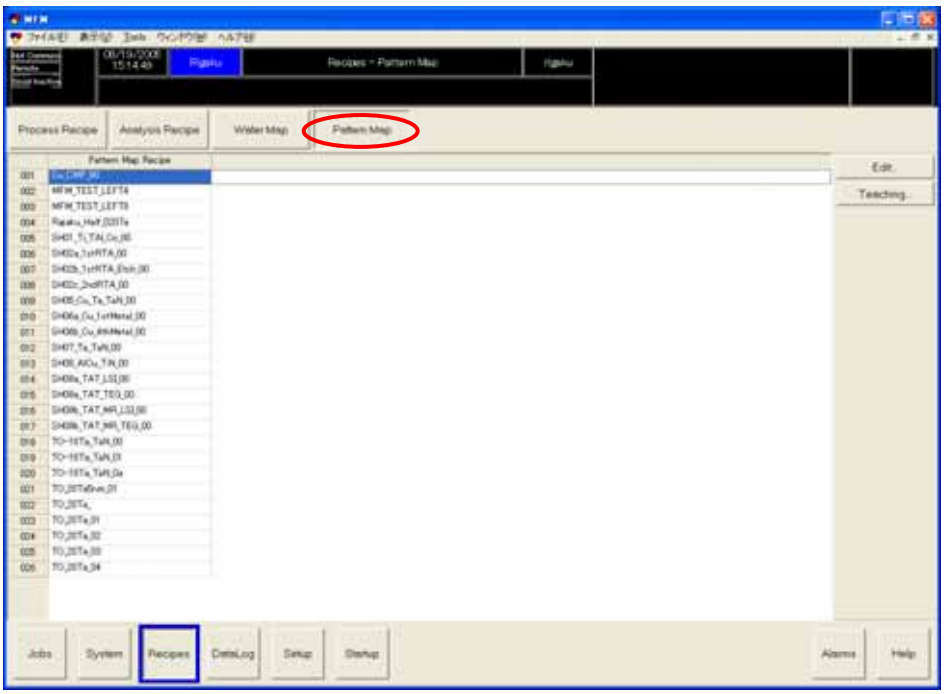


Fig. 8-2-9 Pattern Map Button

Items	Contents	Notes
Edit	Edits a recipe without moving sample stage. It is available to edit recipes which are saved already.	See the following dialog box.
Teaching	Edits a recipe with moving sample stage. It is available to create new recipes.	See the following dialog box.

When clicking **[Edit]** or **[Teaching]** button, the following **[Patterned Wafer Map]** dialog box appears.

(1) **[Patterned Wafer Map]** dialog box

The property, **[Edit]** or **[Teach]**, is displayed as below according to click **[Edit]** or **[Teaching]** button in the main window.

This dialog box has five tabs. Choose each tab from the left to the right, and set conditions in each tab. Refer to the following pages about each tab.

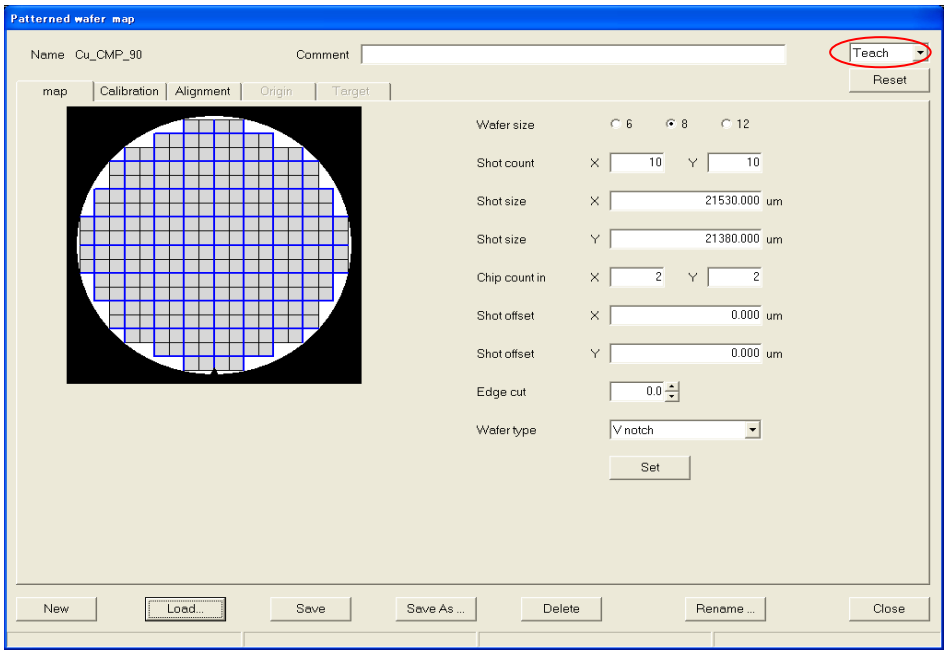


Fig. 8-2-10 [Patterned Wafer Map] dialog box

Items	Contents	Notes
New	Creates a new pattern map recipe.	
Load	Loads an existing pattern map recipe.	
Save	Saves the current contents to the same file.	
Save As	Saves the current contents to another file.	
Delete	Deletes the current recipe file.	
Rename	Renames the current recipe file.	
Close	Closes the dialog box.	
Reset	Resets alarms about Patterned Wafer Map.	

NOTE : Click the [Save] or [Save As] button, when editing is completed.

If the dialog box is closed without clicking on these buttons, the recipe is not changed.

(2) **[Map]** tab

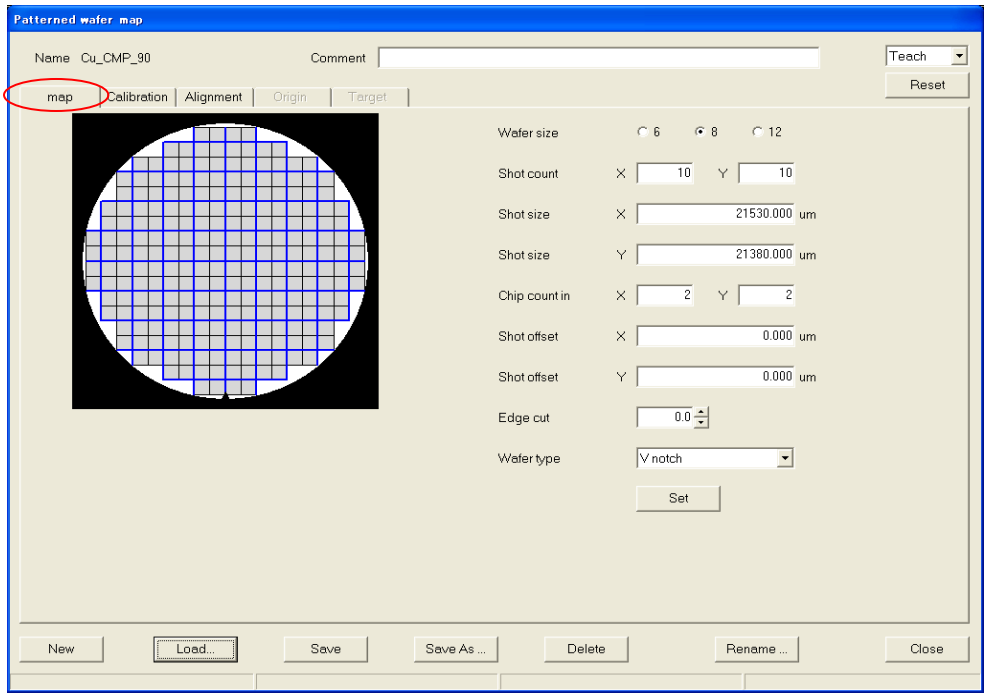


Fig. 8-2-11 [Map] tab

This tab is available to set the pattern information of wafer.

Items	Contents	Notes
Wafer size	Chooses wafer size in inches.	6 inches is not used.
Shot count	Enters the number of maximum shot counts.	Each direction, X and Y.
Shot size X	Enters the shot size of X direction.	
Shot size Y	Enters the shot size of Y direction.	
Chip count in	Enters the number of chips in a shot.	X × Y
Shot offset X	Enters the offset distance at X direction from the wafer center.	
Shot offset Y	Enters the offset distance at Y direction from the wafer center.	
Edge cut	Enters the edge cut.	
Wafer type	Chooses wafer type, notch or orientation flat.	
Set	Clicks this button to set conditions after specifying above items	

(3) **[Calibration]** tab

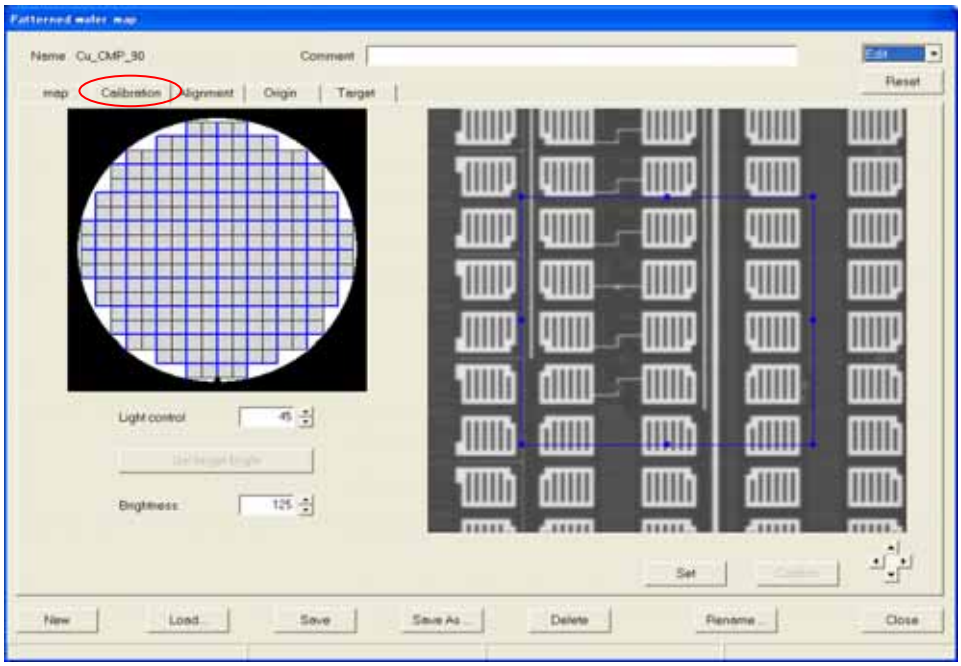


Fig. 8-2-12 [Calibration] tab

This tab is available to set the brightness conditions on the wafer for the pattern recognition.

Items	Contents	Notes
Light control	Sets the light power of the lamp.	1 – 255
Get target bright	Gets the average brightness in the blue rectangle region of the image and displays it into the **[Brightness]** box.	The blue rectangle region is changed by dragging in the image.
Brightness	Displays the average brightness in the blue rectangle region of the image.	Read only.
Set	Sets the light control conditions.	
Confirm	Changes the light power of the lamp to the current value of the **[Light control]**.	
▲/▼/◄/►	Move the blue rectangle region in the image finely.	Up/Down/Left/Right

(4) **[Alignment]** tab

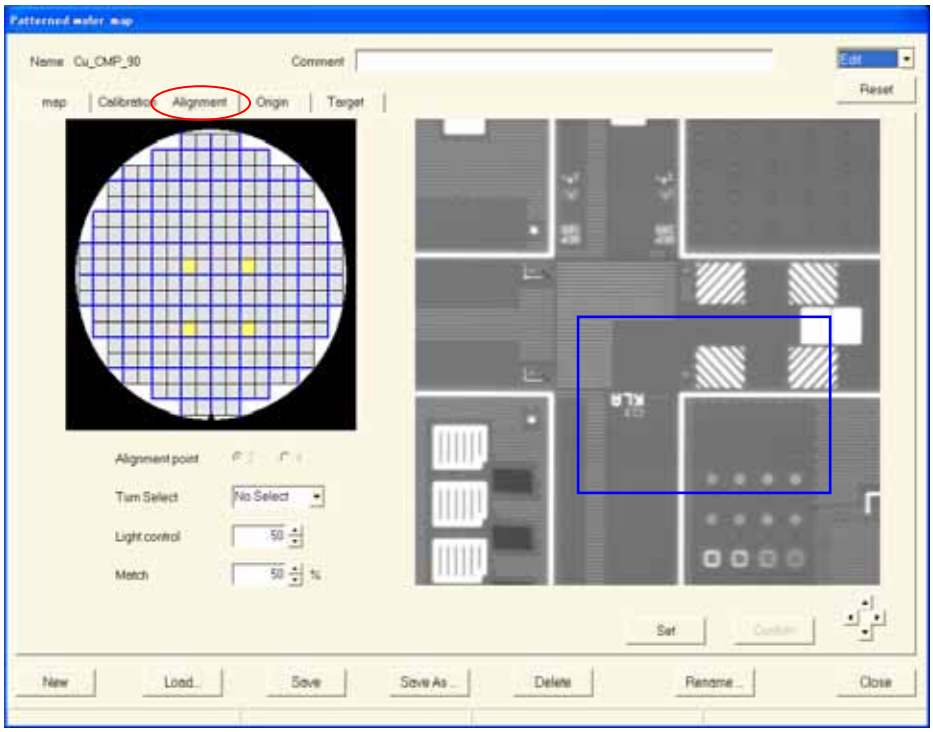


Fig. 8-2-13 [Alignment] tab

This tab is available to set the orientation alignment conditions of the wafer.

The points to be used for alignment are specified on the map figure and image.

Items	Contents	Notes
Alignment Point	Specifies the number of alignment points. **[2]** means two points on the left half of the wafer, and total points are four in the whole wafer.	2 or 4.
Turn select	Chooses the wafer region for setting points, the left half or the right half.	0 : left half 180 : right half
Light control	Changes the light power of the lamp.	1 – 255
Match	Sets the tolerance of pattern matching. The parameter for the errors of brightness, focusing, contrast and particle on the wafer.	Default : 50 %
Set	Sets the conditions of orientation alignment.	
Confirm	Executes the alignment with the current conditions.	
▲/▼/◄/►	Move the blue rectangle region in the image finely.	Up/Down/Left/Right

(5) **[Origin]** tab

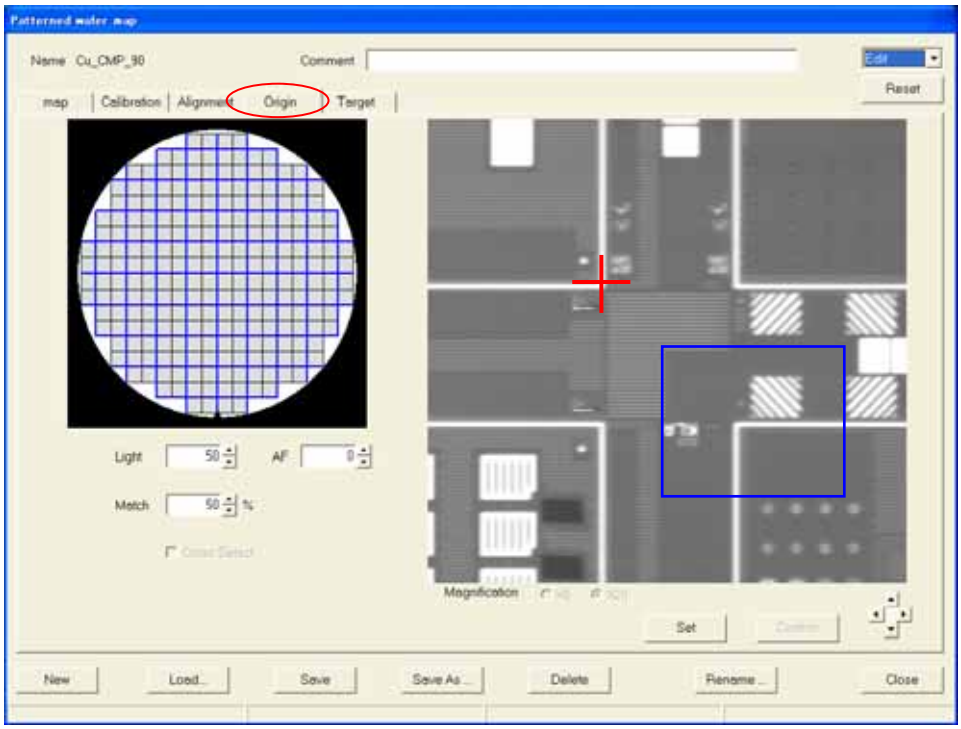


Fig. 8-2-14 [Origin] tab

This tab is available to specify the origin of the wafer.

The rectangle region for pattern recognition and the origin point can be set.

Items	Contents	Notes
Light	Changes the light power of the lamp.	1 – 255
AF	The offset of AF.	Not used.
Match	Sets the tolerance of pattern matching. The parameter for the errors of brightness, focusing, contrast and particle on the wafer.	Default : 50 %
Cross Select	Check to drag the cross cursor on the image.	
Magnification	Magnification of the image.	Not used.
Set	Sets the conditions of origin alignment.	
Confirm	Executes the alignment with the current conditions.	
▲/▼/◄/►	Move the blue rectangle region of the red cross cursor in the image finely.	Up/Down/Left/Right

(6) **[Target]** tab – **[Display = Wafer]**

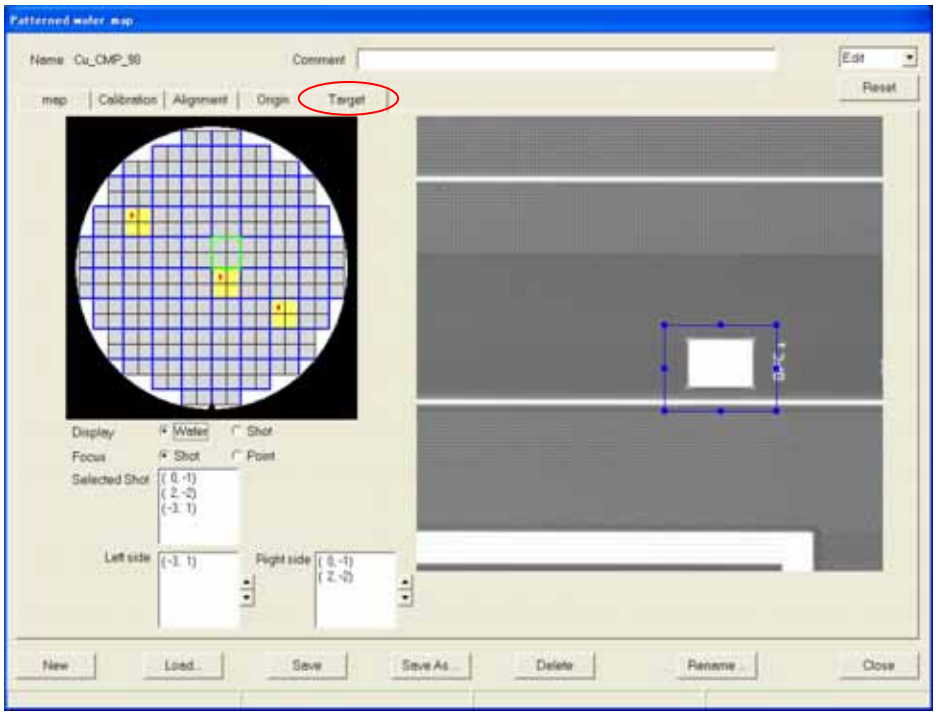


Fig. 8-2-15 [Origin] tab - [Display = Wafer]

This tab is available to specify the measurement position and order on the wafer.

When **[Display]** = **[Wafer]**, the wafer map is displayed.

Items	Contents	Notes
Display	Chosen **[Wafer]** to display the wafer map.	**[Shot]** : Shot map
Focus	Chooses **[Shot]** or **[Point]**.	
Selected Shot	The shot coordinates of measurement points are displayed, when **[Focus]** is **[Shot]**. When **[Focus]** is **[Point]**, the point coordinates in shots are displayed.	Read only.
Left side	The coordinates on the left half of wafer are displayed.	Selectable
Right side	The coordinates on the left half of wafer are displayed.	Selectable
▲/▼	The selected coordinates in **[Left side]** or **[Right side]** move to up/down. The order in **[Left side]** or **[Right side]** means the order of measurement.	

(7) **[Target]** tab – **[Display = Shot]**

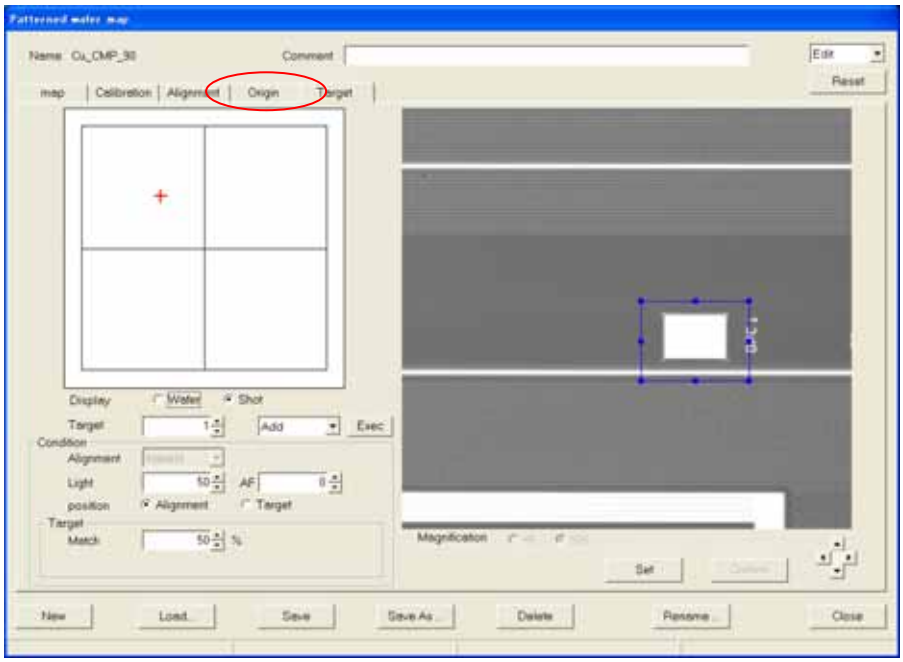


Fig. 8-2-16 [Origin] tab - [Display = Shot]

This tab is available to specify the measurement points in a shot.

When **[Display]** = **[Shot]**, the shot map is displayed.

Measurement points in a shot are set in the shot map by the joy stick.

Items	Contents	Notes
Display	Chosen **[Shot]** to display the shot map.	**[Wafer]** : Wafer map
Target	Specifies an image number to display an image to the right area. When adding a new measurement point, click **[Exec]** button after choosing **[Add]**. When deleting a specified image number, click **[Exec]** button after choosing **[Del]**.	Max. number is 10.
Alignment	Changes alignment mode, Direct / Indirect / No use.	
Light	Changes the light power of the lamp.	1 – 255
Position	Changes the displayed image. (The pattern recognition image or the measurement point image)	
Match	Sets the tolerance of pattern matching. The parameter for the errors of brightness, focusing, contrast and particle on the wafer.	Default : 50 %
Magnification	Magnification of the image.	Not used.
Set	Sets the conditions of target.	
Confirm	Executes pattern recognition and moves the wafer to the measurement position.	
▲/▼/◄/►	Move the blue rectangle region in the image finely.	Up/Down/Left/Right

9. MANUAL OPERATION

This function enables manual operation individually for the setting of measurement conditions, and for maintenance.

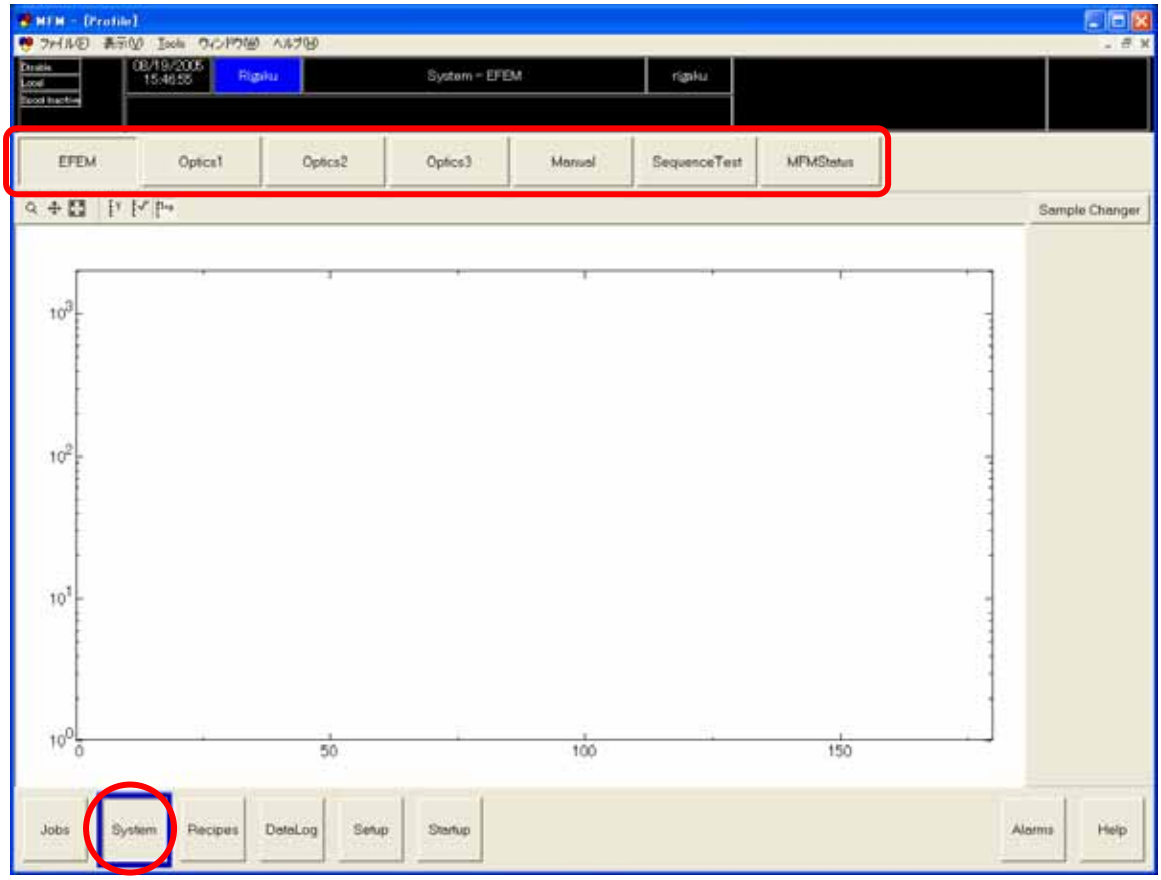


Fig. 9-1 Manual Main Window

Select [System] among the navigation buttons, and Select each sub-navigation button.

(1) [EFEM] Control

(2) [Optics1] ~ [Optics3] Control

(3) [Manual] Control

(4) [Sequence Test] Control

(5) [MFM Status] Control

9.1 Operation in the Chart Screen

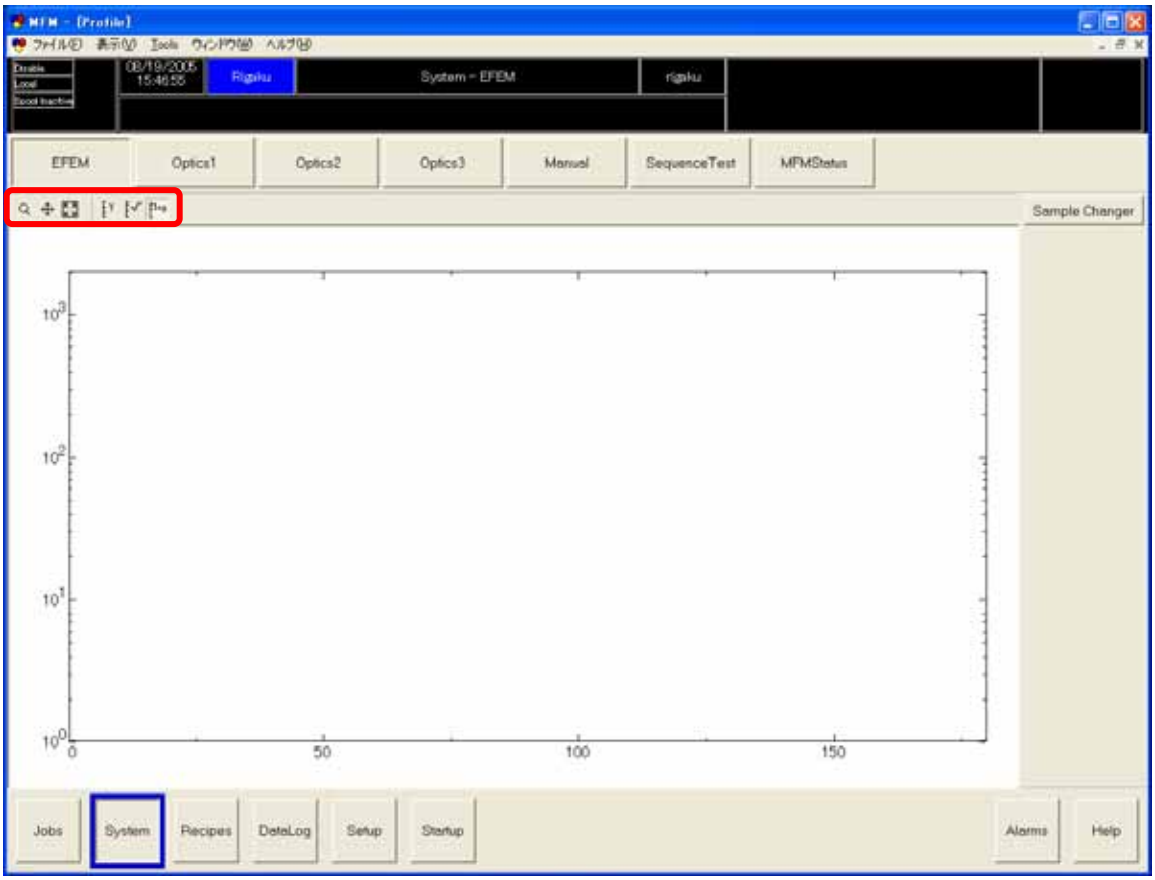


Fig. 9-1-1 Chart Screen

Groups	Items	Functions
Screen	Zoom	Enlarges a part of a figure
	Pan	Enlarges the part near the cursor
	Reset	Restores the original size
Display of the vertical axis	Linear	Linear display of X-ray intensity
	Square root	Square-root-axis display of X-ray intensity
	Logarithm	Log display of X-ray intensity

9.2 [EFEM] Control

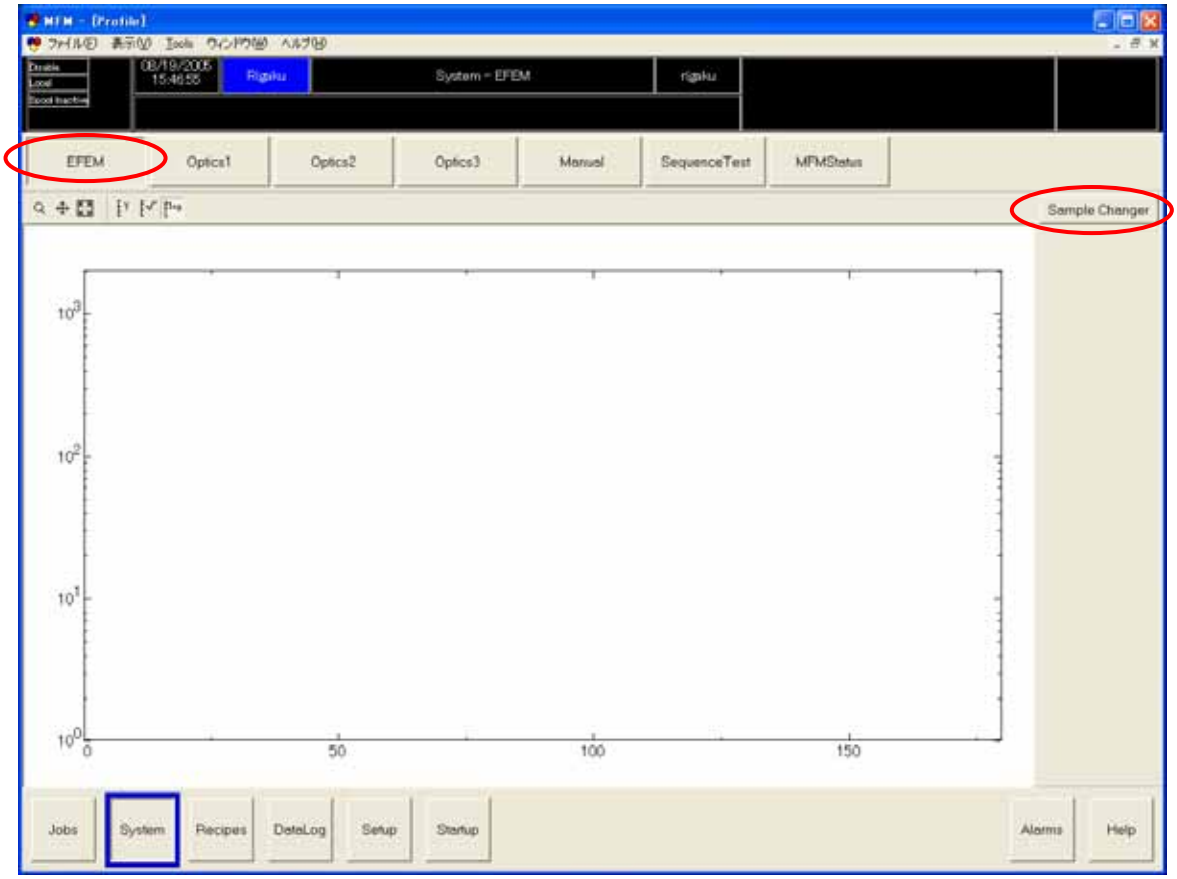


Fig. 9-2-1 [EFEM] Control button

The sample wafer can be removed from the cassette and mounted on the sample stage.

The wafer on the stage can be returned to the cassette.

Click **[Sample Changer]** button to open **[Sample Changer Control]** dialog box for operation.

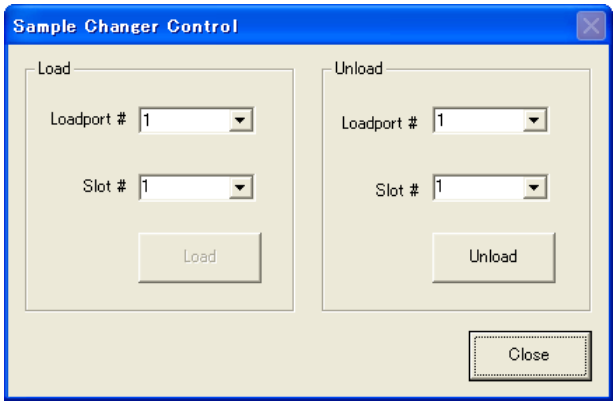


Fig. 9-2-2 [sample Changer Control] dialog box

Items	Contents
Load port #	Choose the load port number, 1 or 2, to load/unload a wafer.
Slot #	Choose the slot number, 1 to 25, in the FOUP on the specified load port.
Load	The specified wafer is removed from the FOUP and the aligner sets the notch position. The wafer is then mounted on the sample stage.
Unload	The wafer on the stage returns to the specified FOUP on the load port.

NOTE : 

This is a manual mode and any slot to which the wafer is to be loaded/unloaded may be selected.

Prior to this control, confirm the cassette size and that the specified slot contains no wafer.

9.3 [Optics1] ~ [Optics3]Control

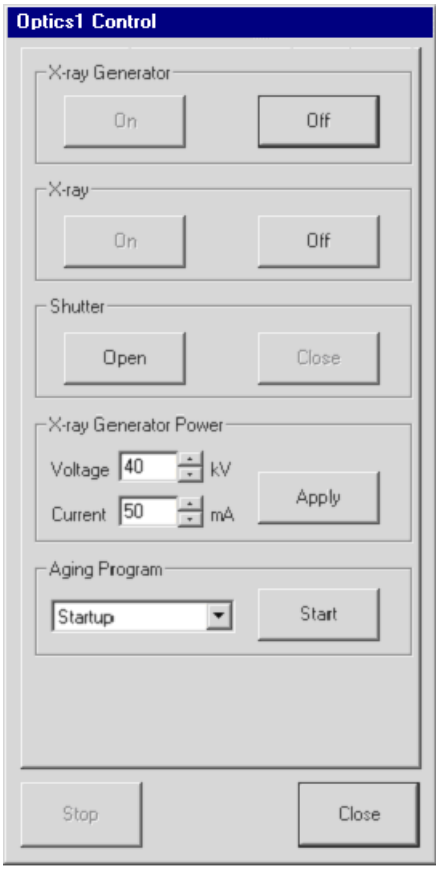


Fig. 9-3-1 [Optics1] ~ [Optics3] Control button

For the Optics1, Optics2 and Optics3 tubes, the followings can be performed.

Items	Contents
X-ray Generator	On/Off of the X-ray generator.
X-ray	On/Off of the X-ray.
Shutter	Open/Close of the shutter.
X-ray Generator Power	Setup of the X-ray generator power.
Aging Program	Stepwise X-ray output control based on the aging program.

9.4 [Manual] Control

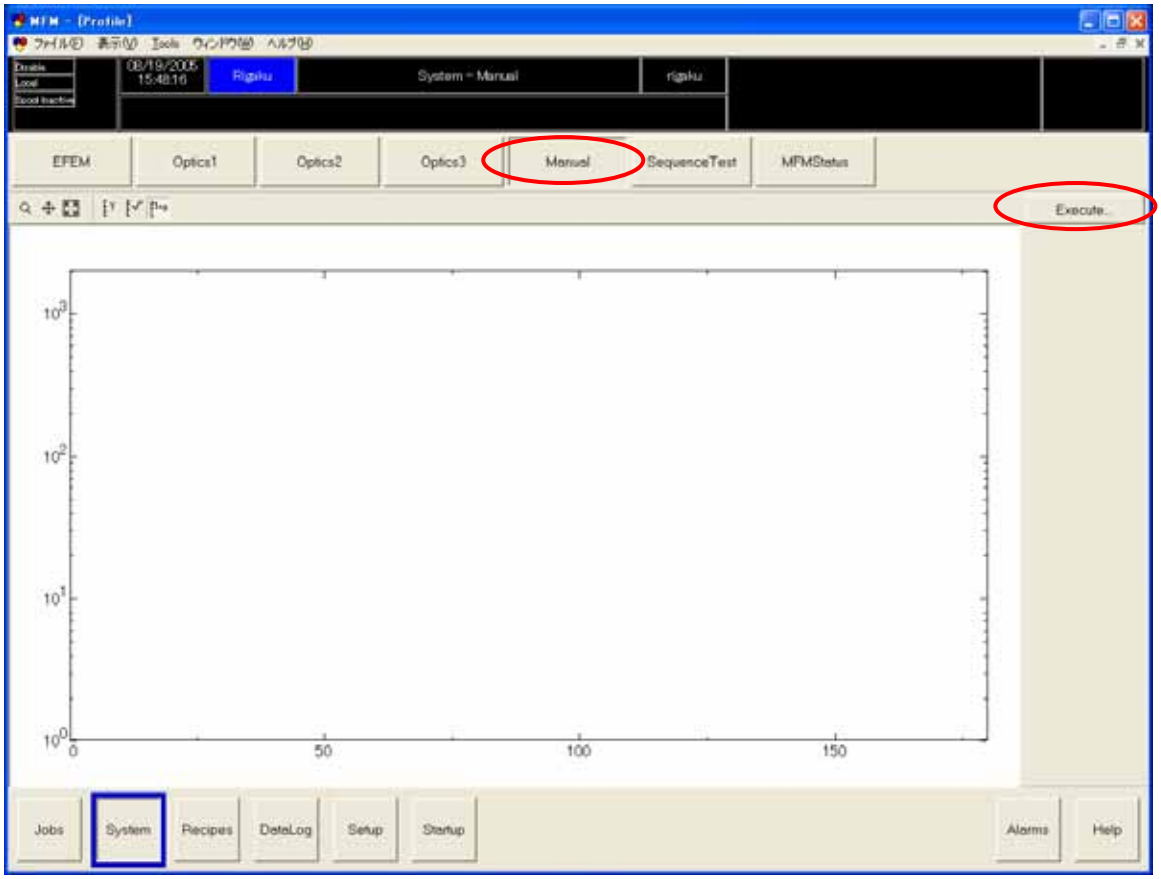


Fig. 9-4-1 [Manual] Control button

Manual control of actuators in the main module, example for positioning, scanning, XG operation and so on, can be performed.

Click **[Execute]** button to open **[Manual Command Control]** dialog box for operation.

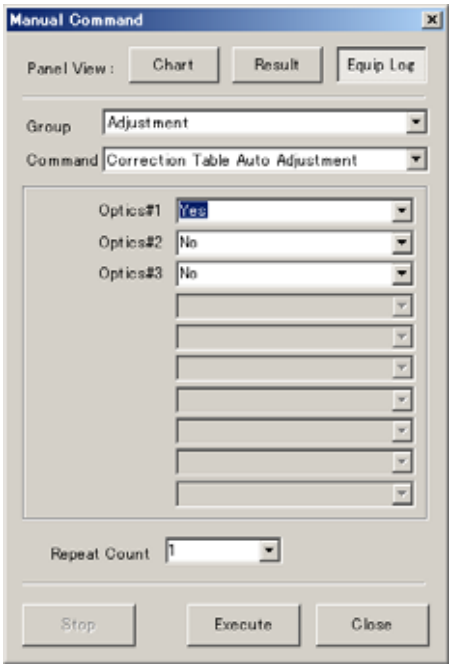


Fig. 9-4-2 [Manual Command Control] dialog box

Items	Contents
Group	Choose the operation group.
Command	Choose the operation command in the specified groupe.
Run	The specified command is executed.
Abort	Abort operation.
Repeat #	Repeat number of operations.

9.5 [Sequence Test] Control

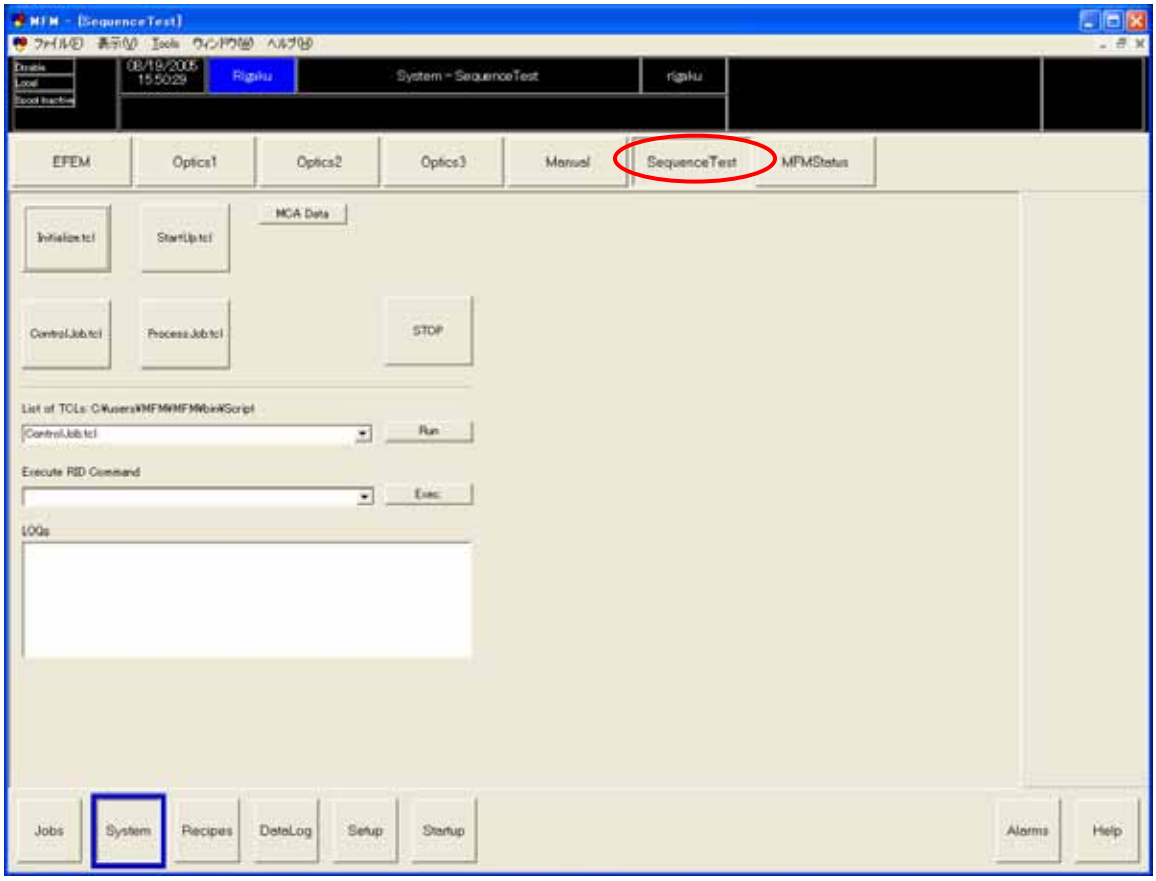


Fig. 9-5-1 [Sequence Test] Control button

Sequences, which are related to a control job, a process job and so on, can be tested.

Items	Contents
Initialize.tcl	Execute the sequence of initializing machine.
Startup.tcl	Execute the sequence of the startup.
ControlJob.tcl	Execute the sequence of the control job to be tested.
ProcessJob.tcl	Execute the sequence of the process job to be tested.
STOP	Stop the sequence during operation.
List of TCLs	Click **[Run]** button to execute the specified tcl sequence after choosing an existing tcl file in the combo box.
Execute RID command	Click **[Exec.]** button to execute the specified RID command after choosing an existing RID command in the combo box.
LOGs	Displayed operation log.

9.6 [MFM Status] Control

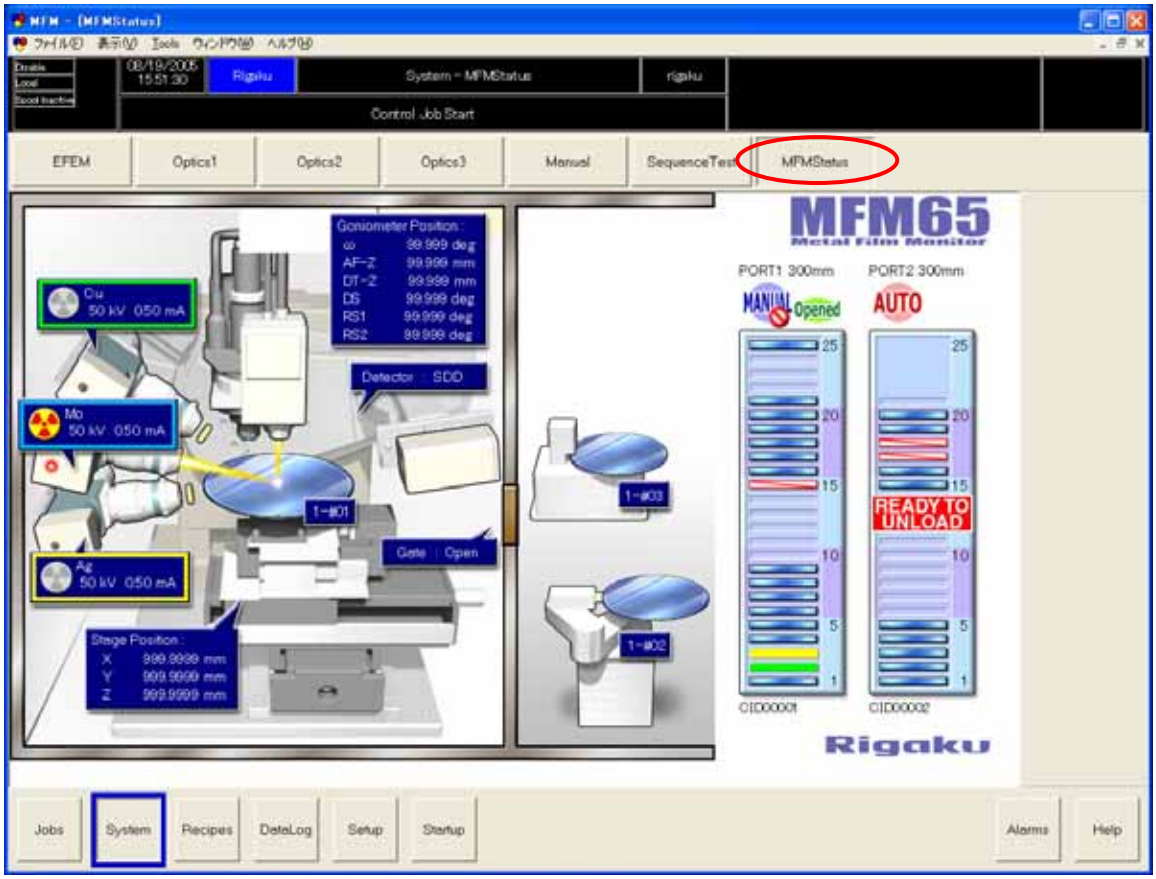


Fig. 9-6-1 [MFM Status] Control button

The status figure of this equipment is displayed on the main window visually.

10. SETUP

Input operational constants specific to the equipment.

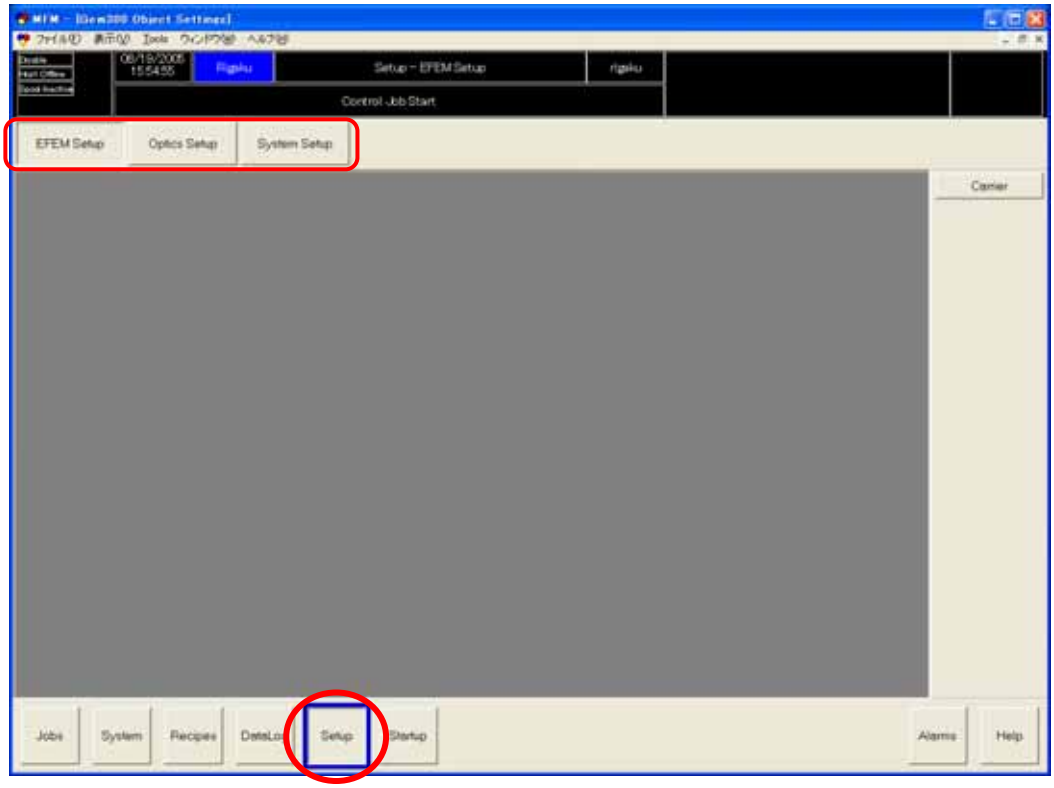


Fig. 10-1 Setup Main Window

(1) EFEM Settings

(2) Optics Setup

(3) System Setup

These commands can be performed as the following pages.

10.1 EFEM Settings

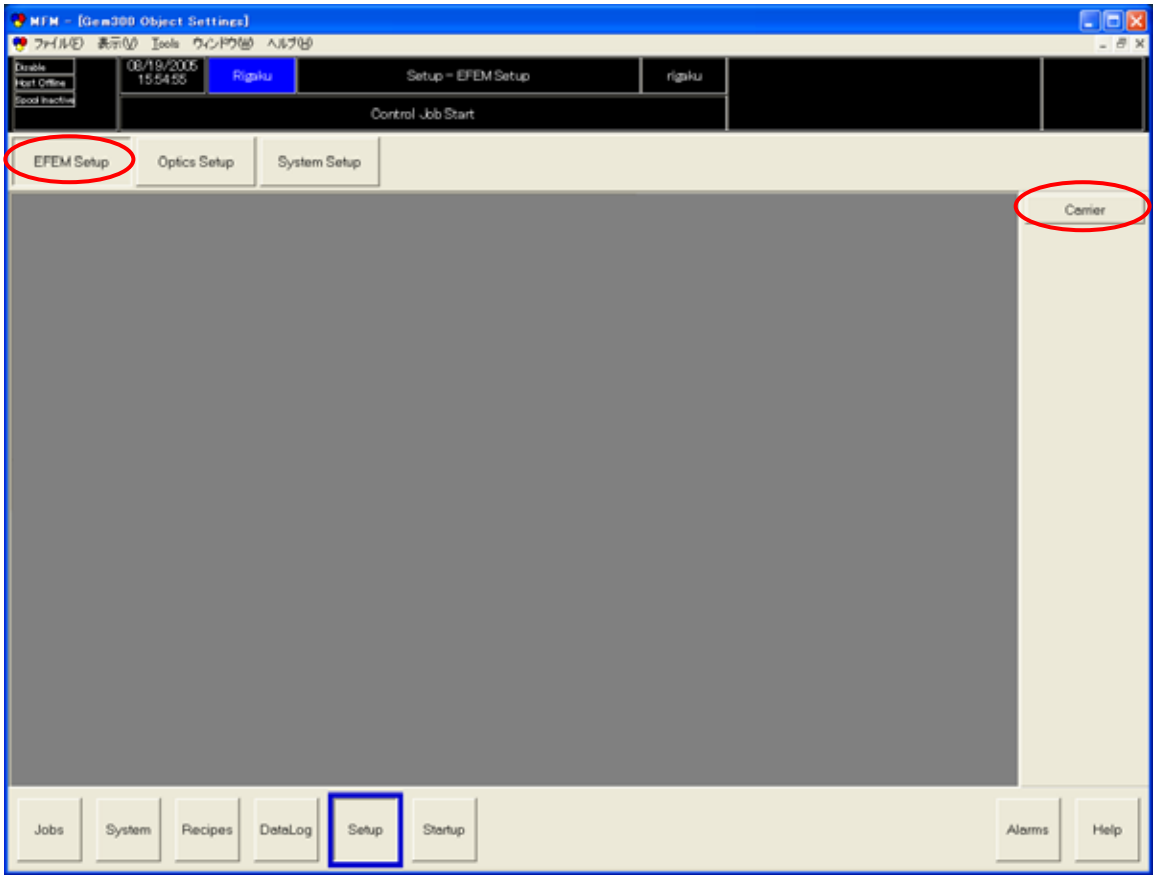


Fig. 10-1-1 [EFEM Settings] button

Click **[Carrier]**, and open the **[EFEM Setup]** dialog box.

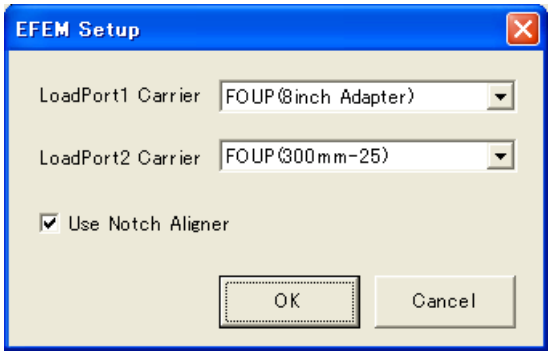


Fig. 10-1-2 [EFEM Setup] dialog box

Items	Contents
Load Port 1 Carrier	Chooses the type of carriers to use on the load port 1.
Load Port 2 Carrier	Chooses the type of carriers to use on the load port 2.
Use Notch Aligner	Check on the case of using wafer aligner. (Default : Checked)

10.2 Optics Setup

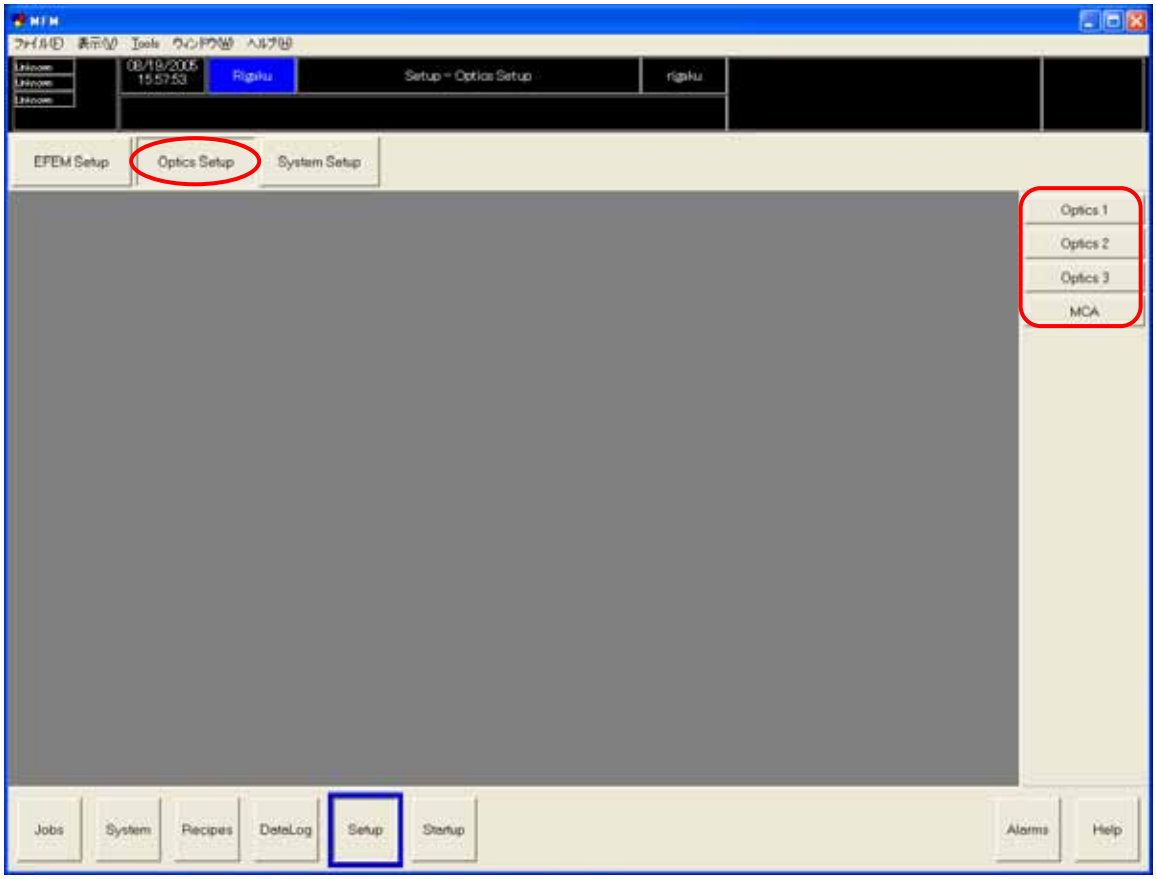


Fig. 10-2-1 [Optics Setup] button

[Optics Setup] has four setup functions (buttons) as below.

See the following pages about each function.

(1) Optics 1

(2) Optics 2

(3) Optics 3

(4) MCA

Click **[Optics1]**, **[Optics2]** or **[Optics3]** to setup the parameters of each optics unit, and open **[Optics Setup 1/2/3]** dialog box.

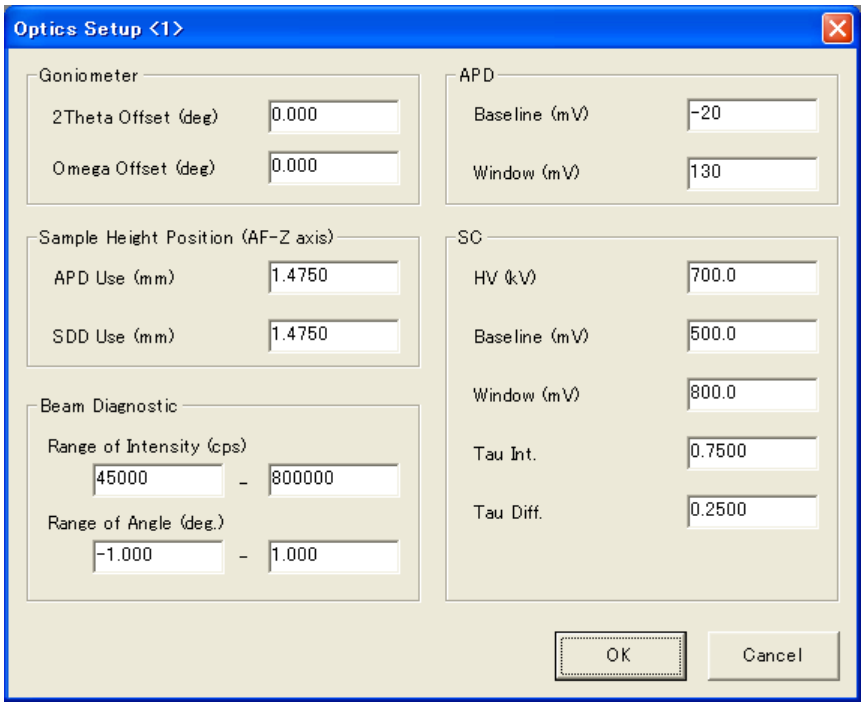


Fig. 10-2-2 [Optics Setup 1] – [Optics Setup 3] dialog box

Item1	Item2	Contents
Goniometer	**2Theta Offset**	The angular offset of 2theta axis.
	Omega Offset	The angular offset of omega axis.
Sample Height Position (AF-Z Axis)	**APD Use**	The AF microscope height for APD.
	SDD Use	The AF microscope height for SDD.
Beam Diagnosis	**Range of Intensity**	The permissible range of x-ray intensity.
	Range of Angle	The permissible range of x-ray beam angular position.
APD	**Baseline**	The PHA baseline of the APD.
	Window	The PHA window of the APD.
SC	**HV**	The HV of the SC.
	Baseline	The PHA baseline of the SC.
	Window	The PHA window of the SC.
	Tau Int.	The integral time constant for the calibration of dead time.
	Tau Diff.	The differential time constant for the calibration of dead time.

Click **[MCA]** to setup the parameters of MCA, and open **[MCA Setup]** dialog box.

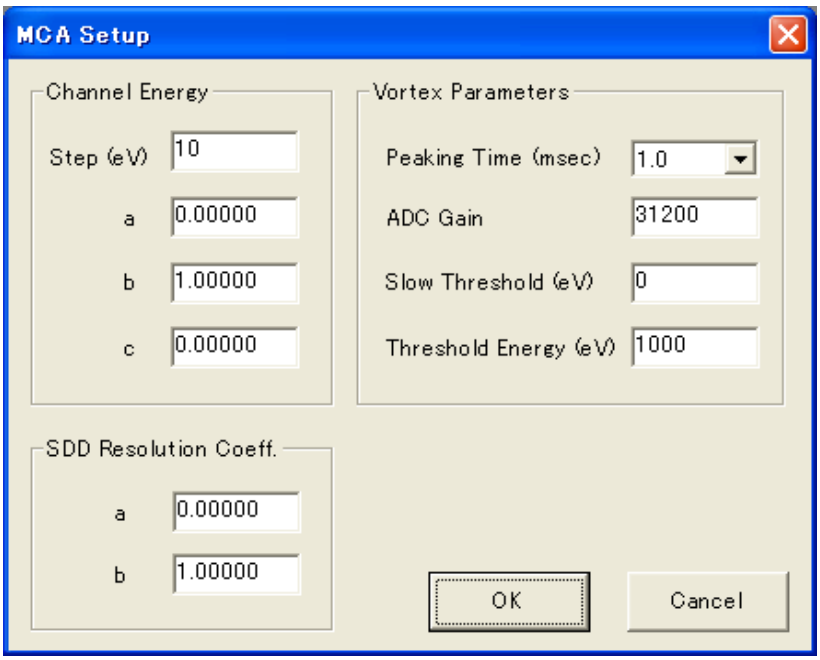


Fig. 10-2-3 [MCA Setup] dialog box

Item1	Item2	Contents
Channel Energy	**Step**	The energy step by channel.
	a	The channel calibration coefficient “a”. ($Y = a X^2 + b X + c$)
	b	The channel calibration coefficient “b”. ($Y = a X^2 + b X + c$)
	c	The channel calibration coefficient “c”. ($Y = a X^2 + b X + c$)
SDD Resolution Coeff.	**a**	The energy resolution coefficient “a” of the detector. ($Y = a + b X$)
	b	The energy resolution coefficient “b” of the detector. ($Y = a + b X$)
Vortex Parameters	**Peaking Time**	The peaking time of data sampling.
	ADC Gain	The ADC gain of the MCA.
	Slow Threshold	The slow threshold energy of the MCA.
	Threshold Energy	The threshold energy of the MCA.

NOTE: The default settings of your system can be used without being changed.



11. DATA LOG

It is available to display the equipment, process and alarm log on the main window.

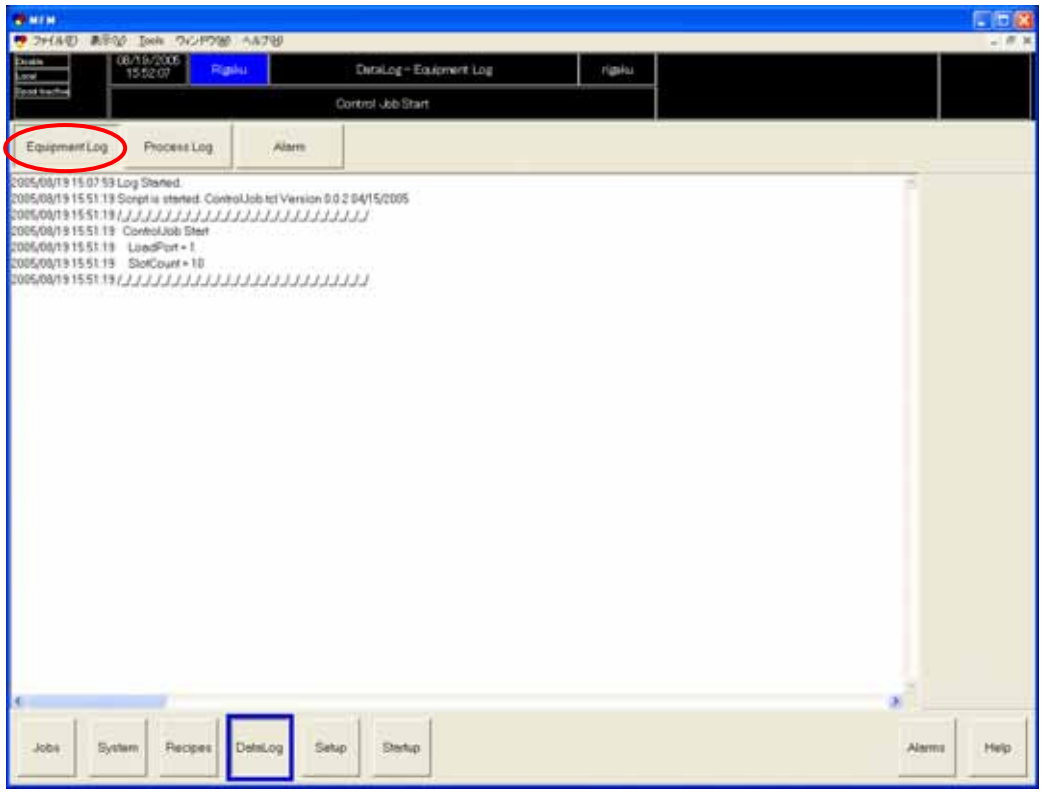


Fig. 11-1 [Equipment Log] button

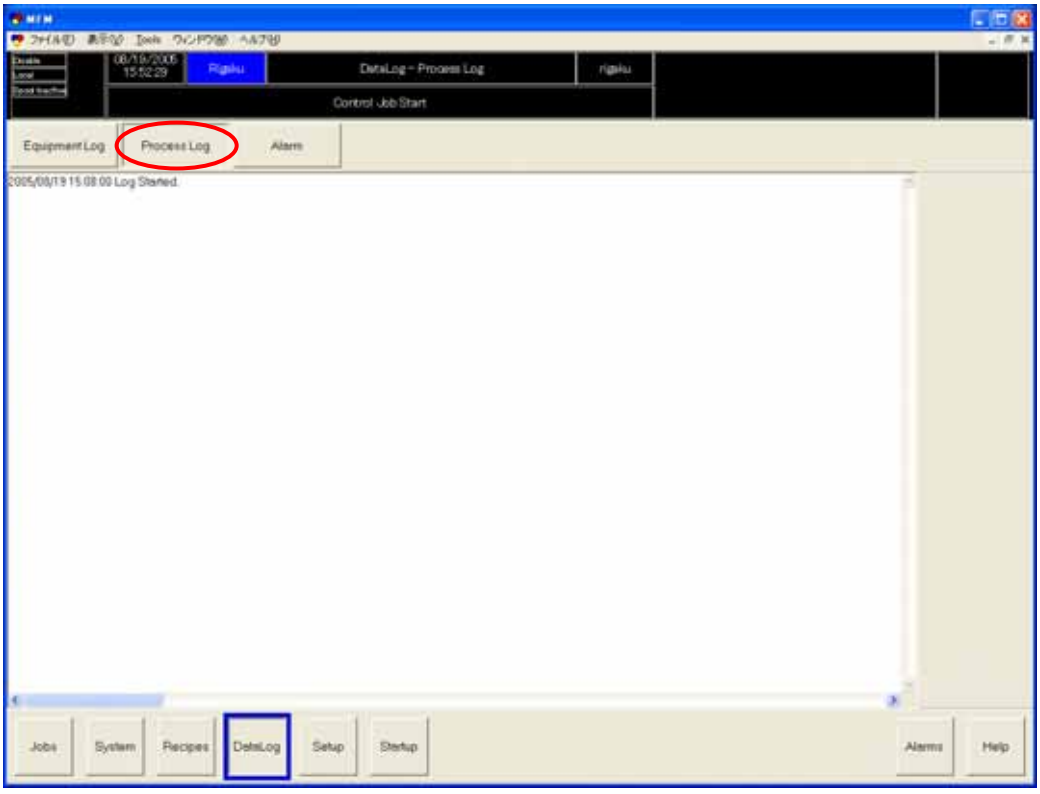


Fig. 11-2 [Process Log] button

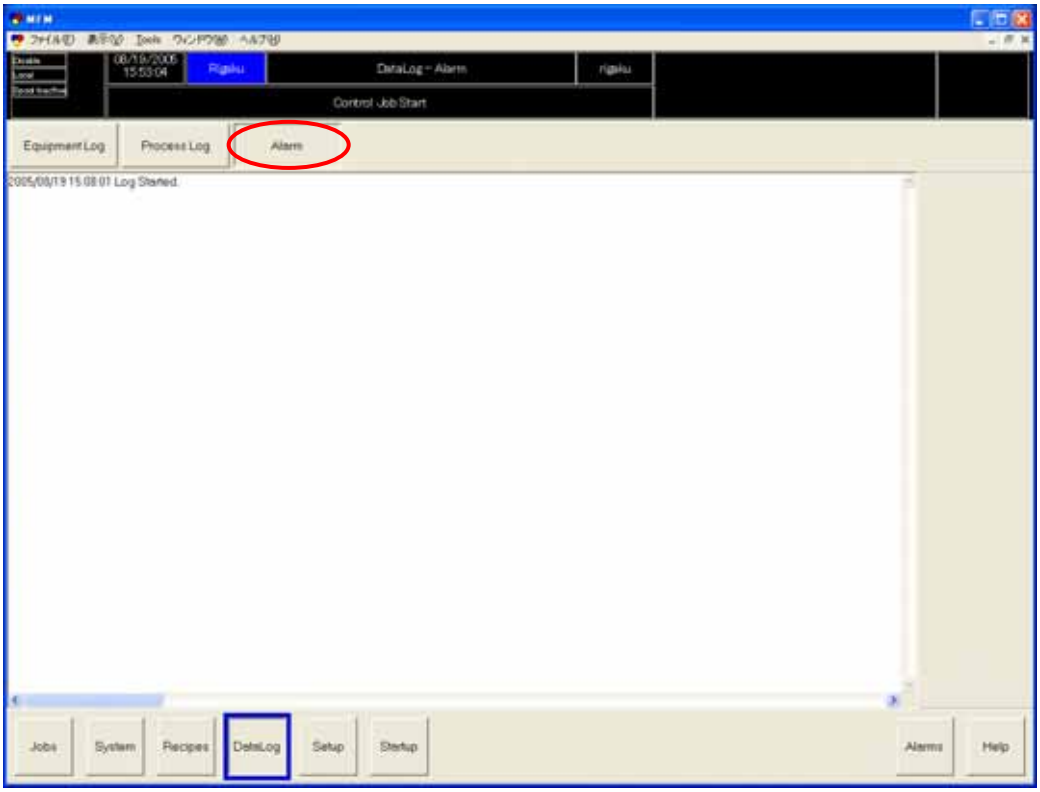


Fig. 11-3 [Alarm] button

12. ALARMS

It is available to display the current alarm status and the history log of past alarms.

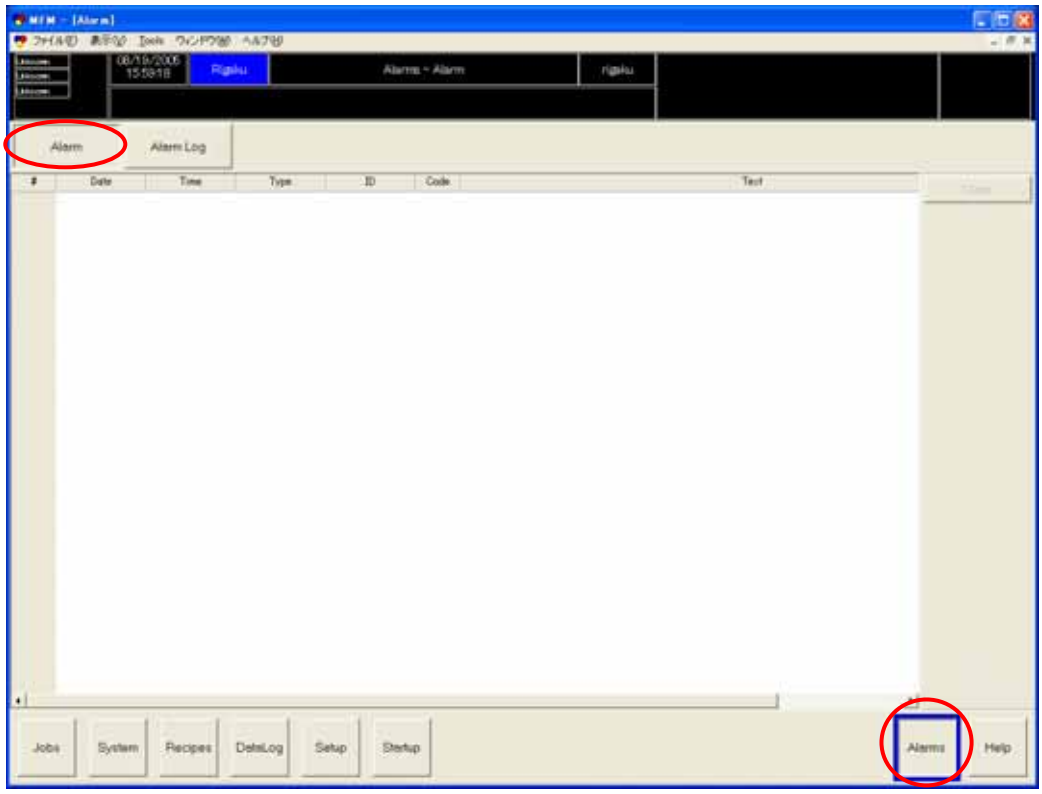


Fig. 12-1 [Alarm] button

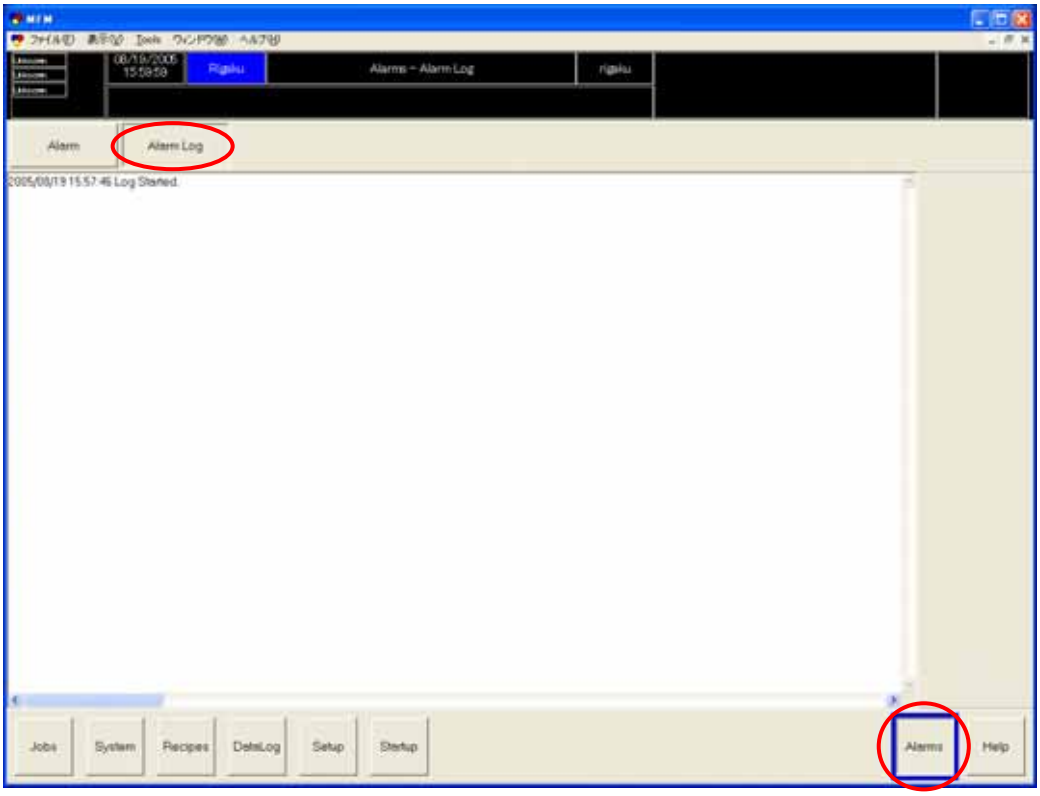


Fig. 12-2 [Alarm Log] button

13. 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					✓	

Refer to the following pages about the contents of the routine checkup.

Items		Contents
1	Cooling water: Checking and adjusting the flow rate of secondary-water flow rate	Check the water flow rate meter at the left side of the equipment. Water flow rate meter reading of about 1.3 – 1.7 L/min. When adjusting, refer to chapter 13.1.
2	Compressed dry air: Checking and adjusting of the pressure of compressed dry air	Check the pressure meter at the left side of the equipment. Pressure meter reading of about 0.48 – 0.52 MPa.. When adjusting, refer to chapter 13.1.
3	Vacuum: Checking and adjusting the suction pressure of vacuum	Check the vacuum meter at the left side of the equipment. Vacuum pressure reading of -75 – -80 kPa. When adjusting, refer to chapter 13.1.
4	Cleaning of the transport line	Wipe the robot hand, aligner suction pads and sample stage by the clean cloth, which soaks up alcohol or pure water. Prepare clean cloth, alcohol and pure water that are used in the facility. When cleaning, refer to chapter 13.2.
5	Exchange of cooling water and filters	In the chiller (circulated water). Refer to the manual of the chiller.
6	Exchange of X-ray tubes	The X-ray tube must be exchanged by our service personnel in charge. **(See "12.3.1 X-ray tube".)** **WARNING:**  **Contact to the personnel in charge of service. When disposing, refer to the attached MSDS of Beryllium.**
7	Check for the operation of the water leak sensor	Drench the water leak sensor and check the operation of the sensor.
8	Add mechanical grease	When periodic maintenance by our service personnel in charge, the mechanical grease for the guide rails of actuators should be added. **CAUTION:**  **Contact to the personnel in charge of service.** Refer to the attached MSDS of the grease.

13.1 Checking cooling water, CDA and vacuum

Open the lower panel on the left side of the Main Module.

Check the flow rate of cooling water, the pressure of the CDA and the suction pressure of vacuum as the following figure.

Refer to the maintenance chapter for adjustments.

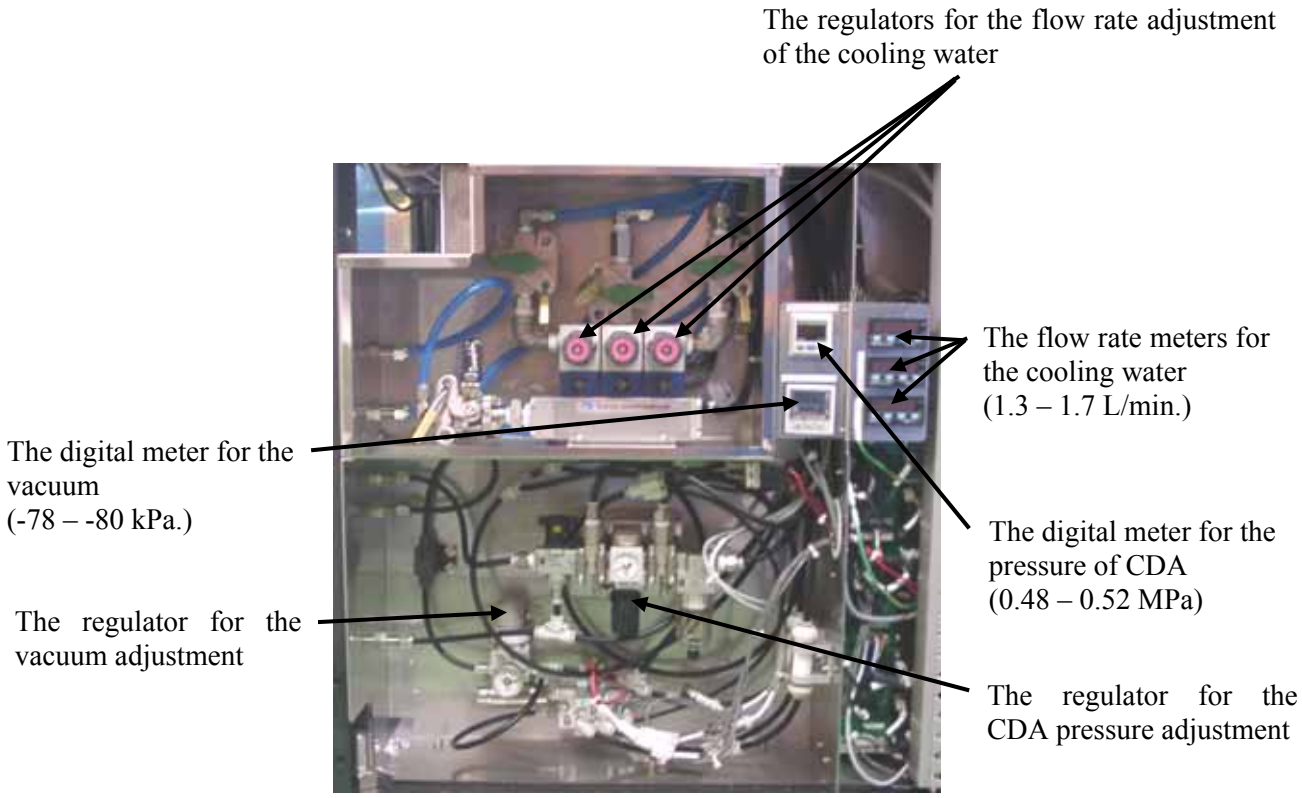


Fig. 13-1-1 The digital meters position

13.2 Cleaning of the transport line

Wipe as below figure, after opening the right side doors of the EFEM and the main module.

WARNING **Do not use the maintenance key, when cleaning.**



Take care to avoid injury from catching your finger in the side doors.

Also, take care to avoid injury from hitting your head against any mechanical projections.



WARNING **Do not touch the SDD.**



The beryllium foil is attached to the head of the SDD.

When ethanol, which should be managed in the customer's FAB, is used for cleaning, wear gloves.

(Refer to the attached MSDS.)

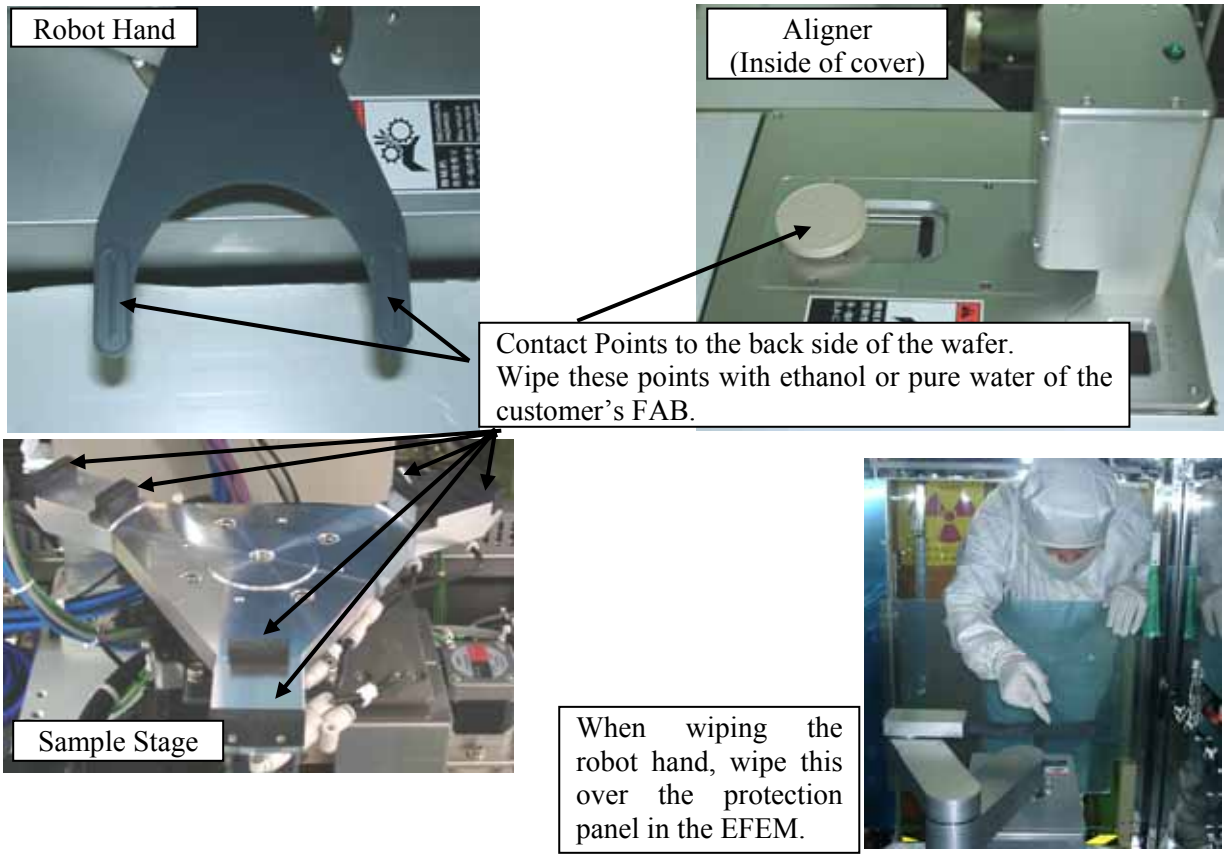


Fig. 13-2-1 Cleaning Points

NOTE: Use the hand light which is attached to the instrument, if necessary.



The handy light can be used by connecting to a socket, and see chapter 14.2 about the connection.

14. MAINTENANCE

14.1 Power Box

WARNING



When performing maintenance inside the Power Box where electrical hazard has any potential of causing personal injury or damage to the system, strictly follow **lock-out/tag-out** of the instrument before starting the maintenance work.

(Refer to "2.4 Lock-out/Tag-out".)

There are protection panels in the Power Box, don't remove these panels during power ON.

(The interlock operates and power OFF, if the protection panels are removed.)



Lock-out / Tag-out handle

(Refer to "2.4 Lock-out/Tag-out".)

The upper side



The connection terminals to the facility.
AC208/200V : 3 lines
Ground : 1 line

Main Breaker

The lower side

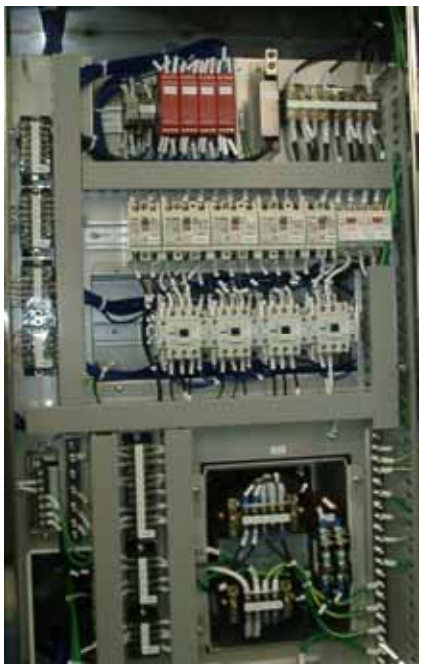


Fig. 14-1-1 Power Box Figure

NOTE: **Check all breakers are ON.**



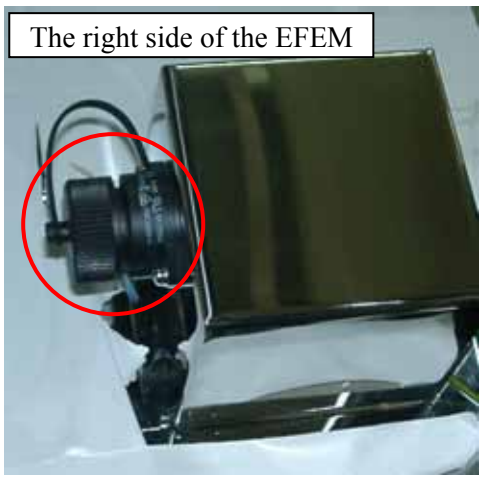
There are protection panels in the Power Box.
When removing these panels, strictly follow lock-out/tag-out of the instrument.
(Refer to "2.4 Lock-out/Tag-out".)

14.2 Using the handy light

It is available to use the handy light, when maintaining inside the EFEM or the main module.

There are three sockets for the handy light as below. If necessary, connect it to a socket after shutdown.

The handy light can be turned on at the state of the lock-out handle on and the power button on.



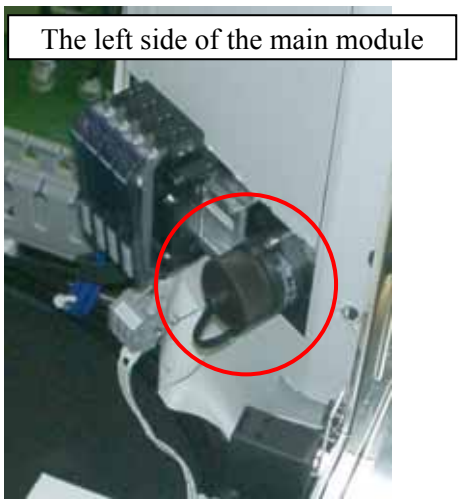




Fig. 14-2-1 The Sockets for the handy light

14.3 Utility Adjustment

The adjustments of cooling water, compressed dry air and vacuum are as following figures.

In general, the flow rate of cooling water is adjusted in the water chiller side, and the pressure of compressed air is adjusted by using the bulb of the facility side.

(1) Turn the main breaker lock-out handle on. (Refer to "2.4 Lock-out/Tag-out".)

(2) Remove the lower panel on the right side of the Main Module.

(3) Check the current adjustments as the following figures.

(4) Re-install the panel that was removed.

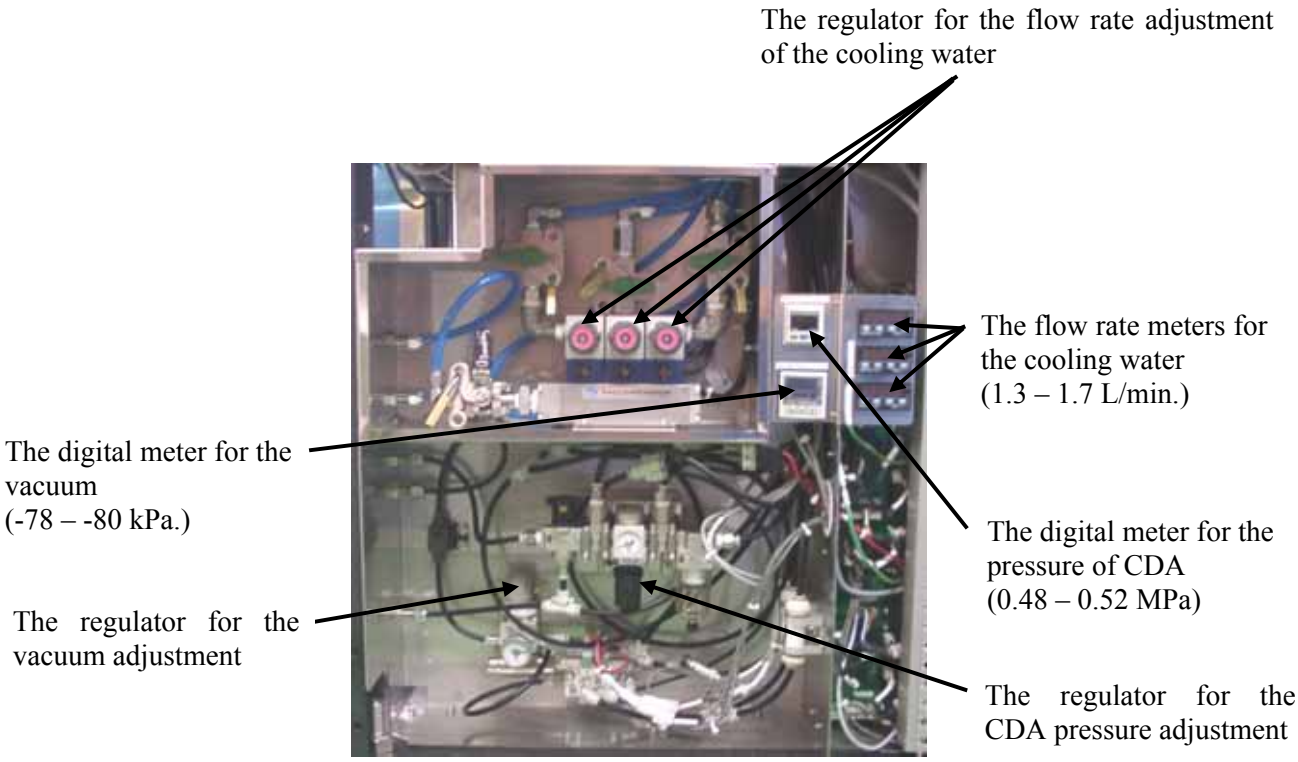


Fig. 14-3-1 The digital meters and regulators

14.4 Exchanging Parts

The Consumables and Maintenance parts are made a list in APPENDIX 1.

How to exchange old parts to new parts is described in this section.

14.4.1 Cooling Water

The cooling water for X-ray tube (secondary cooling water) is pure water.

When exchanging cooling water, refer to the manual of the water chiller.

CAUTION: 	Strictly follow **lock-out/tag-out** of the instrument before exchanging the cooling water. (Refer to “2.4 Lock-out/Tag-out”.)

14.4.2 UPS Battery

The UPS is used to protect the PC from the loss of electric power. (See the below figure.)
When exchanging the built-in battery in the UPS, refer to the manual of the UPS.

CAUTION



When exchanging the built-in battery in the UPS, strictly follow lock-out/tag-out of the instrument before exchanging.
(Refer to “2.4 Lock-out/Tag-out”.)

Refer to “A4.1 Power Circuit Diagram” for the UPS power connection.

(1) Turn off the main breaker lock-out handle. (Refer to “2.4 Lock-out/Tag-out”.)
(2) Remove the lower panel on the left side of the Main Module.
(3) Turn off the power switch of the CPU.
(4) Pull out the PC rack and the front unit of the PC and exchange the built-in battery.

NOTE



About the details for exchange, refer to the manual of the UPS.

CAUTION



The PC rack in the left lower side of the Main Module can be pulled out for the maintenance.
Take care not to trip over it.

(5) Re-install the PC and the PC rack, and turn on the power switch of the PC.
(6) Re-install the panel that was removed.
(7) Turn on the main breaker lock-out handle, and battery charging starts.

14.4.3 Accessories of PC

The PC has some exchangeable accessories, which are the LCD, keyboard, trackball and joystick.

NOTE **Shutdown PC and turn off the instrument with the POWER OFF button on the Power Box of the rear side before exchanging them.**

CAUTION Take care to avoid injury from catching your fingers in the slider of PC panel.
Take care to avoid injury from hitting your head against the PC panel.



(1) LCD

Remove four screws on the rear side after pulling out cables, and then exchange the LCD.

(2) Keyboard

Pull out the external USB connector of the keyboard, and then exchange the keyboard.
(The original USB cable which is fixed to the keyboard is not used.)

(3) Trackball

Remove the cover of the PC panel, and then exchange the trackball.

(4) Joystick

Remove the cover of the PC panel, and then exchange the joystick.

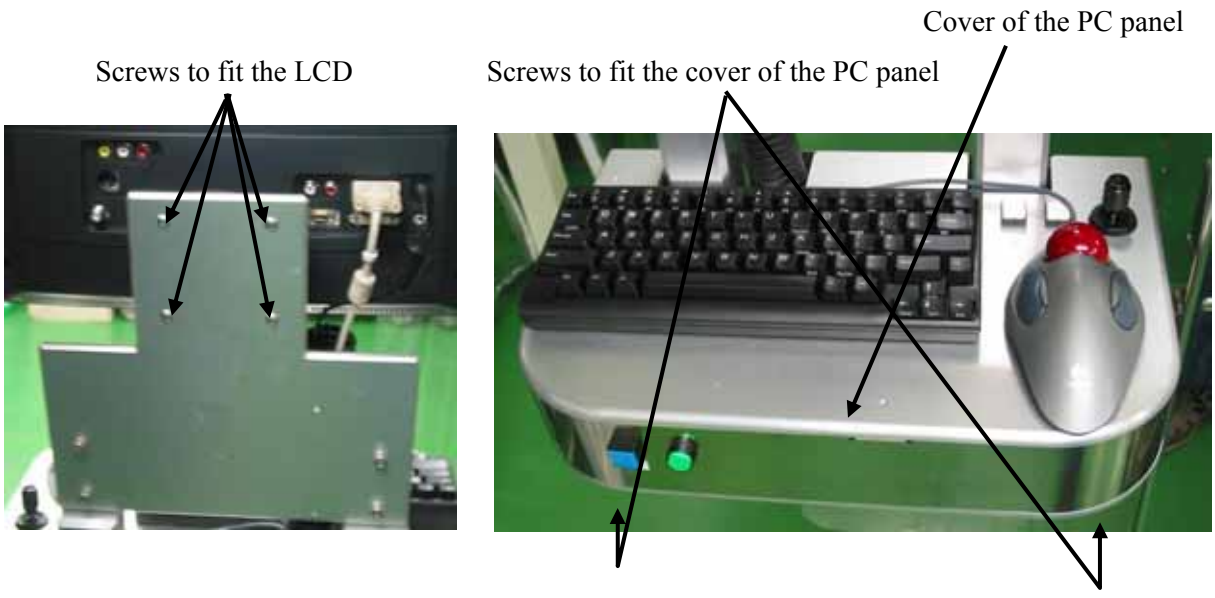


Fig. 14-4-2 PC panel

15. TROUBLE SHOOTING

15.1 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.
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 inside the maintenance doors where electrical hazard or unexpected movement of mechanical parts has any potential of causing personal injury or damage to the system, **strictly follow lock-out/tag-out of the instrument before checking. (Refer to "2.4 Lock-out/Tag-out".)**
	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".)

15.2 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).
	Check to make sure that CDA and vacuum are supplied. Make sure of utility connections. (Refer to “14.3 Utility Adjustment” for checking inside.)
	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”.)
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 (refer to the operation manual of the water chiller).

Troubles	Causes and remedies
	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”.)

15.3 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.

15.4 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" in the operation manual.
	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.

15.5 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. (Refer to "14.3 Utility Adjustment" for checking inside.)
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" in the operation manual.)
	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" in the operation manual.)
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. (Refer to "14.3 Utility Adjustment" for checking inside.)
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".)

15.6 Sample Alignment

Troubles	Causes and remedies
Sample alignment fails.	Check to make sure that the alignment condition (scanning range) is appropriate. Observe the scan profile of ω-axis during the sample alignment. Widen the scanning range so that the above-mentioned profiles can be obtained.
	Check to make sure that the incident angle (2θ) of the reflection alignment is appropriate. Angle setting should be made for the total reflection range as a principle. Check the setting.
	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.

15.7 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.
The measurement profile intensity is extremely low.	Check to make sure that the sample alignment is conducted properly. In the sample alignment conducted prior to the XRR measurement, observe the scan profile of ω-axis and make sure that there is no abnormality.
	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. In that case, make sure that the ω scan alignment is appropriate.
	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.

15.8 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. Refer to the manual of the XRF analysis software.
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.
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.

15.9 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. (Refer to "15.2 Startup".)
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 Consumables and Maintenance Parts

(1) List of consumables

Items	Models	Frequency of exchange	Suppliers
X-ray tube (Cu-target)	752-004982	5000 hours	Rigaku
X-ray tube (Mo-target)	752-004981	5000 hours	Rigaku
Filter of FFU	BV-R13TU1G3R	One year	Rigaku
Halogen lamp	JCR15V150WH5	One year	Rigaku
Secondary cooling water	(Pure water)	Six months	

NOTE: **X-ray tubes, filters of FFU and the halogen lamp should be exchanged by Rigaku service personnel.**



Contact to Rigaku service center for exchange.

WARNING



Metal Beryllium foil is used for the X-ray tube window. Solid Beryllium usually has no influence on human health, but evidence exists that the personnel who inhales the beryllium powder or vapor risks a possibility of serious injury or death. Do not scratch, polish, and sweep with neither chemical nor bake up to temperature so as to generate vapor or powder. In case that beryllium window is ruptured, Personal Protective Equipment must be used and collect as much chips as possible. Then dispose them according to local regulations. If difficulty in local disposal exists, please gather the pieces of fractured Beryllium window up carefully and send back them together with X-ray tube back to the manufacturer.

(Refer to the attached MSDS.)

WARNING



Used a halogen lamp in the light unit for the pattern recognition.

Do not touch before cooling.

Wear safety gloves, when exchanging this lamp.

(2) List of maintenance parts

Items	Models	Suppliers	Remarks
Multi-layers mirror for Cu	C086-13-1	Rigaku	×
Multi-layers mirror for Mo	C086-14-1	Rigaku	×
UPS Battery	BS10A-H24/2.0L	Nipron	×
Robot Hand	C093-25-1	Rigaku	×
X-ray detector (APD)	A989-001-3-4	Rigaku	×
X-ray detector (SDD)	C093-24-1	Radiant	×
X-ray detector (SC70)	Cat.No.5738E401	Radiant	×
Load port	TAS300	TDK	×
Keyboard	PD-KB200B/U	Rigaku	
Trackball	H56-5600 White	Rigaku	
Joystick	30JEK-ZU-06R3	Rigaku	
LCD	LCD-AD174CB	Rigaku	
DC power supply	AC4-000HH-00	Rigaku	×
FAN (bottom)	T-MDS1451-24L-G	Rigaku	×
FAN (driver)	T-MD825B-24L	Rigaku	×
FAN (rear)	T-MD825-24L	Rigaku	×
Surge arrester	RAV-781 BXZ-2A	Rigaku	×
Fuse (RCD/XGC)	NF60-NR5A	Rigaku	×
Fuse (AFC)	T1L250V	Rigaku	×
Fuse (Power Box)	FNQ-R-15	Rigaku	×

NOTE: **Items of × mark should be exchanged by Rigaku service personnel.**



Contact to Rigaku service center for exchange.

WARNING



Metal Beryllium foil is used for the windows of X-ray detector APD and SDD. Solid Beryllium usually has no influence on human health, but evidence exists that the personnel who inhales the beryllium powder or vapor risks a possibility of serious injury or death. Do not scratch, polish, and sweep with neither chemical nor bake up to temperature so as to generate vapor or powder. In case that beryllium window is ruptured, Personal Protective Equipment must be used and collect as much chips as possible. Then dispose them according to local regulations. If difficulty in local disposal exists, please gather the pieces of fractured Beryllium window up carefully and send back them together with X-ray detector back to the manufacturer.

(Refer to the attached MSDS.)

A1.2 Disposing the Equipment and parts

The MFM65 system can be used for a long time by exchanging broken parts and consumable parts.

When disposing the MFM65 system, units of this system or parts of this system, please pay attention of the hazard materials and recyclable materials.

(1) Hazard materials

Refer to “2.1 Hazards and Risks” and the attached MSDSs in APPENDIX 5.

WARNING When disposing hazard materials, conform to the regulations and the local regulations, and contact to the specified traders or Rigaku service center.



(2) Recyclable materials

The MFM65 system has some recyclable materials, metals (iron, stainless steel, aluminum etc.), polycarbonate etc.

The products related to PC system are recyclable materials.

APPENDIX 2

A2.1 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

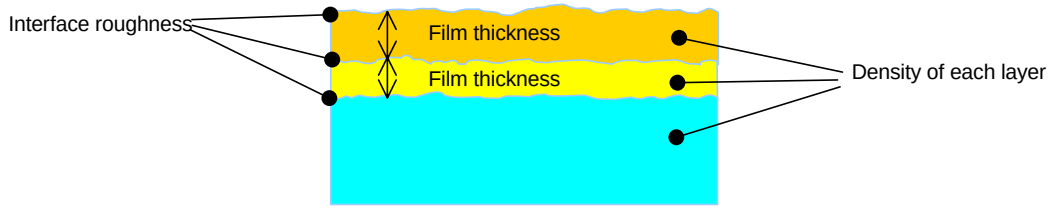


Fig. A2-1-1 Layer Model

(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..))

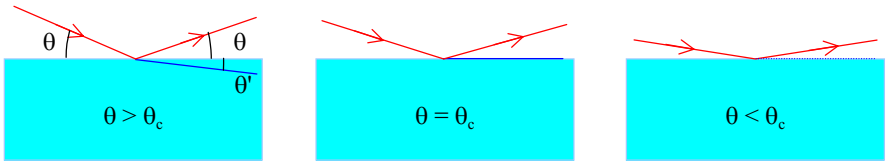


Fig. A2-1-2 Critical Angle

(2) When reflection occurs only on the surface

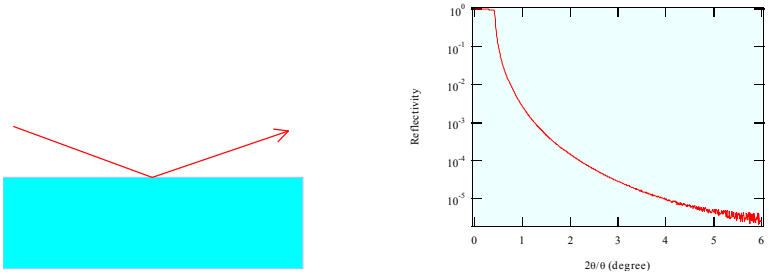
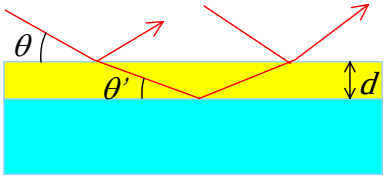


Fig. A2-1-3 Surface Reflection

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

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



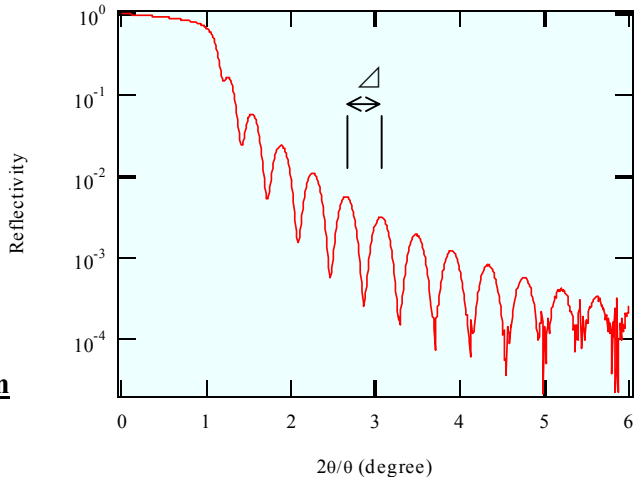


Fig. A2-1-4 Thickness Oscillation

(4) Interpretation of the XRR profile

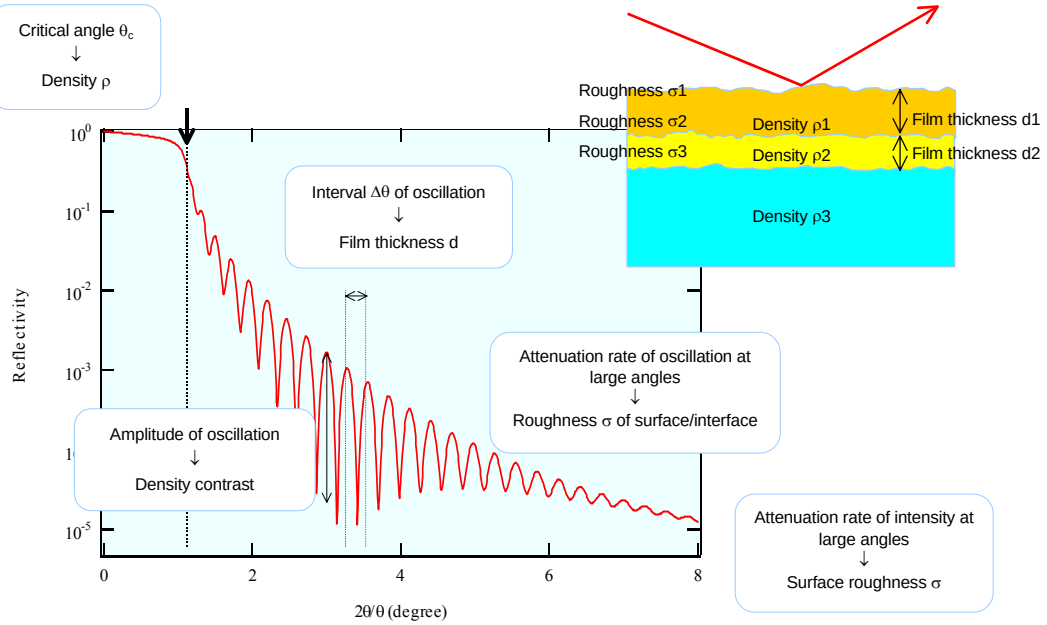
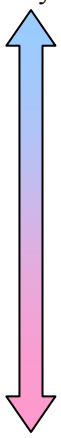
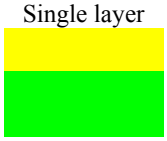
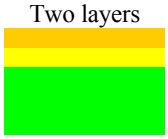


Fig. A2-1-5 XRR Profile

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 

A2.2 Analysis/Measurement Flow

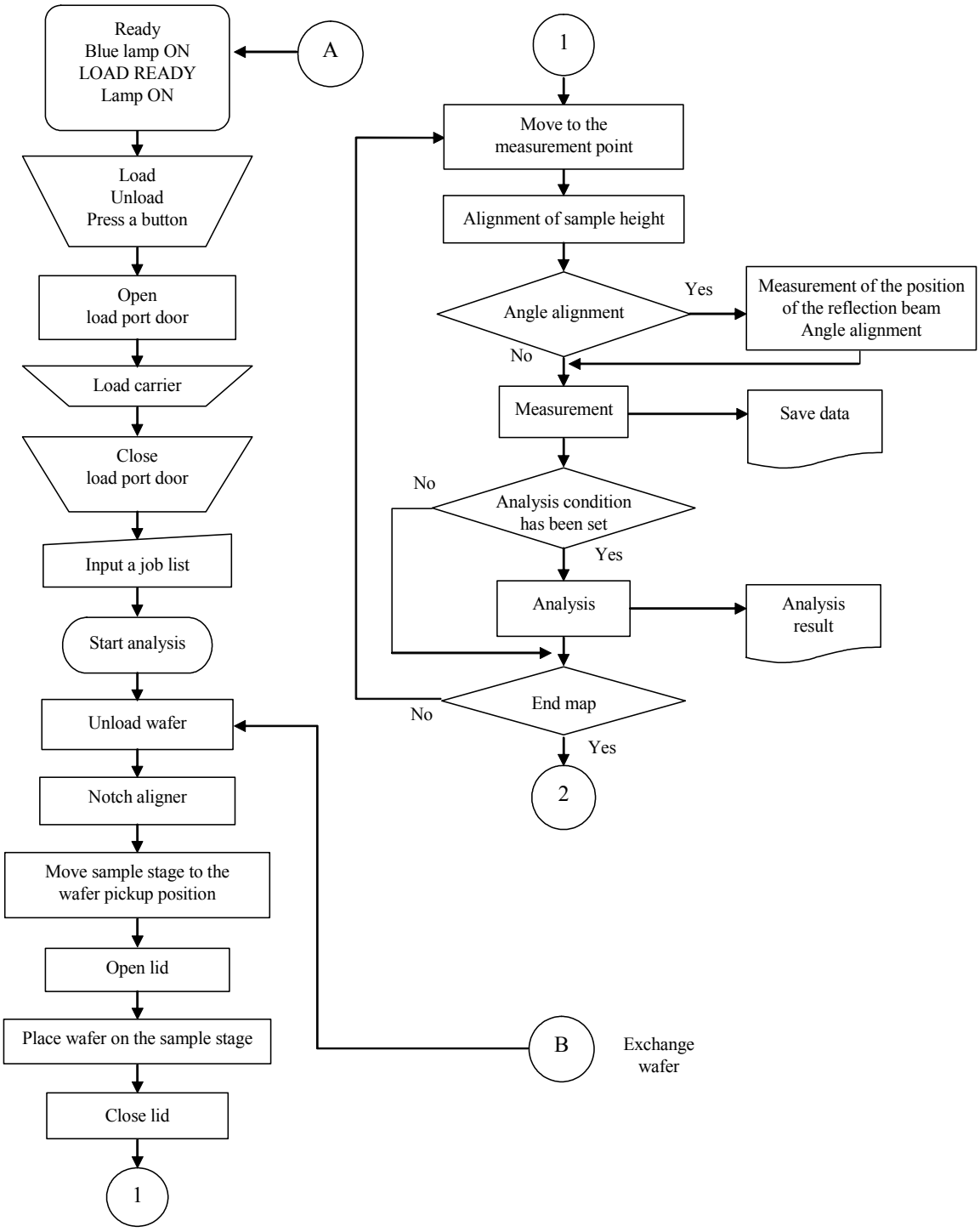


Fig. A2-2-1 Analysis Measurement Flow 1

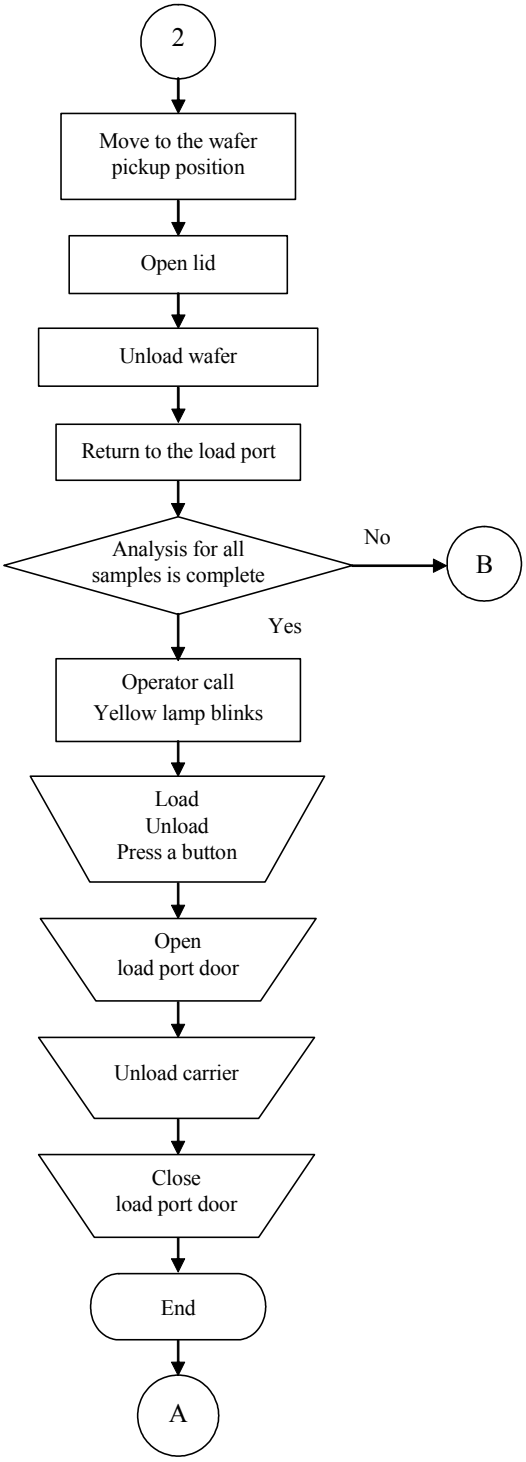


Fig. A2-2-2 Analysis Measurement Flow 2

APPENDIX 3

A3.1 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 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 optional measurement (XRD) * 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 4

A4.1 Power Circuit Diagram

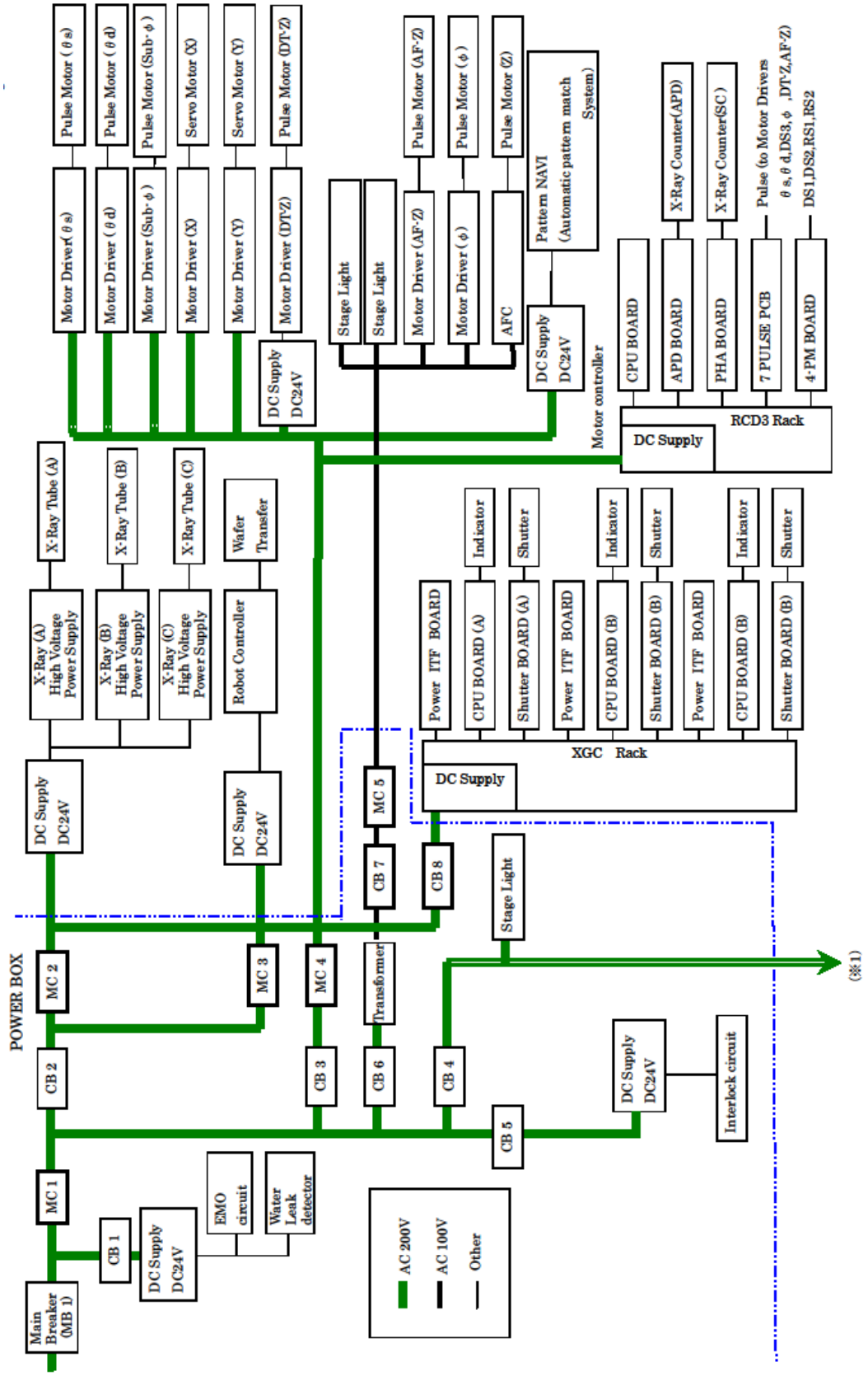


Fig. A4-1-1 Power Circuit Diagram 1

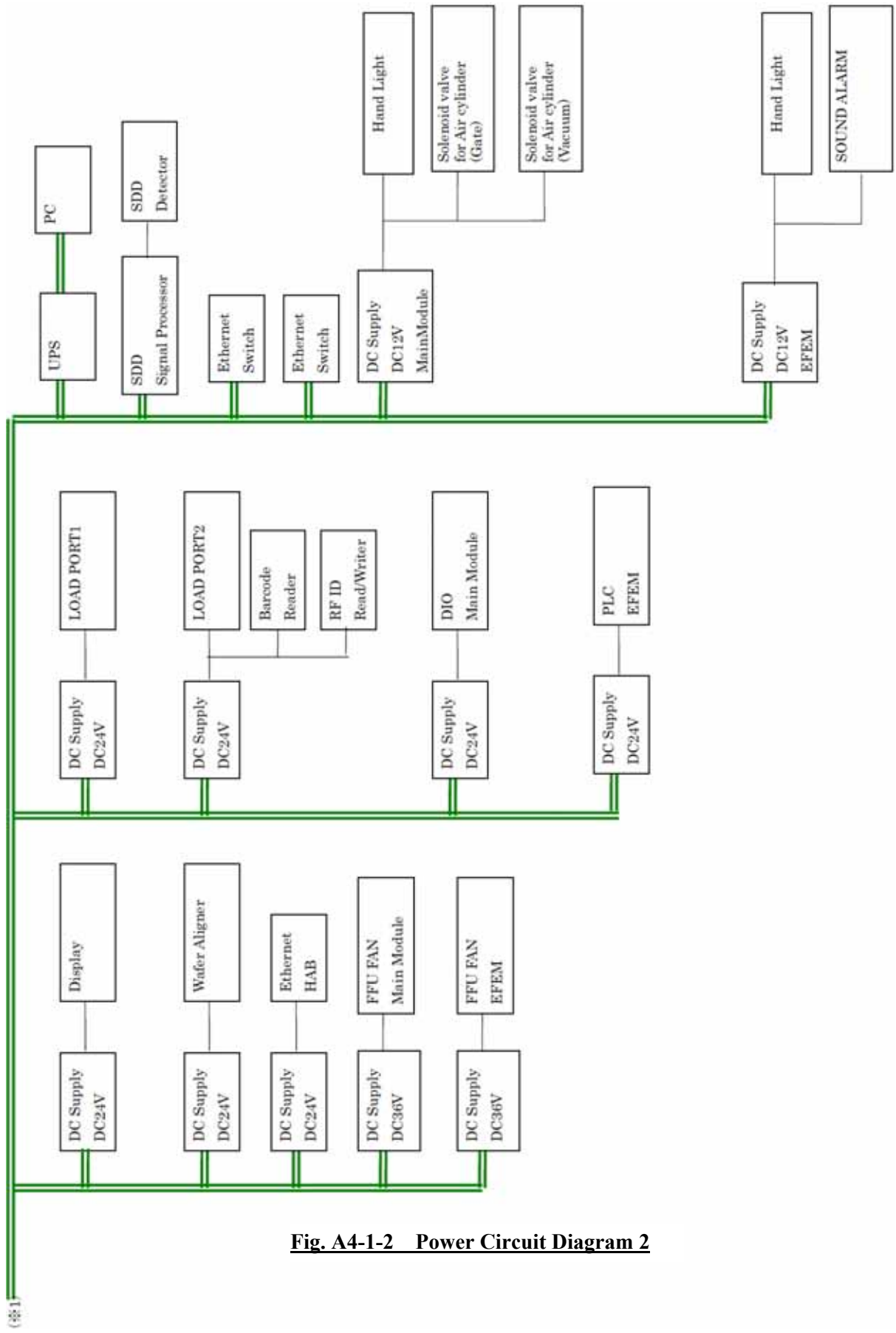


Fig. A4-1-2 Power Circuit Diagram 2

A4.2 EMO Circuit

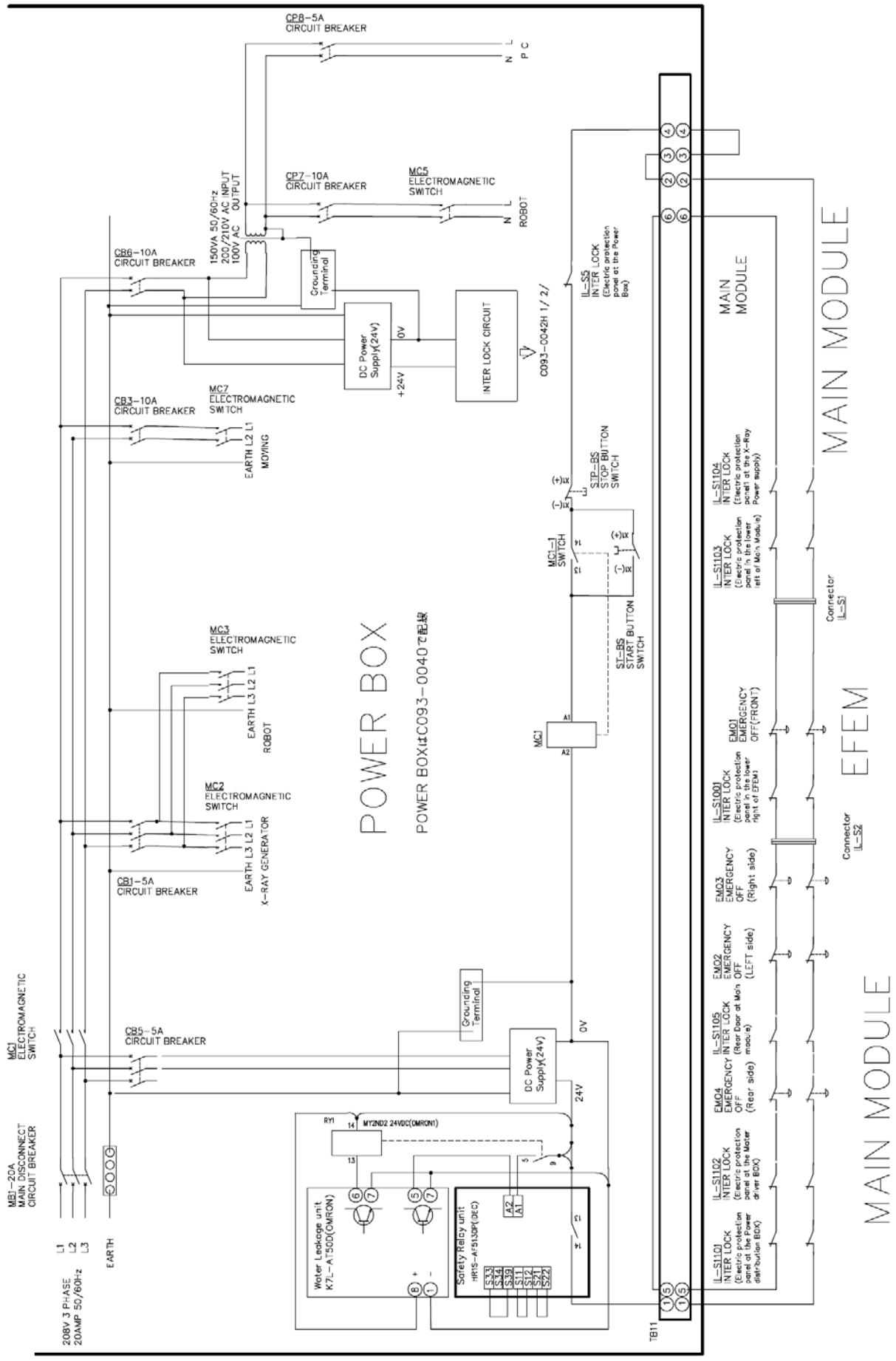


Fig. A4-2-1 EMO Circuit

APPENDIX 5

A5.1 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)

A5.2 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.

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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.

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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

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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.

A5.3 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

A5.4 MSDS of Lithium

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.

A5.5 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.

A5.6 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/

Rigaku

A5.7 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

Rigaku Corporation **Tokyo Branch**
4-14-4, Sendagaya, Shibuya-ku, Tokyo 151-0051, Japan
Phone: 81-3-3479-0618 Fax: 81-3-3479-6112 e-mail: rinttyo@rigaku.co.jp

Rigaku Corporation
Head Office
3-9-12, Matsubara-cho, Akishima-shi,
Tokyo 196-8666, Japan
Phone: 81-42-545-8189 Fax: 81-42-544-9223

Rigaku Industrial Corporation
14-8, Akaoji-cho, Takatsuki-shi,
Osaka 569-1146, Japan
Phone: 81-72-693-7990 Fax: 81-72-693-6746

Rigaku Americas Corporation
9009 New Trails Drive
The Woodlands, TX 77381-5209, USA
Phone: 281-362-2300 Fax: 281-364-3628
e-mail:info@rigaku.com
http://www.rigaku.com/

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