

S-Former Rectifiers

Recommendations of preventive maintenance and renewal



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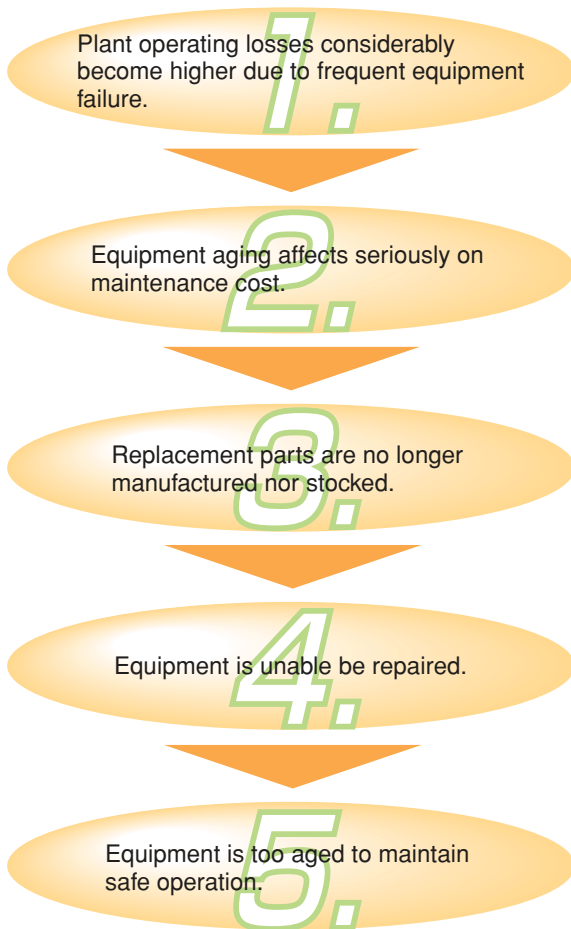
Are your facilities sounds?

A DC power supply for electrolysis (rectifier hereafter) is ranked high as important equipment in electrolytic facilities, and high reliability is essential. In order that its high reliability in operation can be maintained up to the end of expected life, it is necessary that you properly carry out routine and periodic checkups. It is also necessary for you to schedule and execute periodic replacement of deteriorated parts, updating to a more dependable structure, etc.

Life of rectifier

How to judge the end of life

You cannot simply say, "The life of rectifier is deemed ended when it is no longer usable on account of breakage". You can restore its function even if its components have become defective, by replacing them. The life of rectifier is deemed ended in any of the following cases.

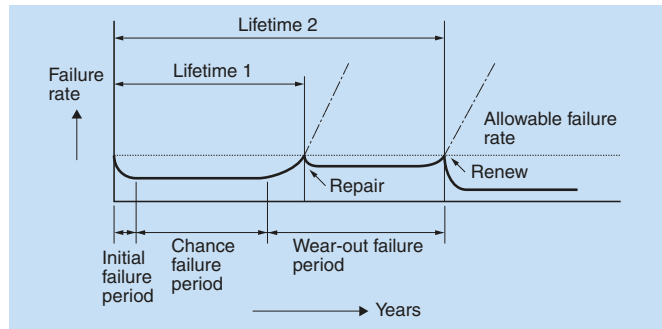


According to many actual results and experiences, Fuji Electric considers "The expected life of a rectifier is 20 years", and asks users to replace the rectifier after about 20 years' use.

Proposal of overhaul and deterioration diagnoses

The expected life of 20 years, as stated above, is possible only by executing to routine maintenance, periodic overhaul, and replacement of parts at early stages of their deterioration. As devices get old, they deteriorate and tend to experience problems. Fig. 1 shows a typical pattern of failure by deterioration.

Fig. 1 Device failure pattern



As is clear from Fig. 1, in order that the device can be used for an extended length of time, it is important to:

- Replace parts discovered to be deteriorated by periodic checkup with new ones;
- Replace parts with latest ones that have high reliability and easy maintenance; and
- Check whether the device is deteriorated or not when it is getting near its end of life, thereby knowing the remaining lifetime and the time to replace.

Different types of checkups are outlined below.

Routine checkup (while running)

The purpose of routine maintenance and checkup is to grasp the running status of the device under usual operation. Watch the meter readings, check whether the cooling fan or pump produces unusual sound, and note any anomalies. All these can help avoid occurrence of problems and allow you to estimate when to overhaul the device.

Periodic checkup (device turned off)

Carry out periodic checkup upon stopping the equipment. According to how long the equipment has been used, carry out normal or detailed checkups, with intervals determined accordingly.

The checkup frequency is as follows.

Normal checkup : Every year.

Detailed checkup : Every 5 years.

Overhaul

Replace parts identified by routine or periodic checkup, change any parts found deteriorated thereafter, check the performance of electric parts, and proceed to overall tests to refresh the equipment.

It is advised to overhaul the equipment every 10 years.

How long is the expected life of structural parts?

Checkup intervals and replacement intervals of main component parts

Part	Checkup/renewal frequency	Procedure
Power semiconductor (thyristor, diode)	<ul style="list-style-type: none"> ● Detailed checkup every 5 years. ● Replace semiconductor if its forward/reverse current is larger than specified. 	<ul style="list-style-type: none"> ● Leakage current measurement Judge whether power semiconductor is deteriorated or not in terms of leakage current.
Resistor (enamel resistor, others)	<ul style="list-style-type: none"> ● Detailed checkup every 5 years. ● Replace every 10 to 15 years depending on environment conditions. 	<ul style="list-style-type: none"> ● Resistance measurement and external inspection Resistors often suffer from open circuit due to corrosion.
Capacitors	<ul style="list-style-type: none"> ● Detailed checkup every 5 years. ● Replace every 10 to 15 years. 	<ul style="list-style-type: none"> ● Capacitance measurement and external inspection (oil oozing, etc.) Capacitor life is 10 years according to manufacturers.
Semiconductor protective fuse	<ul style="list-style-type: none"> ● Detailed checkup every 5 years. ● Replace every 10 to 15 years. 	<ul style="list-style-type: none"> ● Resistance measurement and external inspection (crack, discoloration, etc.) Replacing every about 10 years is recommended for ensuring the reliability.
Main circuit insulating material	<ul style="list-style-type: none"> ● Checkup every 2 years (for air cooled type). ● Replace every 10 to 15 years. 	<ul style="list-style-type: none"> ● External inspection and insulation resistance measurement Beware of deterioration of insulation due to moisture absorption of bakelite. Insulating materials get thin. To fasten them, retighten bolts.
Insulated hose	<ul style="list-style-type: none"> ● Replace every 10 to 15 years. 	<ul style="list-style-type: none"> ● External inspection Oxidized copper caused by electric erosion may stick to hose inside and blackens, thereby deteriorating the insulation.
Cooling fan	<ul style="list-style-type: none"> ● Replace bearings every 2 to 3 years. ● Replace motor every 5 to 10 years. 	<ul style="list-style-type: none"> ● External inspection and unusual sound check Replace bearings when worn (judged by unusual sound).
Demineralized water pump	<ul style="list-style-type: none"> ● Replace bearings every 3 to 5 years. ● Replace pump every 5 to 10 years. 	<ul style="list-style-type: none"> ● External inspection and unusual sound check Replace bearings when worn (judged by unusual sound or monitor).
Gasket	<ul style="list-style-type: none"> ● Replace every 10 to 15 years. 	<ul style="list-style-type: none"> ● External inspection If water leakage or cracking of the gasket is observed, there is a possibility where the gaskets have deteriorated or damaged. Replace the gaskets at abnormal points.
Protective instruments (dial thermometer, water flow indicator, dial water level meter, thermostat)	<ul style="list-style-type: none"> ● Replace every 10 to 15 years. 	<ul style="list-style-type: none"> ● Operation test Replace if found faulty at checkup.
Contactors, relay	<ul style="list-style-type: none"> ● Replace every 5 to 10 years. 	<ul style="list-style-type: none"> ● Operation test Contact life depends on operation frequency and environment conditions.

Note: The above table does not indicate the guarantee periods of parts.

Checkup and overhaul

Checkup criteria for air cooled rectifier

Division	Checkup type	Routine checkup (while running)	Periodic checkup (normal)	Periodic checkup (detailed)	Overhaul	
Description	Check every:		year	5 years	10 years	
General	Unusual sound, unusual odor, unusual vibration	○	○	○	○	
	Rust, roof leakage, painted status	○	○ Retouch	○	○ Repaint	
Main circuit	Door opening, packing	○	○	○	○ Replace	
	Dust accumulation (cleaning)	△ Visual	○	○	○	
	Electric circuitry					
	• Input/output terminals overheat	△ Visual	○	○	} Replace as required	
	• Input/output terminal connection loosening	△ Visual	○	○		
	• Insulating plate, support insulator damage, getting lean	△ Visual	○	○		
	• Wiring, soldering	△ Visual	○	○		
	Power semiconductor					
	• Tightening torque, contamination	—	○	○	○	
	• Leakage current measurement	—	—	○	○ Replace as required	
• Contamination check	△ Visual	○	○	○		
R-C snubber circuit, absorber circuit						
• Capacitor oil oozing	△ Visual	○	○	} Replace as required		
• Resistor appearance, mounting	△ Visual	○	○			
• Capacitance, resistance measurement	—	—	○			
Main circuit conductor overheat, discoloration	△ Visual	○	○	○		
Main fuse						
• Appearance check	△ Visual	○	○	} Replace as required		
• Resistance measurement	—	—	○			
Insulating tube, insulating plate	—	○ Retighten	○ Retighten			
Cooler	Air filter cleaning	○ every month	○	○	○ Replace	
	Cooling fan					
	• Unusual sound	○	○	○	} Replace as a set	
	• Bearing replacement	—	○	○ Replace		
• Insulation resistance measurement	—	○	○			
Protective instrument	Thermometer (reading)	○	○	○	○ Replace	
	Wind cut relay	—	—	○	○ Replace	
	• Operation check	△ Visual	○	○	○	
Overall equipment	Insulation resistance measurement	—	○	○	○	
	Dielectric strength test	—	—	—	○	
	Sequence operation test	—	○	○	○	
Controller	ACC (automatic current controller)					
	• Controller source voltage check	—	○	○	} Replace parts as required (by printed boards)	
	• Synchronizing signal voltage check	—	○	○		
	• Setter circuit voltage check	—	○	○		
	• Pulse check	—	○	○		
	• Sequence operation test	—	○	○		
	• External structure check	△ Visual	○	○		
	Monitor panel, etc.					
	• External structure check	△ Visual	○	○		

■ Checkup criteria for water cooled rectifier

Division	Description	Checkup type	Routine checkup (while running)	Periodic checkup (normal)	Periodic checkup (detailed)	Overhaul
		Check every:		year	5 years	10 years
General	Unusual sound, unusual odor, unusual vibration Rust, roof leakage, painted status Door opening, packing Dust accumulation (cleaning) Electric circuitry • Input/output terminals overheat • Input/output terminal connection loosening • Insulating plate, support insulator damage, getting lean • Wiring, soldering	○	○	○	○	○ ○ Repaint ○ Replace ○ ○ } Replace as required ○
		○	○	○ Retouch	○	
Main circuit	Power semiconductor • Tightening torque, contamination • Leakage current measurement • Contamination check R-C snubber circuit, absorber circuit • Capacitor oil oozing • Resistor appearance, mounting • Capacitance, resistance measurement Main circuit conductor overheat, discoloration Main fuse • Appearance check • Resistance measurement Insulating tube, insulating plate	△ Visual	○	○	○	○ ○ Replace as required ○ ○ } Replace as required ○
		△ Visual	○	○	○	
Cooler	Insulating water hose contamination, crack, leakage Cooling water inspection Cooling fan • Unusual sound • Bearing replacement • Current measurement Demineralized water pump • Unusual sound • Bearing replacement • Current measurement Heat Exchanger • Water leaking • Internal cleaning	△ Visual	○	○	○	○ ○ Replace as required ○ ○ } Replace as required ○
		△ Visual	○	○	○	
Protective instrument	Thermometer, flow meter, level gauge, etc. • Reading check Thermal switch, etc	△ Visual	○	○	○	○ ○ Replace as required ○
		△ Visual	○	○	○ Operation check	
Overall equipment	Insulation resistance measurement Dielectric strength test Sequence operation test	△ Visual	○	○	○	○ ○ ○
		△ Visual	○	○	○	
Controller	ACC (automatic current controller) • Controller source voltage check • Synchronizing signal voltage check • Setter circuit voltage check • Pulse check • Sequence operation test • External structure check Monitor panel, etc. • External structure check	△ Visual	○	○	○	○ ○ } Replace parts as required (by printed boards) ○ ○ ○ ○ ○
		△ Visual	○	○	○	

Recommendation of part diagnosis and replacement

Diagnosis of main parts

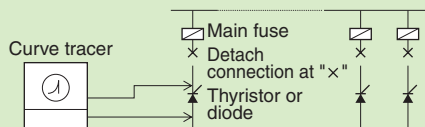
Diagnosis of power semiconductors (thyristors, diodes)

Characteristics of some power semiconductors used in the main circuit of rectifier change if exposed to thermal stresses for an extended period of time. If used in poor atmosphere (corrosive gas, etc.), the case of power semiconductor may be pierced, thereby causing poor insulation or deteriorated characteristics. For preventive maintenance of power semiconductors, periodic diagnoses (reverse leakage current measurement) are important.

● Leakage current measurement

For deterioration diagnosis for power semiconductors, we adopt a method of measuring leakage current. There are two ways of measurement. One is reading the leakage current while watching the waveform by curve tracer, and the other is reading the voltage and current by leakage current checker. Because a side of the power semiconductor is detached, the measurement is carried out at periodic checkup when the rectifier is shut down. The measurement setup is shown in Fig. 2.

Fig. 2 Leakage current measurement setup



Careful review of the secular changes of readings is effective for locating anomalies of power semiconductors at early stages.

Whether the leakage current is normal or not depends on particular power semiconductors. For details, contact us.

● Replacement of power semiconductors

If a semiconductor is found faulty by inspection, it must be replaced with a new one. Some types may have become obsolete and are no longer available.

In such a case, replace the relevant semiconductor and all others on the relevant arm all together with ones of the same type.

● Discontinuance of power semiconductors

Small-capacity and old thyristors and diodes are discontinued on account of:

- Lack of demand because of trend toward large-capacity design of power semiconductors; and
- Lack of availability of related materials.

Table 1 gives discontinued types, and Table 2 indicates substitutes for maintenance.



Table 1 Discontinued types

Name		Typical type of power semiconductor
Diode	Si	Si150, Si150-1, Si250-1, Si250-3
	SIN	SIN01-12, SIN01A-12
	KS	KS250H
	KSN	KSN01-12, KSN02-12, KSN02-12A
	KSP	KSP03-20, KSP03-25, KSP03-30, KSP03-30A
	ERN	ERN13-16, ERN13-20, ERN14-08, ERN04-20
	ERP	ERP13-16, ERP15-16, ERP04-20, ERP04-25, ERP04-30, ERP04-35
	ERR	ERR15-16, ERR15-19, ERR03-30
	ER	ER1601FL-30
	Thyristor	GTN
EGN		EGN03-16, EGN04-08, EGN05-12, EGN05-16, EGN13-16, EGN14-08
KGP		KGP11-08, KGP11-12, KGP11-12A
EGP		EGP13-16, EGP14-08, EGP14-09
EGS		EGS03-40

Table 2 Substitutes for maintenance

Name		Typical type of power semiconductor
Thyristor	EGR	EGR13-16, EGR03-25

Note: The delivery term for substitutes for maintenance is rather long. We encourage users to plan ahead and allow sufficient time for scheduling and arrangement of replacement parts.

Diagnosis of semiconductor protective fuse

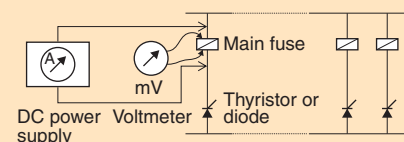
High reliability is imposed on the semiconductor protective fuse, which is connected in series with power semiconductor for over current protection. It is important to periodically diagnose it and, if faulty, replace it with a new one, taking advantage of detailed checkup executed every 5 years.



● Fuse resistance measurement

For fuse diagnosis, measure the element resistance and compare it with its control value (initial characteristics value). Contact us for the control value because it depends on the particular fuse type. Measure the resistance by DC voltage drop method. Its measurement setup is shown in Fig. 3.

Fig. 3 Resistance measurement setup



● Fuse replacement

Replace the fuse which was found abnormal by resistance measurement or whose appearance is abnormal with a new one of the same type. There are no substitutes. We recommend you to purchase spare ones to have on hand at your facility.

Some fuses will be discontinued in the near future, and long delivery term will be required for some types.

We encourage you to have sufficient spares on hand at all times.

● Discontinuance of semiconductor protective fuses

Table 3 gives discontinued types.

Table 3 Discontinued types

Type	Type
RF1233f-180B	SRF-3-350B
RF1233f-200	SRF-3-500
RF1233f-350F	SRF-3-700
RF1233f-350B	SRF-8-500
RF1233f-350	SRF-8-1400
RF1233f-500	
RF1244-3-350	

Note: For substitute fuses, contact us specifying the existing types also.

Capacitor and resistor diagnosis

The protective network for main circuit of rectifier uses many capacitors and resistors. Depending on part layout, a checkup is available as it is for some networks but not for others unless disassembled enough. Diagnose them by routine checkup if available, and others by periodic checkup. We recommend you to replace capacitors and resistors taking advantage of detailed checkup or overhaul. A guidepost for replacement is every 10 years.



● Capacitor and resistor diagnosis

- Measure the capacitance and compare the reading with the specified value for judging whether serviceable or not.
- The typical judgment criteria is within $\pm 10\%$, except for special ones.
- Visually check whether the capacitors suffer from leakage or not. If oil has leaked or oozed, replace the affected ones immediately.

Resistors

- Measure the resistance and compare the reading with the specified value for judging whether satisfactory or not.
- The typical judgment criteria is within $\pm 10\%$, except for special ones.
- Visually check whether the resistors suffer from discoloration on the surface, enamel cracks and peeling-off.



● Capacitor and resistor replacement

Replace faulty ones with the same types or, if unavailable, with selected substitutes. If the mounting method or structure is different, use adapters or take other modifications.



Cooling fan and pump bearing diagnosis

The rectifier cooling fan (fan hereafter) is used for cooling in the rectifier room and for circulation. The demineralized water pump (pump hereafter) is used for cooling water for power semiconductors, etc. If the fan or pump bearing breaks, the bearing seizure or motor burnout will occur, the rectifier cooling performance will deteriorate, and an overheat may occur.

By routine checkup, check whether there is unusual sound or vibration of the cooling fan, and replace the bearings according to a predetermined schedule.



● Fan bearing life

The bearings use lubricant (grease hereafter). The grease has limited life, which is considerably shorter than the life of the bearing itself. The life of bearings as a set depends on the grease. The life is approximately 2 years based on 24 hours daily operation.



● Pump bearing life

The bearings are used in demineralized water, and their life is considerably affected by the temperature of demineralized water. Under continuous operation, they are usually usable for service of over 1 year. If the conditions are poor, increase the periodic checkup frequency accordingly.



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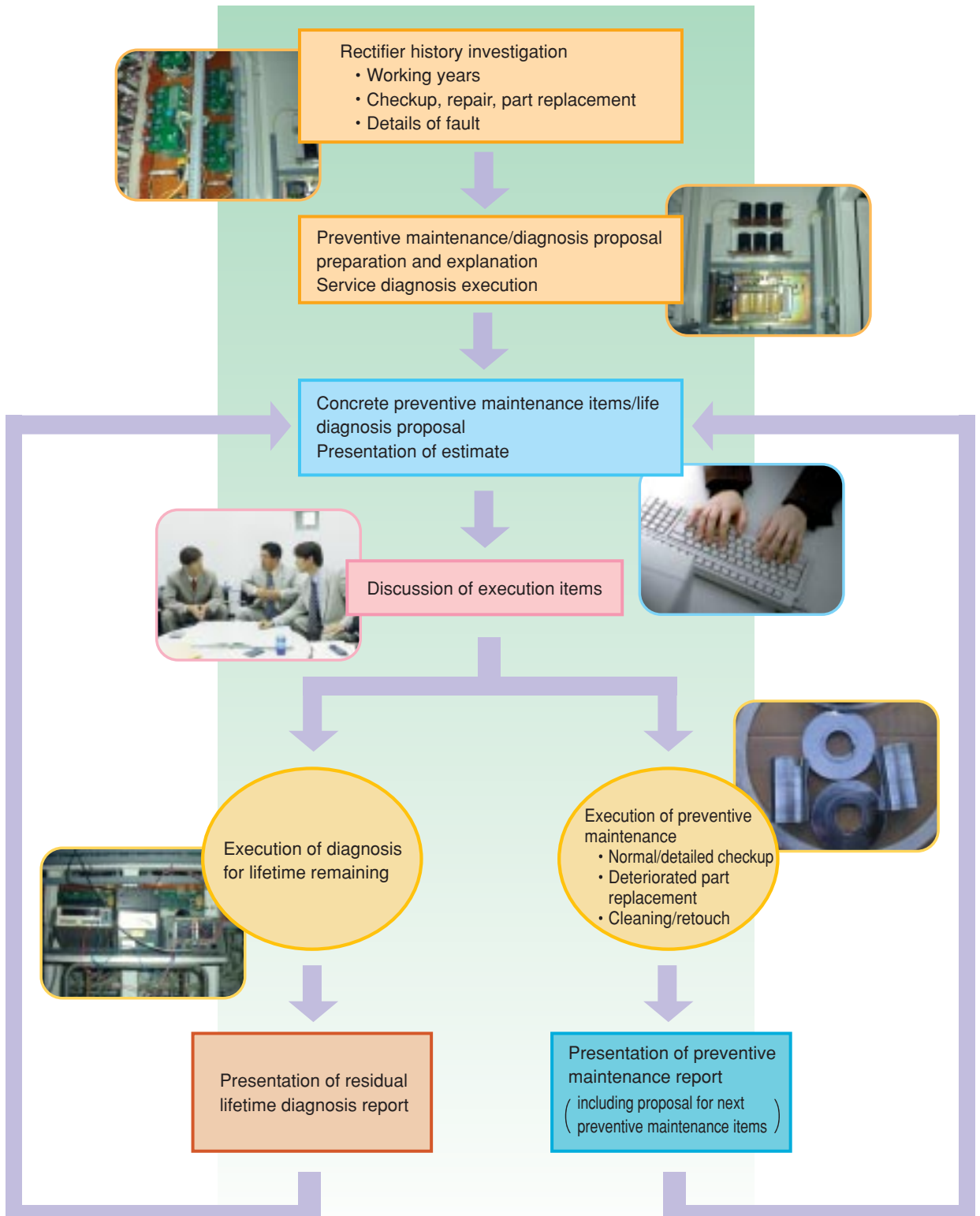
Some types of previously delivered fans and pump may have been discontinued.

In such a case, they will have to be replaced with substitutes of equivalent specifications.



Preventive maintenance and diagnosis procedure

Rectifier diagnosis procedure



**Maintenance specialists of the Fuji Electric Group
satisfy your needs with expertise and technical skills.**



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 Fuji Electric Co., Ltd.

Gate City Ohsaki, East Tower, 11-2, Osaki 1-chome, Shinagawa-ku, Tokyo 141-0032, Japan
Phone : (03)5435-7111

Internet address : <http://www.fujielectric.co.jp>

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